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Bio-based Industries
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CELEBio

D.2.2

Biobased Economy Business Opportunities in 6 CELEBio Neighbouring Countries

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 838087

EDITORS: BERIEN ELBERSEN & JULIEN VOOGT

WAGENINGEN
UNIVERSITY & RESEARCH

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EXECUTIVE SUMMARY

Work package	2
Activity	A.2.1 – Sustainable Biomass Assessment
Task	n/a
Deliverable No	D.2.2
Deliverable Title	Biobased Economy Business Opportunities in 6 CELEBio Neighbouring Countries
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Publishable executive summary in English	This report compiles the 6 country reports for the CELEBio neighbouring region Albania, Bosnia and Herzegovina, Greece, Montenegro, North Macedonia, and Serbia. Every country report is organized in 9 chapters. In chapter 1 a first description is given of the key characteristics of the country. In the chapters 2, 3, and 4 the biomass production including their current uses and opportunities for what biomass can be additionally mobilised, is summarized for respectively the agricultural, forest, and waste sectors. In Chapter 5 a description is given of the current biobased industries and markets, in Chapter 6 the infrastructure, logistics, and energy sector are described. Chapter 7 focusses on the innovation potential. Chapter 8 focusses on the policy framework, in chapter 9 potential financing options related to the development of biobased production chains are discussed. The chapters are closed by SWOT analysis.

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SUMMARY

This report compiles the 6 CELEBio neighbouring region country reports for Albania, Bosnia and Herzegovina, Greece, Montenegro, North Macedonia, and Serbia.

Every country report is organized in 9 chapters. In chapter 1 a first description is given of the key characteristics of the country. In the chapters 2, 3, and 4 the biomass production including their current uses and opportunities for what biomass can be additionally mobilised, is summarized for respectively the agricultural, forest, and waste sectors. In Chapter 5 a description is given of the current biobased industries and markets, in Chapter 6 the infrastructure, logistics, and energy sector are described. Chapter 7 focusses on the innovation potential. Chapter 8 focusses on the policy framework, in chapter 9 potential financing options related to the development of biobased production chains are discussed. The chapters are closed by swot analysis.

1. Introduction

1.1. Objectives

This report compiles the 6 CELEBio neighbouring region country reports for Albania, Bosnia and Herzegovina, Greece, Montenegro, North Macedonia, and Serbia. These 6 country reports follow a similar structure and are based on a similar approach.

The main objective of CELEBio is to contribute to strengthening bio-economy-related activities in Bulgaria, Czech Republic, Croatia, Hungary, Slovak Republic, Slovenia and the neighbouring countries. To this end one of the key activities is to develop comprehensive reports for all 6 target countries and the 6 wider neighbouring countries on the availability of sustainable biomass, logistics, costs and biomass business opportunities assessed through an analysis of the Strengths, Weaknesses Opportunities and Threats (SWOT). The 6 neighbouring countries reports are presented in this report. A separate report (D2.1) presents the reports on the countries that make up the target CELEBio. A separate report (D2.4) summarizes all main finding of the 6 target country reports and of the wider region country reports. This last Deliverable will be made public by the end of August 2020.

1.2 APPROACH

This report aims to provide the necessary background information needed to evaluate the possibilities for setting up bio-based production chains in all countries covered in the CELEBio project which are beside the 6 target countries mentioned above also the neighbouring countries of Greece, Albania, Serbia, Montenegro, Bosnia and Herzegovina, and North-Macedonia.

The information structure and analysis presented in the 6 country reports was developed by building on the method designed and applied by Van Dam et al. (2014)[1] and was further refined through the execution of interviews with bio-based business developers and other experts. In these interviews further information was obtained on key factors that guide the choice of setting up bio-based activities in countries. Most of the experts stressed that all the identified factors are important and that a system approach is key in developing bio-based initiatives. If one link in the chain is missing, the bio-based initiative will not succeed. The identified factors are mapped in these 6 country reports and were the basis for performing the SWOT analysis for development of bio-based production chains. SWOT analysis results are also presented in the country reports. They were performed using the information compiled in the country reports and consultations with stakeholders in the 6 countries.

[1] van Dam, Jan E.G.; Elbersen,W. & Van Ree, R. (2014). Setting up international biobased commodity trade chains. A guide and 5 examples in Ukraine. May, 2014. Netherlands Programmes Sustainable Biomass. Wageningen University & Research, NL Agency.

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COUNTRY REPORTS

Horizon 2020
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D.2.2 COUNTRY REPORT: ALBANIA

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 838087

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AUGUST 2020

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Executive Summary

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Level of dissemination	PU

Publishable executive summary in English

Since the 1990s, Albania has undertaken major efforts to reform its governance and economy, with the ultimate aim of full integration into the European community. The effort is still ongoing and this is reflected in many ways on the current status of the bioeconomy sector in Albania.

The biomass potential in Albania is not insignificant for the size of the country. The agricultural (both crop and livestock) and agro-processing sectors represent important economic activities in Albania and have the potential to provide exploitable biomass resources. The waste management sector also offers significant opportunities and receives the lion's share of the attention when it comes to the management of its biological resources. The situation in the forestry sector is much more complicated; Albanian forests suffer from overexploitation and efforts are made to limit the extraction of biomass resources, which mostly go to local heating applications.

At the moment, there seems to be limited production of advanced bio-based products beyond those that involve a first, simple processing of agricultural products in the country. Policies and laws are generally in line with the European directives and regulations, but the key challenge is implementation, establishment of cooperations and funding allocation. A more thorough integration with the European R&I sector through knowledge transfer, as well as allocation of funds, both public and private, would be needed to set off the bio-based industry.

This report on Albania's bioeconomy sector is organized in 9 chapters. In chapter 1 a first description is given of the key characteristics of the country of Greece. In the chapters 2, 3, and 4 the biomass production including their current uses and opportunities for what biomass can be additionally mobilised, is summarized for respectively the agricultural, forest, and waste sectors. In Chapter 5 a description is given of the current biobased industries and markets, in Chapter 6 the infrastructure, logistics, and energy sector are described. Chapter 7 focusses on the innovation potential. Chapter 8 focusses on the policy framework, in chapter 9 potential financing options related to the development of biobased production chains are discussed. The chapters are closed by swot analysis.

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1 Introduction

1.1 Objectives and approach

The main objective of CELEBio is to contribute to the strengthening bioeconomy-related activities in Bulgaria, Czech Republic, Croatia, Hungary, Slovak Republic, Slovenia and neighbouring countries. To this end, one of the key activities is to develop seven comprehensive reports for the target countries and the wider neighbouring region on the availability of sustainable biomass, logistics, costs and biomass business opportunities assessed through an analysis of the Strengths, Weaknesses Opportunities and Threats (SWOT).

This report aims to provide the necessary background information needed to evaluate the possibilities for setting up bio-based production chains in Albania. Albania is one of the six countries adjacent to the core project area for which the CELEBio project also extends its activities.

The information structure and analysis presented in this report was developed by building on the method designed and applied by Van Dam et al. (2014) and was further refined through the execution of interviews with bio-based business developers and other experts. In these interviews further information was obtained on key factors that guide the choice of setting up bio-based activities in countries. Most of the experts stressed that all the identified factors are important and that a system approach is key in developing bio-based initiatives. If one link in the chain is missing, the bio-based initiative will not succeed. The identified factors are mapped in this report and will be the basis for performing a SWOT analysis for development of bio-based production chains.

In Annex 1 a further explanation is given of the approach used to set-up this country report.

1.2 Reading guide

This report is organised in 9 main chapters. Chapter 1 gives an overview of Albania's key characteristics. In the chapters 2, 3, and 4 the biomass production including its current uses and opportunities for what biomass can be additionally mobilised, is summarized for respectively the agricultural, forest, and waste sector. First the main traditional production and availability of biomass for food, feed, forest biomass and wood products are discussed and how this is handled in further processing industries and/or used for domestic markets and exports. Subsequently an overview is given of additional biomass potentials that are likely to be still unused or only partly used and that are a good basis for development of new bio-based activities. In Chapter 5 a description is given of the current bio-based industries and markets, advanced bio-based initiatives, and future biomass valorisation options. Chapter 6 describes the infrastructure, logistics, and energy sector. Chapter 7 focusses on the innovation potential, particularly in the context of bio-based research and development options. The research and educational infrastructure are discussed and the potential for developing bio-based start-ups and Public-Private-partnerships will be taken into a consideration. Chapter 8 gives an overview of the policy framework and describes extensively what regulations, legislation, taxes and tariffs exist of relevance for the development of bio-based production chains. Additionally, attention will be paid to situations where regulation and support measures are actually missing and to which extend the rule of law situation influences the establishment of new bio-based activities. In Chapter 9 potential financing options related to the development of bio-based production chains are discussed.

1.3 Short characteristics of country

Albania has a surface of 28,748 km². With 2,870,324 million inhabitants its corresponding population density is 100 persons/km² (See table 1.3.1). Despite economic progress, the average income level is significantly below the EU average. The population is mostly concentrated on the large urban centres of Tirana and Durrës. On the other hand, agriculture is a major economic sector, with its share in the GVA far higher than the EU average.

Table 1.3.1 Main population, land surface, GDP and trade characteristics of Albania benchmarked against EU average

Category	Albania	EU	Unit	Year
Population	2.9	512.4	million	2018
Area (total)	2.7	447	million ha	2018
% population in urban areas	61.4%	44.9%	% of total population	2018
% territory predominantly rural	82.2%	43.8%	% of total territory	2018
% territory predominantly urban	5.7%	10.7%	% of total territory	2018
Agricultural Area	0.7	173.3	million ha	2016
Forest area	1.1	164.8	million ha	2016
Population density	100	115	n°/km²	2018
Agricultural Area per capita	0.24	0.34	ha/capita	2016
Forest area per capita	0.37	0.32	ha/capita	2016
GDP/capita	4,446	30,956	at current prices	2018
	9,609	30,956	GDP at purchasing power	2018
GVA by Agriculture, forestry and fishing	21.1%	1.6%	% of total GVA	2018

GDP = Gross Domestic Product; PPS = Purchasing Power Standard; GVA = Gross Value Added; UAA = Utilised Agricultural Area
Sources: Eurostat, World Bank, INSTAT

More than 70% of Albania's territory is mountainous, one of the highest shares in the world. Together with numerous lakes and rivers, Albania has a large hydropower potential which covers a major part of its electricity production. Forest's cover about 37% of Albania's area. Around 24% (695,000 ha) of the land is agricultural1, of which 43% is located in lowlands and the other 57% in hilly and mountainous areas. Pastures and meadows extend to about 15% of the total area and the rest is urban land, lakes, waterways and unused rocky and mountain land. The main land cover distribution is presented on figure 1.3.1.

[1] www.fig.net/resources/proceedings/2012/Hungary_2012_comm7/4.3_presentation_tarelli.pdf

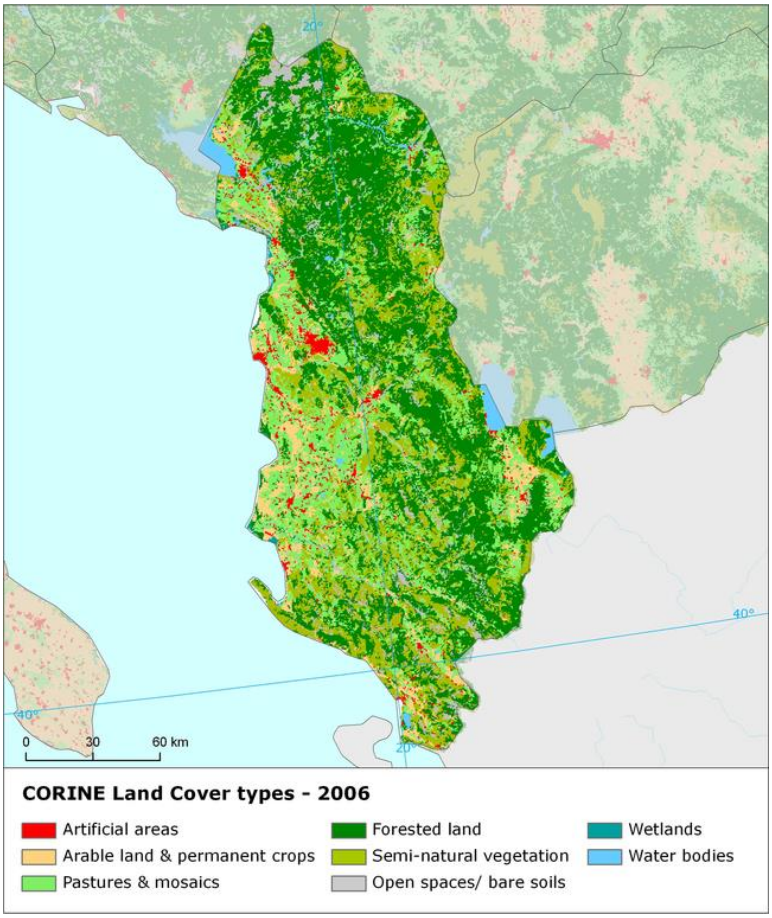


Figure 1.3.1 Main land cover distribution over Albania (Source: European Environmental Agency).

Albania shares land borders with Greece (south), North Macedonia (west), Kosovo (north-west) and Montenegro (north), as shown on figure 1.3.2.

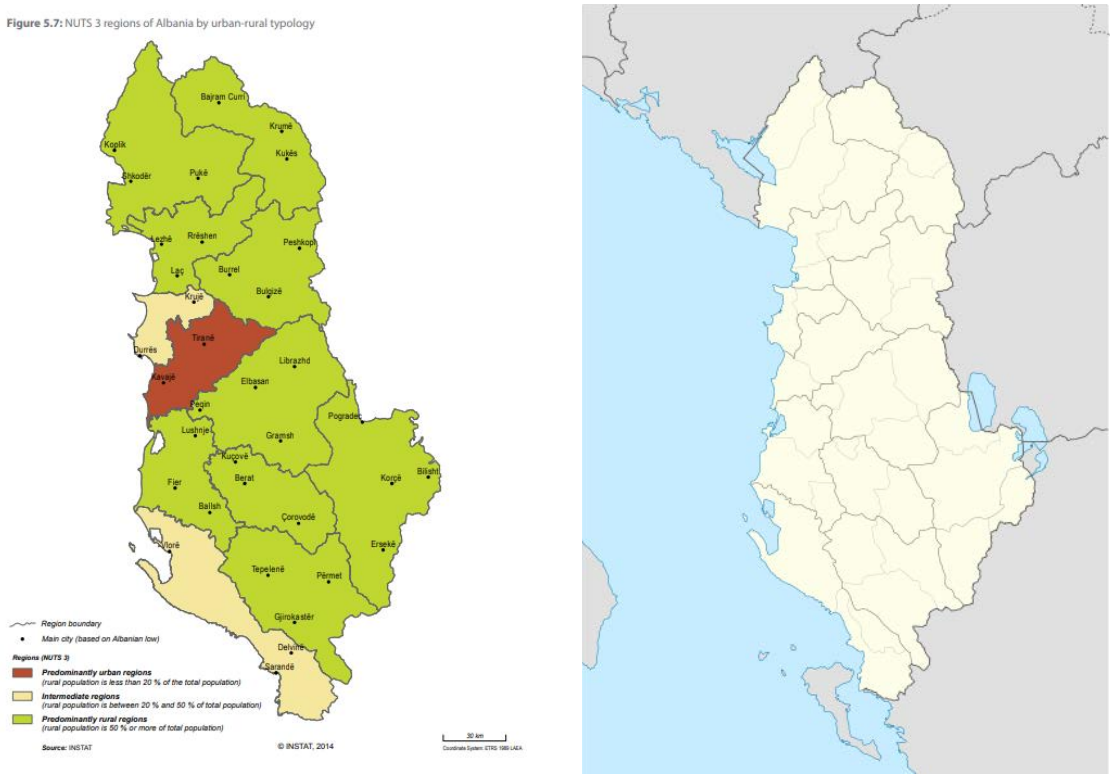


Figure 1.3.2: Albania NUTS3 regions and typology (left) – Albania and its bordering countries (right)

Albania is included in the extension of the Trans-European Transportation Network through the Mediterranean Corridor, running down from Rijeka along the Adriatic cost, passing through the ports of Durrës and Vlore and connecting to the International Airport of Tirana and finally reaching the Orient/East-Med corridor in Greece, as shown in Figure 1.3.3.

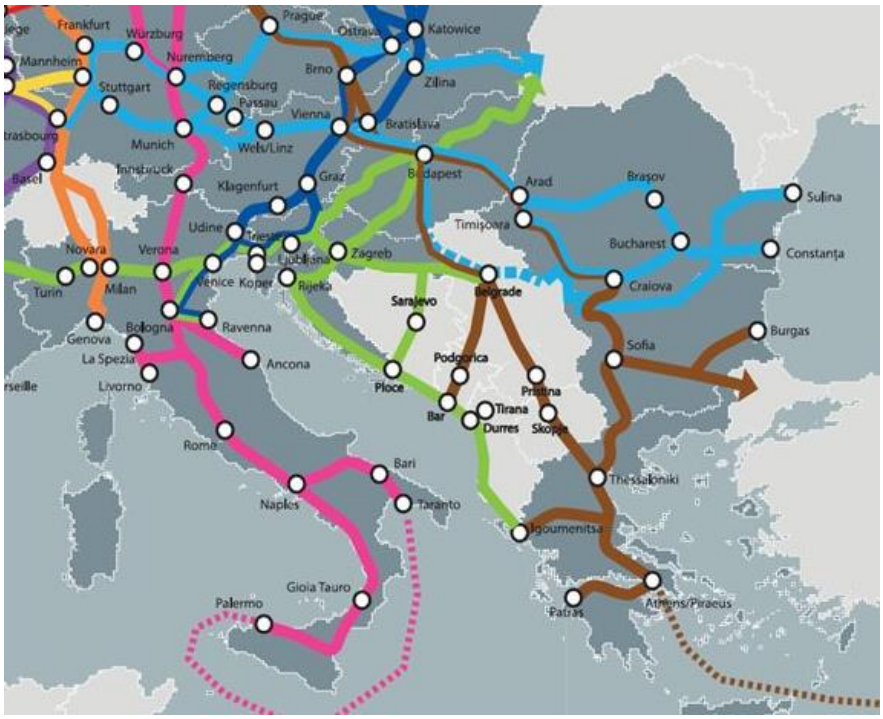


Figure 1.3.3: Position of Albania in the Trans-European Transportation Network

2 Biomass supply: agriculture

2.1 Introduction

In this chapter the agricultural biomass production and main uses is described. A distinction will be made between the main economic products produced and their main process chains and residual biomass potentials from primary production and available as by-products of food processing industries. In addition to presenting the main biomass production attention will also be paid to the importance and the structure of the agricultural sector and to the main environmental challenges associated with agriculture in Albania.

2.2 Characterisation of current agriculture sector

Despite decreasing contribution to the GDP, agriculture remains a major economic activity for Albania, while the agricultural sector is the second largest employer, having fallen behind the service sector[2]. The Mediterranean climate of the country and the varied topography allow for the cultivation of a wide range of crops. The most productive regions are Durrës, Fier and Vlorë in the western part and Korçë in the eastern part of the country, which together account for 55% of the agricultural production of the country, with only 45% of the arable area.

About 44% of the agricultural area has a slope of 5% or less. The hilly and mountainous areas are particularly affected by soil erosion; 70% of the agricultural land is eroded at a rate of 30 t/year, 20% is eroded at a rate of 5t/year and only 10% of agricultural land is unaffected[3].

Until 1991, all agricultural land in Albania was state-owned. The land privatization scheme transformed Albania into a nation of smallholders, distributing to 445,000 families (circa 65% of the population) various arable and non-arable land parcels based on a per-capita basis through village-based land commissions. The process was completed in 2008, with around 80% of the agricultural land in private hands. The process led to very high fragmentation (3.8 parcels per farm, 1.2 – 1.3 ha per farm), which is affecting the productivity of the agricultural sector. A slow process of land consolidation is taking place, assisted by pilot programmes. Around 20% of the land is still retained by the state; 26,000 ha are mostly reserved for compensation of old owners whose property was expropriated by the communist system as well as for agricultural research institutions, joint venture enterprises, for leasing and other purposes. Another 108,000 ha of state-owned agricultural land are administered by local government units and include numerous sites of low fertility, difficult access, etc.; these might be of interest for the cultivation of fruit trees, aromatic plants or herbs, or for conversion back to pasture[4,5].

In addition to the small size of holdings, several other problems are affecting Albanian agriculture: migration from rural areas, poor marketing of products, underdeveloped irrigation and drainage systems, low technological level, weak organisation of farmers and low level of development of the processing industry[6]. In general, a major part of the Albanian agricultural sector can be characterized as "substinence" agriculture.

[2] www.statista.com/statistics/454897/employment-by-economic-sector-in-albania
[3] http://publications.jrc.ec.europa.eu/repository/bitstream/JRC95833/jrc95833%20web%20final%20printed.pdf
[4] www.fig.net/resources/proceedings/2012/Hungary_2012_comm7/4.3_presentation_tarelli.pdf
[5] www.fao.org/tempref/GI/Reserved/FTP_FaoSeur/events/landcons/docs/Albania%20pres.pdf
[6] https://ec.europa.eu/info/food-farming-fisheries/farming/international-cooperation/enlargement/agriculture-eu-enlargement/candidates_en

Table 2.2.1: Key characteristics for the agricultural sector in Albania.

Category	Greece	EU	Unit	Source / Year
Agriculture in % of total employment	38.2%	4.1%	% of total employment	2017 / [1]
Agricultural area per capita	0.24	0.34	ha/capita	2018 / [2]
Cereal yield	5.0	5.2	t/ha	2019 / [3]
Crop output in total output	46%	56%	% of total agricultural output value	2012 / [4]
Livestock output in total output	54%	44%	% of total agricultural output value	2012 / [4]
Agricultural income (2010=100)	n/a	121	Index 2010=100	2018 / [1]
Livestock density	0.63	1.02	LSU/ha UAA	2017 / [5]
High input farms	n.a.	29%	%/ total farms	2016
Low input farms	n.a.	39%	%/ total farms	2016
Gross nutrient balance nitrogen	n.a.	47	kg of nutrient per ha	Average 2011-2015 / [4]
Gross nutrient balance phosphorus	n.a.	1	kg of nutrient per ha	Average 2011-2015 / [4]
Irrigated utilised agricultural area	43%	n.a.	% of UAA	2019 / [3]
Average farm size	1.2	16.6	ha UAA/holding	2012 / [4]
% of agr. holdings < 5 ha	98.9%	62.6%	%/total no. of holdings	2012 / [6]

Sources:
[1] http://www.instat.gov.al/media/4156/albania-in-figures-2017.pdf
[2] Eurostat; agricultural area of 700,000 ha considered according to JRC
[3] INSTAT, Agriculture Statistical Yearbook 2019
[4] JRC (2015) Characteristics of farming systems in Albania
[5] FAOSTAT, Livestock Patterns
[6] INSTAT, Agricultural Census 2012

2.2.1 Crop production

According to INSTAT[7], sown areas in Albania / 2019 amounted to 417.0 thousand hectares; cereals covered 32% of that area, forage crops 53%, industrial crops (e.g. tobacco, sugarbeet, aromatic plants) 2% and vegetables / melons, potatoes and beans 13%. For other sources, it can be estimated that permanent crops cover an area of about 82.6 thousand hectares[8]. Around 43% of the sown area is actually irrigated, although the potential is much higher.

It is interesting to note that about 10% of the area devoted to vegetables corresponds to greenhouses; the expansion is quite rapid, going from 1,733 ha in 2013 to 3,323 ha in 2019.

Cereals

The total surface area devoted to cereals exhibits a decreasing trend, losing ground to forage plants. However, production is more stable as a result of improved yields over the last years. At the moment, wheat and maize are almost on equal footing in terms of surfaces cultivated, with higher total production of maize. Cereals are grown in all 12 Albanian regions, but those with the most surfaces are Fier, Elbasan and Korce.

[7] INSTAT, Agriculture Statistical Yearbook 2019
[8] https://ec.europa.eu/info/food-farming-fisheries/farming/international-cooperation/enlargement/agriculture-eu-enlargement/candidates_en

Table 2.2.2: Surfaces and production of cereals in Albania (Source: INSTAT, 2019)

Cereal type	Surfaces (1,000 ha)	Production (1,000 tons)	Yield (tons/ha)
Wheat	57.3	233.2	4.07
Rye	1.2	2.6	2.17
Oat	15.8	33.4	2.11
Barley	2.7	7.9	2.90
Maize	55.1	389.0	7.05
Total	132.2	666.1	5.04

Industrial crops

Medicinal / aromatic plants and tobacco are among the main agricultural exports of Albania. Medicinal crops can be found all over the country, but 76% of the cultivated areas are located in the region of Shkoder. Sugarbeet in cultivated exclusively in Korce, while almost all of sunflower cultivation takes place in Fier. Tobacco is mostly grown in Elbasan and Shkoder. Finally, soya is grown in Lezhe, Fier and Durres.

Table 2.2.3: Surfaces and production of major industrial crops in Albania (Source: INSTAT, 2019)

Industrial crops	Surfaces (1,000 ha)	Production (1,000 tons)	Yield (tons/ha)
Tobacco	0.8	1.4	1.75
Sunflower	0.4	1.0	2.50
Soya	0.2	0.6	3.00
Sugarbeet	0.8	30.7	38.38
Medicinal crops	5.6	12.9	2.30

Permanent crops

Olive trees: as a Mediterranean country, Albania has good conditions for growing olive trees, especially near the coastal areas and the production is on increasing trends. Olive trees are cultivated mostly in Fier, Berat, Vlore and Elbasan, but there are also productive trees in other regions (with the exception of some mountainous areas). 11% of the total olives production corresponds to table olives, with the main centre of production being Berat (about 50% of total table olives). The main production centre for olives for olive oil is Fier (about 33% of the production). Olive oil consumption per capita in Albania is quite low compared to other Mediterranean countries; on the other hand, per capita consumption of table olives is among the highest[9]. In both cases, Albania is a net importing country.

Grapes: grapes in Albania are produced under two different cultivation schemes. Pergolas correspond to about 40% of the total grape production and they are more evenly distributed among the Albanian regions, with each having a production share ranging from 4.6% (Lezhe) to 14.9% (Vlore). Grapes of vineyards are more concentrated, with the region of Fier being the main leader, corresponding to 19.9% of the surfaces and to 30.6% of the production.

Citrus trees: 57% of the total citrus fruit production in Albania corresponds to tangerines grown in Vlore, which is also an important area for both oranges and lemons. Citrus production also takes place in Fier, Elbasan, Durres, Tirane and Berat.

[9] http://agroweb.org/archive/?id=10&l=2114

Fruit trees: pomefruit trees are the most important fruit trees in Albania in terms of production. 56.4% of pomefruit trees are produce in the county of Korce; Diber follows with 10.4%. Apples are the most widespread pomefruits in Albania. Stonefruit trees are more evenly spread around the countries, with the counties of Elbasan, Fier, Korce and Diber corresponding to 20.0, 17.3, 13.9 and 10.5% of the production respectively.

Nut trees: Albanian nut production is on an increasing trend. One of the main products is chestnuts, especially from the Tropojë municipality in Kukës County; the area features more than half of the 336,500 chestnut trees that can be found in the country. There is no chestnut processing facilities in Albania, so apart from local consumption, major quantities are exported to Italy. Harvesting and selling of chestnuts is a major source of income for rural households in the Albanian Alps area[10,11,12].

Table 2.2.4: Permanent crops in Albania (Source: INSTAT, 2019)

Permanent Crops		Productive trees (1,000 trees)	Production (1,000 tons)
Grapes – Vineyards		10,255 ha	113.8
Grapes – Pergolas		6,008	76.1
Olive trees	For olive oil	8,226	87.4
	For edible olives		10.9
Citrus trees	Lemons	1,265	4.1
	Oranges		11.6
	Tangerines		31.2
	Others		-
Pomefruit trees		4,667	124.9
Stonefruit trees		3,933	85.4
Subtropical trees		1,469	42.4
Berries		100	2.5
Nuts trees		1,065	14.2
Other trees		345	3.3

2.2.2 Livestock production

The mountainous / hilly nature of Albania's terrain is considered to make the country quite suited for livestock production, contributing 52% of the total agricultural output.

Fragmentation / small-size is a common issue for both agricultural and livestock production. In 2013, 85% of the farms in Albania were mixed (farming & livestock), but only 3.8% of cattle farms owned more than 5 cows and only 18.6% percent of sheep and goat farms had flocks with more than 50 heads. Despite these challenges, the total output of the livestock sector has increased since the 1990s as a result of improved production techniques, feeding and overall animal health care[13].

The table below summarizes the number of livestock in Albania as well as the main outputs of the livestock sector.

[10] https://agroweb.org/archive/?m=t&id=10&l=526
[11] https://invest-in-albania.org/from-tropoja-to-korca-where-to-find-chestnuts/
[12] https://invest-in-albania.org/tropojas-chestnuts-ready-international-market/
[13] G. Gjeçi, F. Shytaj, Y. Biçoku (2018) Livestock Sector in Albania: Trends and Challenges. Albanian Journal of Agricultural Sciences / Special edition - Proceedings of ICOALS, 2018. https://ajas.ubt.edu.al/wp-content/uploads/2018/10/19_AJAS_Full-Paper_Ylli-Bicoku_ICOALS-2018.pdf

Table 2.2.5: Animal heads and main products in Albania (Source: INSTAT, 2019[14])

Animal species	# of 1,000 heads	Products (1,000 tons)
Cattle	416	Meat: 66.1 Milk: 946.6
Pigs	184	Meat: 16.7
Sheep	1,758	Meat: 35.1 Milk: 81.7
Goats	863	Meat: 19.0 Milk: 84.0
Equidae	87	-
Poultry	8,179	Meat: 20.0 Eggs: 865 (million pieces)
Beehives	288	Honey: 4.1

Livestock raising takes places in all Albanian counties. For most species, such as cattle, sheep and goats, the distribution is more even across the counties. Poultry farms seems to be the most concentrated one, with a major presence in Durrës and Fier.

2.3 Biomass potentials from agricultural residues and unused lands

Primary agricultural residues – arable crops

The table below summarizes the biomass potential from primary crop residues in Albania, as calculated by the S2Biom toolset.

Table 2.3.1: Crop residue potential (kton dm) in Albania from S2Biom

Arable crop residues	S2Biom (Reference year: 2020)		
	Technical	Base	User Defined
Cereal straw	287	137	0
Maize stover	184	88	88
Sugar beet leaves	10	5	5
Sunflower straw	4	2	2
Oil seed rape straw	0	0	0
Rice straw	0	0	0
Olive tree prunings	39	8	n/a
Vineyard prunings	10	4	n/a
Fruit tree prunings	62	37	n/a
Citrus tree prunings	2	0	n/a
Total	598	281	95

[14] INSTAT, Livestock Statistics 2019. www.instat.gov.al/en/themes/agriculture-and-fishery/livestock/publication/2020/livestock-statistics-2019

Most of the technical potential from agriculture in Albania corresponds to cereal straw, followed by maize stover. Prunings for permanent crops are not insignificant, amounting to 113 kton dm in total. However, the estimation of the base potential, which takes into account the amount of biomass that should be left on the soil to maintain the soil organic carbon, reduced the agricultural biomass potential by more than half. The large number of animals from the livestock sector has a further impact on the user defined potential, effectively minimizing the amount of cereal straw that can be mobilized, leaving only maize stover as significant biomass resource.

However, it may be the case that the S2Biom platform underestimates the potential of agricultural prunings in Albania. A simple, alternative calculation that starts from the assumption that about 12 kg of prunings are generated from a productive olive tree indicates that the technical potential of olive tree prunings in Albania is around 64.2 kton dm, significantly higher than the S2Biom estimation[15]. It is also unclear whether the S2Biom tool considers the pruning potential from grape pergolas, since this is a quite distinct feature of Albanian viniculture. Moreover, regarding limitations that are applied for the base potential estimation, there are still uncertainties, even on the European level, as to whether it is best to remove the agricultural prunings for phytopathological reasons or to mulch them and integrate them on the soil.

Overall, the potential of primary agricultural residues in Albania is not insignificant; further studies would be needed to evaluate in more details the conditions for their sustainable mobilization, as well as potential technical limitations that may apply (e.g. sloped terrain). Considering however their territorial distribution, it is more likely that any additional mobilization of agricultural biomass will be geared towards small to medium scale heat and/or electricity production rather than biorefinery models.

Box 2.2: Methodology of S2BIOM to calculate the crop residues potentials.
It identifies the part of the residues that can be removed from the field without adversely affecting the Soil Organic Carbon Content in the soil. For cereal straw a subtraction is also applied according to demand for straw for animal bedding & feed. For corn stover, rice straw, and sunflower and rape stubbles NO competing uses are assumed. The soil organic carbon balance is the difference between the inputs of carbon to the soil and the carbon outputs. A negative balance, i.e. outputs are larger than the inputs, will reduce the SOC stock and might lead to crop production losses on the long term. To calculate the soil carbon balance at regional level S2BIOM used the MITERRA-Europe model (Lesschen et al., 2011) to provide the input data and the "RothC-26.3" model (Coleman & Jenkins, 1999) to calculate the soil carbon dynamics in a spatially detailed assessment. For further details on the whole assessment of biomass potentials in S2BOM consult Dees et al[16] and a summary is given in Annex 2.

Manure from livestock production

Scarlat et al.[16] have performed in 2018 a spatial analysis of biogas potential from manure in Europe. The key findings for Albania are as follows:

- Total manure production is estimated at 6.6 million tons per year, while the collectable volume is 3.6 million tons.
- The theoretical biogas potential is 153 million m^3 of CH_4, while a realistic estimate brings it to 64 million m^3 of CH_4. This is compared to a natural gas consumption of 12 million m^3 of CH_4.
- The biogas plant capacity in Albania has a potential of 66 MW, however a more realistic estimate is for 32 MW, which can produce 237 GWh of electricity annually.
- Considering a constant collection radius, 83 manure-based biogas plants can be built; 10 would have a capacity range between 0.5 – 1MW, while all others would be smaller. The average plant capacity would be 302 kW and the total combined would add up to 25.1 MW.

[15] The 12 kg of prunings per tree ratio corresponds to a Residue-to-Product Ratio (RPR) of around 1.0, which is commonly used for olive tree prunings. The average moisture content of olive tree prunings is assumed to be 35% on a weight basis.
[16] N. Scarlat, F. Fahl. J.F. Dallemand, F. Monforti, V. Motola (2018) A spatial analysis of biogas potential from manure in Europe. Renewable and Sustainable Energy Reviews Vol 94, pp 915-930. https://doi.org/10.1016/j.rser.2018.06.035

- In the scenario of variable radius / fixed capacities, biogas units in Albania would amount to 110. Of these, 10 units would have a capacity of 0.5 MW and 68 units would be at 100 kW. The average plant capacity would be 191 kW and the total combined would add up to 21 MW.

Unused / abandoned lands

A World Bank study of 2015[17] indicated that 173,885 hectares were abandoned, corresponding to about 10% of the agricultural productive land; most of it had been abandoned for at least five years at the time of the survey. Fragmentation was not the main reason for this; most respondents cited lack of capital (for purchase of equipment or fertilizers) and inconvenient location of the plots as the main reason for the abandonment.

A recent study[18] investigated the areas that can be characterized as "marginal" in Europe. Albania was one of the countries in which marginal lands amount to more than 20% of their total area. The suitability of different bioenergy crops in these marginal lands was also evaluated considering various cut-off criteria (protected areas, specific land uses, and slope steepness). For Albania, the crop suggested was predominantly poplar, with some smaller areas allowing the possibility of selection between poplar and switchgrass.

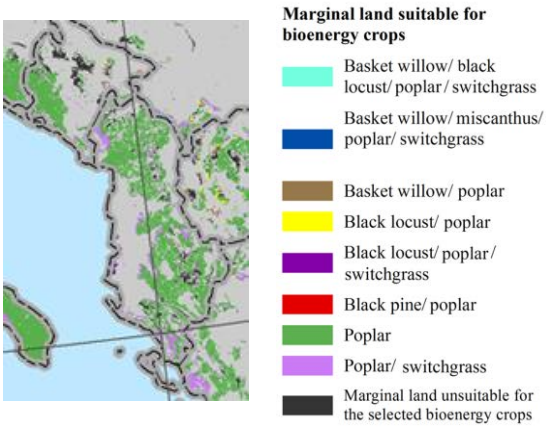


Figure 2.3.1: Marginal lands suitable for bioenergy crops in Albania (Source: Gerwin et al., 2018).

2.4 Secondary agricultural residues from processing industries

The S2Biom biomass supply tool indicates that Albania has a relative small potential of secondary agricultural residues from processing industries, amount to 7 kton dm of olive stones and another 4 ktom dm of cereal bran (reference year 2020).

Olive oil production in the 2017-2018 season was 11,000 tons, down by 4% compared to the previous[19]. There are about 400 – 450 olive mills in Albania, the vast majority of which are small, local units operating at village level and with production capacities of 0.8-1.5 tons/hour. There are some modernized, small plants with new technology that may produce around 10 tons per season and sell either to domestic consumers or to even to exports. Finally, there are about 25 larger olive mills, with production capacities above 1.5 tons/hours and with typical olive oil production of 80 tons per year[20]. Older data suggest that the vast majority is reported to use the three-phase production system rather than the two phase one; this is considered appropriate considering the size of the olive mills[21]. Management of residues from olive oil processing is considered an issue. Wasterwater mostly goes to sewage, while for pomace alternatives for its valorization are considered. Olive mills are reported

[17] http://documents1.worldbank.org/curated/en/322931468007498994/pdf/WPS6032.pdf
[18] W. Gerwin, F. Repmann, S. Galatsidas, D. Vlachaki, N. Gounaris, W. Baumgarten, C.Volkmann, D. Keramitzis, F. Kiourtsis, D. Freese (2018) SOIL, 4, pp. 267–290, https://doi.org/10.5194/soil-4-267-2018
[19] www.internationaloliveoil.org/1281-albania-returns-to-the-ioc
[20] http://aasf.com.al/wp-content/uploads/2019/08/olive-Oil-EN.pdf
[21] www.ishp.gov.al/resource-efficiency-and-cleaner-production-in-the-olive-oil-industry-cakraj

to use it as a fuel for own process and it is sold as a fuel for agro-industries, greenhouses and heating. A greenhouse seedling facility in Tirana reports the use of olive cake supplied by local olive mills as a heating fuel[22]. Due to the lack of extraction of residual olive oil from the pomace, it is considered that treatment of olive mill waste is not up to the latest environmental standards. The lack of a pomace mill /refinery is recognized as a weakness of the olive oil sector in Albania; it would be a major investment, that would transform the overall value chain[23]. Innovative ways of valorizing olive cake are also explored by projects[24].

Regarding cereal bran, it can be assumed that it is used for the production of bran flour or otherwise disposed. Five larger milling plants are located in Albania, covering about 50% of the market demand[25]. Atlas Mills (https://atlasmills.com.al/about-us/) is a modern cereal mill that started operated in 2015. The company is treating imported wheat from Russia and Austria and produces flour, covering about 35% of the Albanian market.

There are about 426 wineries in Albania, producing dry wines, sweet wines and raki, both for domestic consumption and for exports. 10 wineries have processing and preservation capacities exceeding 20,000 hl/year; in 2016, they produced about 17.5% of the Albanian wine production which in total amounted to 118,744 hl. The other 82.5% was produced by small, family wineries. 141,648 tons of grapes were used for wine production in 2016; considering the ratios employed by S2Biom, it can be estimated that production of pressed grape residues (dregs and stalks) is around 8,640 tons.

There are also processing plants for the production of edible oil from various seeds, mostly sunflower. Two of the most important ones are OLIM (www.facebook.com/OLIMCOMPANY) and Vajra Bimore Fiol (http://www.vajrabimore.com). It is not clear whether these companies valorize their biomass residues for feed or for energy production.

Box 2.3: Methodology of S2BIOM to calculate the secondary residue potentials from food processing

All the secondary agricultural residues presented refer to residues of crops that are mostly grown and processed in the same country. Their assessment can therefore be based on production information (area and/or yield information) derived from national agricultural statistics.

For further details on the whole assessment of biomass potentials in S2BOM consult Dees et al (2017) and a summary is given in Annex 2.

2.5 Cost of main biomass source

Since for primary agricultural residues and energy crops no commodity market has developed yet in Greece it is very difficult to provide figures on prices. Instead cost estimates can be presented building on the S2BOM methodology and assessment. The cost refers to *Roadside cost* and these cover all biomass production collection and pre-treatment cost up to the road where the biomass is located. The roadside cost are only a fraction of the total 'at-gate-cost.' The range of road side costs (min, average, max) for Albania are presented in Table 2.5.1 below; for further details on the cost calculation in S2BOM see Annex 2.

[22] www.ipatechproject.eu/main/index.php/hr/najbolje-prakse/83-olive-cake-an-energy-source
[23] http://aasf.com.al/wp-content/uploads/2019/08/olive-Oil-EN.pdf
[24] www.cci.al/en/visit-in-the-olive-oil-mill-musai-ltd-vlora
[25] www.see-industry.com/en/albania/2/1437/

Table 2.5.1: Road side cost levels (€/ton d.m.) for agricultural biomass sources in Greece based on S2BIOM cost calculations

Road side cost for agricultural biomass	(€ ton dm, 2020 cost level) Average
Herbaceous energy crops (miscanthus, switchgrass, giant reed, cardoon, reed canary grass)	32
Short Rotation Coppice (willow, poplar, other)	32
Rice straw	16
Cereals straw	16
Oil seed rape straw	13
Maize stover	10
Sugarbeet leaves	28
Sunflower straw	12
Residues from fruit tree plantations (apples, pears and soft fruit)	110

The data from the S2Biom methodology indicate very low roadside costs for most agricultural residues in Albania. It seems that this is due to the low cost of labour considered by the methodology rather than due to high biomass on-field productivity which reduces the cost of supply. The cost of residues from fruit tree plantations seems quite high and it is possible that lower costs should be expected.

2.6 Summary and conclusions in relation to SWOT elements

The Albanian agricultural sector is one of the major economic activities of the country and involves almost half of the country's population. The de-collectivization process and land distribution schemes of the 1990s have transformed Albania into a nation of small land owners. However, the small size of the agricultural holdings, along with several other weaknesses, is a major bottleneck for the take-off of the agricultural sector.

Regarding the further development of the bioeconomy, with the mobilization of unused agricultural residues, Albania offers some modest possibilities. Considering the total volume of agrobiomass as well as the fairly small-size of the agrifood processing sector, it is considering more likely that new opportunities will emerge mostly in the energetic valorization of residues in small / medium scale systems, as well as in the production of some specialized bio-based products, rather than in formation of commercial, large-scale biorefineries.

Table 2.6.1: SWOT elements in relation to biomass supply from agriculture in Albania

Strengths	Weaknesses
Varied agricultural sector Cheap agricultural labour / Competetiveness of several products	Fragmentation of agricultural holdings Emphasis on substinence farming Lack of modernization Terrain difficulties Lack of a coordinated bioeconomy policy focusing on residues Limited capacities for agro-food processing
Opportunities	**Threats**
Increased export orientation Possibilities to enhance agricultural supply Increased emphasis on sustainability Consolidation of farms	Soil erosion Rural abandonment

3 Biomass supply: Forestry

Different statistical sources indicative different values for the areas covered by Albanian forests, probably as a result of different definitions. INSTAT indicates that the total forest areas exceeds 1 million hectares (including pastures), while FAOSTAT indicates a forested area of 776 thousand hectares in 2010. Both sources agree on the fact that Albanian forests are almost exclusively owned by the state, with private forests being less than 2-3% of the total area. The importance of forests in Albania's economy has declined since the 1990s, with the share of employment in the total workforce dropping to 0.1% in 2006 (from 2.2%) and the contribution for the corresponding sectors (forestry and logging, wood processing, paper and pulp) dropping to 0.2% of the GDP (from 2.5%)[26].

Despite this, the exploitation of Albanian forests has set at dramatic levels, probably not seen elsewhere in Europe. According to the European Environmental Agency, the forest utilization rate (annual fellings as a percentage of annual increment) in Albania were consistently higher than 200% since the 1990s, compared to the suggested rate of 70%. In 2005 the utilization rate was 550.3%, while in 2010 it was 440.3%. Specialists estimate that only 400 thousand hectares of true forests remain in Albania, while the rest have been transformed into low forests, bushes and barren land[27].

This dramatic state of affairs has prompted the Albanian government to impose in 2016 a national moratorium on forest logging operations[28], effectively banning the exporting of roundwood and forcing wood processing companies to rely mostly on imported wood. An exception is granted for the harvesting of firewood for the use of local populations, which anyway corresponded to the majority of fellings in Albania. Reforestation and sustainable forest management awareness raising projects have already been launched by Austrian companies and development agencies[29], while in early 2018 the Albanian government announced an ambitious programme to plant 20.2 million trees in the country by 2020[30].

Table 2.6.1: Albanian forests in numbers

	Value	Unit	Source / Year
Forest area	776.0	1,000 ha	2010 / [1]
Productive forests	613.0	1,000 ha	2010 / [1]
Growing stock	97	m^3/ha	2010 / [1]
	66.2	m^3/ha	2015 / [2]
	75	1,000,000 m^3	2010 / [1]
Coniferous trees	19	1,000,000 m^3	2010 / [1]
Deciduous trees	57	1,000,000 m^3	2010 / [1]
Industrial roundwood removals	27	1,000 m^3	2010 / [1]
Woodfuel removals	164	1,000 m^3	2010 / [1]
Other uses	12.3	1,000 m^3	2018 / [3]
Firewood	758.1	1,000 m^3	2018 / [3]

Sources:
[1] FAO, Global Forest Resources Assessment 2010. www.fao.org/3/i1757e/i1757e.pdf
[2] European Environmental Agency, Forest: growing stock, increment and fellings. www.eea.europa.eu/data-and-maps/indicators/forest-growing-stock-increment-and-fellings-3/assessment
[2] INSTAT, Forest Statistics 2018

[26] www.fao.org/forestry/country/57033/en/alb/
[27] https://balkaneu.com/moratorium-wood-cutting-albania-prohibited-ten-years
[28] Law No. 5/2016 proclaiming the moratorium on forests in the Republic of Albania. www.ecolex.org/details/legislation/law-no-52016-proclaiming-the-moratorium-on-forests-in-the-republic-of-albania-lex-faoc163381
[29] www.pulpapernews.com/20200115/11091/lenzing-launches-sustainable-reforestation-project-albania
[30] www.poandpo.com/politics/albania-pledges-to-plant-202-million-trees-2712018166/

3.1 Primary biomass resources from forestry

Table 3.2.1. describes the primary biomass potential from forests in 2020. Data was obtained during the S2Biom project. It should be noted that biomass potential is expressed in thousands of tons (Kton) of dry matter (d.m.). Comparison with the results of removals presented in the previous section (expressed in m^3) is not straightforward, however with conservative conversion factors[31], it can be concluded that the final fellings, especially from non-coniferous trees, are already quite close to the base potential. Biomass mobilization from thinnings and logging residues might be possible, but it is expected to be difficult consider the sloped terrain of Albanian forests and the lack of modern means for biomass collection.

Table 3.1.1: Primary biomass potential from forests in kton d.m. (S2BIOM Base potential 2020).

Type	Albania
Final fellings from non-conifer trees	648
Final fellings from conifer trees	114
Thinnings from non-conifer trees	110
Thinnings from conifer trees	36
Logging residues from final fellings of non-conifer trees	103
Logging residues from final fellings of conifer trees	17
Logging residues from thinnings of non-conifer trees	8
Logging residues from thinnings of conifer trees	9
Total	1,045

Table 3.2.2 summarizes how the harvest levels and the total additionally harvestable stemwood and residue resource relate to the total yearly forest biomass increment. It becomes clear from this table that in almost all countries the common harvest levels are considerably below the yearly increment level. However, as was explained in the previous section, this does not apply to Albania, with a forest harvesting rate far exceeding the annual increment.

[31] An average wood basic density of 542 kg/m^3 (dry weight) for non-conifer tree fuelwood is assumed (www.unece.org/fileadmin/DAM/timber/meetings/20150318/2014_Draft_Questionnaire.pdf). Although INSTAT indicates a firewood production of 758,100 m^3 in 2018, FAOSTAT publishes even higher estimates, reaching 1,100,000 m^3 of non-coniferous firewood for 2018.

Table 3.1.2: 2010, 2020 and 2030 EFI-GTM harvest levels expressed as % of yearly average biomass increment level in forests. (Source: Biomass Policies, Elbersen et al., 2016)

		% Harvest & residues potential/Increment			% Harvest & residues potential + Maximum additional harvestable potentials/increment		
Country code	Country	2010	2020	2030	2010	2020	2030
AT	Austria	60%	53%	59%	110%	91%	86%
BE	Belgium	55%	55%	53%	87%	87%	85%
BG	Bulgaria	22%	18%	18%	55%	44%	43%
HR	Croatia	72%	67%	64%	181%	169%	162%
CZ	Czech republic	69%	75%	72%	110%	99%	100%
DK	Denmark	24%	17%	17%	68%	46%	41%
EE	Estonia	56%	68%	68%	103%	98%	93%
FI	Finland	59%	57%	53%	64%	58%	53%
FR	France	29%	26%	35%	83%	68%	71%
DE	Germany	43%	47%	50%	76%	76%	74%
EL	Greece	35%	46%	48%	80%	80%	80%
HU	Hungary	23%	33%	30%	79%	75%	66%
IE	Ireland	36%	40%	47%	67%	60%	68%
IT	Italy	8%	10%	13%	88%	84%	80%
LV	Latvia	44%	42%	55%	94%	95%	115%
LT	Lithuania	49%	49%	53%	84%	74%	76%
LU	Luxembourg	44%	48%	63%	109%	98%	108%
NL	Netherlands	36%	31%	33%	60%	53%	53%
PL	Poland	47%	56%	53%	79%	78%	73%
PT	Portugal	58%	56%	63%	88%	85%	97%
RO	Romania	26%	36%	35%	65%	56%	53%
SK	Slovakia	95%	81%	82%	120%	105%	104%
SI	Slovenia	21%	31%	45%	161%	167%	156%
ES	Spain	41%	39%	35%	73%	65%	60%
SE	Sweden	69%	62%	62%	93%	81%	77%
UK	United Kingdom	45%	47%	49%	80%	78%	84%

3.2 Secondary biomass resources from wood processing industries

The table below presents the secondary biomass potential from wood processing, as calculated by S2Biom.

Table 3.2.1: Secondary biomass potential from wood processing in kton d.m. (S2BIOM Base potential 2020).

Type	Albania
Sawdust (conifers)	2
Saw dust (non-conifers)	9
Other residues (conifers)	3
Other residues (non-conifers)	15
Residues from industries producing semi finished wood based panels	0
Residues from further wood processing	23
Total	52

A 2013 study[32] investigated the main issues of 49 private wood industries located in 18 Albanian districts. The study noted that only 20% of the surveyed industries are involved in wood processing as a primary activity, while 68% have furniture production as the main activity. Quality and quantity issues, e.g. insufficient forest resources, were cited as the main issues for the reduced capacity in primary wood processing.

Bioenergy Europe[33] indicates that 11 wood pellet production plants were operating in Albania in 2018, compared to 10 in 2017. The Albanian annual wood pellet production capacity increased from 45,000 to 52,000 tons, while actual production increased from 32,000 to 44,200 tons from 2017 to 2018. Domestic consumption of pellets was relatively stable at 29,500 tons, meaning that Albania is a net exporter of wood pellets.

Ardit Group (www.arditgroup.com) is an example an Albanian wood processing industry that has diversified its activities into pellet production. Established in 1994 near Maliq, in the Korçë region, the company implements a closed production cycle through the planting of poplar seedlings and the processing of wood for pallet production. The company manages its residues for the production of pellets under the name "Redi Pellets". As of 2020, the company was certified with the EN*plus*® pellet quality certification scheme.

[32] E. Çaushi, P. Marku (2013) Current situation of wood processing industry in Albania. Albanian Journal of Agricultural Sciences Vol. 12 (4), pp. 747-750.
[33] Bioenergy Europe (2019) Statistical Report – Pellets. https://epc.bioenergyeurope.org/wp-content/uploads/2020/02/SR19_Pellet_final-web-1.pdf

3.3 Summary and conclusions in relation to SWOT elements

Albania is the only European country where the forest utilization rate is above 100% - in fact, it is reported as four to five times higher. As result, the risk of deforestation in the country is a very real threat that has knock-on effects on various sectors and issues.

Considering this issue, it is unlikely that the forest sector will emerge as a major biomass supplier for the bioeconomy in the near future. However, the reforestation programmes supported by the Albanian government and implemented in a few cases by local enterprises, especially on degraded areas, might eventually lead the way to a more sustainable mobilization of forest biomass resources, provided modern and appropriate forest management schemes are implemented.

Table 3.4.1 summarises SWOT elements in relation to biomass supply from forestry in Albania.

Table 3.3.1: SWOT elements in relation to biomass supply from forestry

Strengths Significant forest area	Weaknesses Difficult terrain Lack of infrastructure (e.g. forest roads) and machinery Very small share of forest sector in the GDP Focus on extraction of firewood
Opportunities Reforestation projects Revitalization of rural settlements through forest management schemes	Threats Massive deforestation through very high utilization rate Continuation of illegal loggings despite moratorium Additional loss of forest areas through wildfires

4 Biomass supply: Waste

4.1 Introduction

Waste management in Albania is still considered to be in early stages of development. A Municipal Solid Waste (MSW) service is provided in most of the country, especially in urban centers, but is still absent in some rural areas[34].

MSW is mostly disposed in uncontrolled landfills; in recent years, the Albanian government has been promoting the deployment of Waste-to-Energy plants in urban centers, a practice which can limit landfilling but has been criticized by various NGOs, citizen groups and others as being incompatible with the European principles of waste hierarchy as well as with the recycling goals set in the national waste management strategy.

4.2 Waste from biological resources

Different sources indicate different levels of MSW production in Albania. INSTAT reported a production of 1,413 ktons in 2015, corresponding to 396 kg/inh; Eurostat reported 1,325 ktons for 2018. Generally though, the historic trend is of increased production, both on a per capita basis and on an absolute level. Other sources, e.g. the National Environment Agency or the Ministry of Transport and Infrastructure report different values, however some aspects of the methodology or production level for some counties are considered as either inappropriate or not realistic according to a technical report performed by EPTISA and funded by the IPA[35].

The same report presented an overview of previous studies on the composition of Albanian MSW. Although data sources were quite limited, it was clear that the organic fraction was the main component of MSW, ranging from 41% in 2013 to 51.4% in 2015 according to INSTAT. In connection with other studies, it was concluded that around 50% of the MSW can be composted, being organic waste, paper, cardboard, textiles, etc. About 60% of the MSW is potentially recyclable, while about 75% can be combusted and converted into energy.

The EPTISA study implemented its own methodology to predict the future production of in Albania; its calculations amount to 931 ktons in 2018, rising to 1,067 ktons in 2029. Assuming that the organic fraction of MSW remains around 50%, the estimated production of biowaste seems to be quite consistent with the estimates from the S2Biom, reported in the table below. Separate collection of biowaste is in line with the overall policy goals of Albania, as outlined in various strategic planning documents and regulations, although little seems to be taking place at the moment.

Table 4.2.1: S2Biom estimation on biowaste and post consumer wood base potential (kton dm) in Albania.

Type	2012	2020	2030
Biowaste unseparately collected	494	424	347
Biowaste separately collected	26	80	160
Hazardous post consumer wood	12	13	16
Non hazardous post consumer wood	22	31	46

[34] www.eea.europa.eu/themes/waste/waste-management/municipal-waste-management-country-profiles/albania-municipal-waste-factsheet-2018/view
[35] https://imswm.al/project_pdf/T1.2.1_Identification_of_MSW_sources_bp_06_2017_final.pdf

4.3 Current waste treatment and unused potentials estimates

As aforementioned, the main current waste management method is landfill disposal. There are some sanitary landfills in Tiranë (Shara landfill), Shkodër (Bushat landfill), Saranda (Bajkaj landfill), Korçë (Maliq landfill) and Vlorë (under implementation), while numerous unregulated sites also operate. Disposal by uncontrolled burning is not uncommon either.

Recycling rates are fairly low, around 18.5% in 2018, compared the targets of 50% and 65% for 2020 and 2025, as set out by the draft strategy on waste management 2018-2033. The Albanian Recycling Association estimates for recycling rates are even lower (10% in 206), while the informal economy plays a major role in supplying recycling industries with raw materials, e.g. manual workers, often from the Roma ethnic minority, collecting materials from garbage bins and landfills under bad sanitary and safety conditions[36].

Waste collection services are not uniformly developed across the Albanian territory. The table below presents the estimated collection rates for 2018; it is assumed that the collection coverage is expected to increase by 3% in agricultural areas and by 1% in all other areas each year, finally reaching 80% across the national territory in 2022 and 95% by 2032.

Table 4.3.1: Estimated waste collection rates in Albania[37].

Locations	Waste collection rate
Tirana	85%
County capitals (> 35,000 inhabitants), regional centres of agglomeration (> 20.000 inhabitants), local centres (district centres, no agglomeration, < 20,000 inhabitants), metropolitan suburban areas (inside Tiranë-Durrës metroplitan area	80%
Suburban (outside Tiranë-Durrës metropolitan area), non-urban mining or energy local units, mixed industrial and service local units	65%
Mixed agricultural plains, mixed agricultural mountains, agricultural in plains, agricultural in mountains	33%

Since 2013, the Albanian government has reversed its initial position towards waste incineration, as set out by the National Strategy for Waste Management, for the 2010-2025 period, and started to actively promote the concept through the planned construction of Waste-to-Energy (WtE) plants in Elbasan, Fier and Tirana. The Albanian government allocated 178 mEUR for the construction of these three WtE incinerators, which is the biggest state investment in the waste sector so far. The plants are to operated under a concession schemed and financed under the provisions of Law 125/2013 on Public Private Partnerships. The Elbasan Waste-to-Energy plant was inaugurated in 2017 and is reported to be the first of its kind in the Balkans. The current status of the plants at Fier and Tirana is unclear. Eurostat reported than in 2018, 2.79% of the MSW generated in Albania were processed at energy recovery plants.

[36] L. Baumann (2019) Albania – the First Balkan Country with an Incineration Plant. www.vivis.de/wp-content/uploads/WM9/2019_WM_107-118_Baumann.pdf
[37] http://energjia.gov.al/wp-content/uploads/2018/12/ISWM-Investment-Albania-Draft-SEA-Study-20181126_English.pdfc

Table 4.3.2: Waste-to-Energy plants in Albania.

Location	Processed quantity of MSW (tons/day)	Installed Capacity (MWe)
Elbasan[38,39]	120 - 140	2.85
Fier[40]	180 - 200	3.80
Tirana[41]	4 x (200 – 220)	4 x 3.85

The emphasis on WtE plants has been challenged by several NGOs, experts, citizen groups and, reportedl, even by the European Commission services. One fundamental aspect of disagreement is that the capacity of the incinerators is oversized if one considers the recycling targets set by Albania, which will simply not leave enough combustible waste for continuous plant operation. Other arguments have been raised regarding the transparency of the tendering process, lack of citizen consultation, environmental issues from the incinerator operation and with prices for the electricity produced by the WtE plants[42,43,44].

Sewage sludge production in Albania was 94,500 tons in 2016. According to the Albanian Water Regulatory Authority, 52.9% of the country's population were served by wasterwater sewage systems[45]. The number of wastewater treatment plants is reported to be seven. There are still improvements required in the wastewater treatment system and the European delegation in Albania has announced support for new projects[46]. At the moment, no energetic valorization of sewage sludge is recorded, with a large part of the production going to agricultural applications.

Table 4.3.3: Sewage sludge production and treatment in Albania, 2016 (Source: Eurostat, Sewage sludge production and disposal).

Sewage sludge treatment	Quantity (tons)
Agricultural use	42,500
Compost and other applications	-
Landfill	-
Incineration	-
Other	52,000
Total	94,500

There are also some recent developments related to Used Cooking Oil (UCO) in Albania. A private company has started the establishment of a UCO management and collection network from restaurants, catering and fast-food chains in the region of Tirana-Durrësi region. Collecting about 400 tons of UCO in the first year of operations, the company has a five-year strategic plan to collect about 15-20% of UCOs in Albania, or around 6,000-8,000 tons per year, meaning that it can consider investment in a biodiesel production plant[47]. Another initiative, supported by the United Nations Development Programme (UNDP), was established in the city of Vlore,

[38] https://balkangreenenergynews.com/first-waste-to-energy-plant-inaugurated-in-albania/
[39] https://exit.al/en/2020/07/09/vlora-landfill-tender-goes-to-shell-company-that-risks-monopolizing-the-countrys-waste-management-sector/
[40] https://balkangreenenergynews.com/waste-energy-plant-built-albania/
[41] https://exit.al/wp-content/uploads/sites/3/2017/08/Feasibility-Study-T.W.T.A-english-1-1.pdf
[42] L. Baumann (2019) Albania – the First Balkan Country with an Incineration Plant. www.vivis.de/wp-content/uploads/WM9/2019_WM_107-118_Baumann.pdf
[43] https://idmalbania.org/policy-paper-waste-management-in-albania-may-2019/
[44] https://exit.al/en/2017/08/29/who-is-paying-for-tiranas-waste/
[45] www.erru.al/doc/Annual_Report_2019_eng.pdf
[46] https://balkangreenenergynews.com/eu-keeps-supporting-clean-water-albania-announces-2-new-programs/
[47] D. Topi (2020) Transforming waste vegetable oils to biodiesel, establishing of a waste oil management system in Albania. SN Appl. Sci. 2, 513 DOI: https://doi.org/10.1007/s42452-020-2268-4

aiming to avoid discharge of UCO in the protected Karaburun-Sazan Marine Park. For almost one year, the project collected 4.2 tons of UCO which were shipped to biodiesel production plants abroad[48,49].

Engagement of donors in the Albanian waste sector is increasing. Germany has been appointed by the Albanian government as the lead donor for the waste management sector in 2016. German involvement in the Albanian waste sector is mostly implemented under the coordination or support of the KfW Development Bank, which supported the preparation of the "Sector Study for Investment Demand in Integrated Solid Waste Management (ISWM) in Albania" in 2018[50]. KfW is also supporting the rehabilitation of Volloder landfill in Saranda and construction of a sanitary landfill for Gjirokaster. GIZ is also working on the development of waste management schemes for the Southern Albanian municipalities of Himara, Peqin and Rrogozhina, with a focus on composting organic matter and increasing waste separation and recycling[51]. In 2017, the Swiss government pledged 2.2 million francs for developing the MSW management system in Berat[52].

Promotion of good practices on waste management, recycling and composting is also a focus of IPA funding for Albania. As an example, the Interreg Cross Border Collaboration (CBC) projects between Greece and Albania WASTE RREACT[53] and LESS-WASTE-II[54] can be mentioned.

48 www.al.undp.org/content/albania/en/home/projects/marine-and-coastal-protected-areas2/
49 https://voyages.eurasia.undp.org/water-and-oil-dont-mix/
50 http://energjia.gov.al/wp-content/uploads/2018/12/ISWM-Investment-Albania-Draft-SEA-Study-20181126_English.pdf
51 www.giz.de/en/worldwide/62845.html
52 www.infrastruktura.gov.al/en/2-2-million-swiss-francs-for-solid-waste-management-in-berat-region/
53 https://greece-albania.eu/projects/integrated-waste-management-facilities-for-boosting-recycling-and-composting-7-regions-through-cross-border-activities
54 https://greece-albania.eu/projects/promotion-waste-prevention-and-recycling-the-cross-border-area

4.4 Summary and conclusions in relation to SWOT elements

The waste management sector in Albania is still in its early development stages compared to other European countries and current practices are generally far from satisfying. Biowaste is a major part of the total MSW produced, but at the moment little emphasis is placed on its separate collection or its utilization.

The positive side is that the need to develop the waste sector in Albania is recognized by all key stakeholders and actors: the Albanian Government, EU, donor organizations and others. The national legislation is mostly harmonized with the European one; the main issue is with its implementation. Therefore, it can be expected that funding and resources will be allocated to this area, which may ultimately facilitate the development of a biowaste-based bioeconomy sector. The late start of the Albanian (bio)waste management sector may even allow the deployment of novel solutions, assuming that there will be no investments that will create a lock-in for the management of large volumes of MSW for the coming years.

Table 4.4.1: SWOT analysis in relation to waste sector in Albania

Strengths Legal framework mostly harmonized with European Directives and Regulations	Weaknesses Incomplete collection rate of MSW Landfilling still prevailing, low recycling rates, no source separation of organic waste Data inaccuracies due to uncoordinated efforts or lack of technical means (e.g. weighting stations)
Opportunities Funding and resources allocated to waste management Possibility to transfer latest technological developments	Threats Improper implementation of waste-to-energy schemes may lead to distortions

5 Bio-based industries, products and markets

5.1 Current bio-based industries

5.1.1 Medicinal Aromatic Plants and Essential Oils

Albania's rich biodiversity also translates into a large number of Medicinal Aromatic Plants (MAPs), about 200 of which are exported. As noted in Section 2.2.1, MAPs are one of the major cultivations in Albania and one of the major agricultural exports. In order to avoid their extinction, good practices should be implemented when harvesting MAPs[55]. About 90% of the MAPs exports from Albania were sage, the production of which reached 12,800 tons in 2017; it is estimated that more than 100,000 Albanian households are closely related to the cultivation or harvesting of MAPs[56].

Most of the MAPs harvested in Albania are sold with minimal processing (only drying) and hence with minimal added value. In 2015, a novel scheme from the company Mediterranean Export – Imports Albania – MEIA was funded by RisiAlbania with the aim to start production of essential oils from MAPs, while simultaneously expanding sourcing through contract farming. MEIA is currently considered a success case, involving 232 contract farmers, employing 90 hired farmers and operating two distilleries in Tirana and Koplik, while planning a third one in Delvina. The success of the company is also prompting other Albanian companies to enter into the business of essential oil production[57]. It is also reported that the company is investigating the possibility of producing bio detergents using wastewater from the distillation process[58].

5.1.2 Textiles and leather

The Albanian textile industry has historically been a vital part of the country's economy. During the days of the centralized economy, the national textile industry was more vertically integrated, producing locally a considerable amount of raw material, and covered a large share of the domestic demand, as well as exporting.

Following the economic reforms of the 1990s and the privatization of factories, the sector was transformed. Raw material (e.g. curtains, rugs, and others) is not longer produced, but ordered from abroad (mostly from Turkey, China, Italy and Bangladesh, as well as other European countries such as Spain, Greece, and Romania) to produce clothing for exports (active processing or "façon"). According to INSTAT, exports of clothes and shoes manufactured in Albania amounts to 44.4% of the total national exports. The textile sector employs a large work-force, estimated at around 150,000 people, of which 95% are women[59]. Among the key advantages offered by the Albanian textile industry are the low wages of workers and the proximity to European markets.

A 2015 report[60] highlighting the main findings of a Dutch mission in Albania indicated that no major environmental issues with the national textile industry have been identified, a point that could be of advantage to environmentally-conscious European markets. Cut waste is transported back to Italy or Turkey to be processed or disposed in landfills.

The leather sector also benefits from low wages as well as from the large livestock sector of Albania. Skins of cows, sheep and goats are processed up to the wet blue stage in the tanning process; subsequent steps, e.g. crust and finished leather are performed mostly in Turkey and Italy. This creates a gap in the leather value chain, forcing Albanian manufacturers of leather products (almost exclusively shoes) to wait for the importation of finished hides. Albanian tanneries produce large volumes of wastewater, which is not processed and contributes to local environmental degradation. The establishment of a sustainable tannery can contribute to the vertical

[55] www.sustainicum.at/files/projects/261/en/additional/Broschure%20-EN.pdf
[56] https://invest-in-albania.org/the-economic-potential-of-medicinal-and-aromatic-plants-in-albania/
[57] www.helvetas.org/en/switzerland/how-you-can-help/follow-us/blog/inclusive-systems/Investment-gone-right
[58] www.risialbania.al/expanding-made-in-albania-essential-oil-business-production/?lang=en
[59] https://invest-in-albania.org/industries/clothing-manufacturing
[60] www.rvo.nl/sites/default/files/2016/05/CSR Report Albania 2016.pdf

integration of the Albanian leather industry, while also meeting the environmental standards expected for products to be exported in various European markets.

5.1.3 Advanced biofuels

At the moment, there is no production of advanced biofuels from cellulosic or lignocellulosic feedstocks in Albania.

5.1.4 Commercial biorefineries

The JRC "Map for Bio-based industry and biorefineries"[61] does not include any entries for biorefineries in Albania. It is not clear if this because the data sources on which the map is based exclude Albania or whether there is indeed no biorefinery facility in the country. However, considering the types of facilities on the map and the lack of any production plants for liquid biofuels, paper and pulp and sugar[62], it seems very unlikey that any type of commercial biorefinery operates in Albania.

5.1.5 Regional bio-based initiatives

BIOECO-RDI (https://bioecordi.adrioninterreg.eu/) is a project funded by the Interreg ADRION programme; it aims to develop a Regional Innovation System for the Adriatic-Ionian area based on a structured bio-economy sector though the development of Research Driven Innovation (R.D.I.) strategy at regional and transnational level. The project is active in Italy, Greece, Slovenia, Serbia and Albania. The Albanian partner is the Chamber of Commerce and Industry, Tirana (www.cci.al). Various activities, such as focus groups[63] and international peer review and matchmaking sessions[64] have been organized in Albania in the framework of BIOECO-RDI.

Although not a dedicated bio-based initiative, RisiAlbania (www.risialbania.al) should be noted. RisiAlbania is an innovative project, supported by the Swiss Agency for Development and Cooperation, SDC and implemented by Helvetas and Partners Albania in partnership with the Deputy Prime Minister's Office of the Albanian Government. It focuses on providing more employment opportunities for young women and men in Albania by implementing interventions related to job demand, skills supply, career guidance and intermediation and gender / social inclusion. Among other sectors, RisiAlbania has a strong focus on agribusiness and has supported companies such as MEIA (see Section 5.1.1) in established new business lines that are closely connected to the bioeconomy.

5.2 Advanced bio-based initiatives: demo and pilot plants and major innovation activities

Participation of Albanian partners in major EU innovation actions related to bio-based products, e.g. flagship and demonstration BBI projects, H2020 projects, is practically non-existent. Moreover, no activities related to demo and pilot plants for biorefineries have been detected in Albania.

[61] https://publications.jrc.ec.europa.eu/repository/bitstream/JRC119288/200219_biorefineries_visualisation.pdf
[62] A sugar refinery at Maliq, near Korçë, was built in 1951 but it has stopped production in the 1990s. Plans for the reinstatement of sugar production in the city through a Polish investment were announced in 2014, but it seems that the plan has not materialized as of now (https://invest-in-albania.org/polish-investment-re-establish-sugar-factory-maliq-city).
[63] https://bioecordi.adrioninterreg.eu/activities/first-focus-group-meeting-in-albania-in-the-framework-of-bioeco-r-d-i-project
[64] https://bioecordi.adrioninterreg.eu/events/international-peer-review-and-matchmaking-event-in-the-field-of-bioeconomy

5.3 Future Biomass valorisation options

Future options for biomass utilization in Albania are outlined in some policy documents, e.g. the consolidated National Action Plan on Renewable Energy Sources 2019-2020. Generally, more emphasis is given on the energetic utilization of biomass, while no information can be found as to the future potential of bio-based industries. Some key points:

- An ambitious plan to increase the installed capacity of municipal solid waste power plans to 41 MW (from 8 MW initially planned) is mentioned.
- Wood biomass consumption for heating will not be further increased, considering also the moratorium on forest logging.
- Initially, transport biofuels were foreseen to amount to 65 ktoe, or around 3% of the final energy consumption in Albania. However, the Plan concedes that only about 20 ktoe (equivalent to the 2018 amount) can possibly be consumed. This inability is what prompted the government to emphasize the RES-e production, mostly from wind solar and small hydro power, so as to reach the 38% target of RES by 2020, over an actual share of 35% in 2018.

The potential of alternative, non-forest biomass resources is recognized as being relevant but untapped; at the moment, there is no clear plan for its utilization however.

5.4 Summary and conclusions in relation to SWOT elements

The Albanian bio-based sector is in very early stages of development. The potential of biomass for the bioeconomy appears to be mostly overlooked by policy makers. Only a few isolated initiatives are operating at the moment. Kick-starting the Albanian bio-based sector will probably require foreign investment as well as expertise; the Albanian diaspora, which has good knowledge of the country conditions, may play a significant role in this. Knowledge transfer projects can also contribute towards this goal.

It also seems likely that new bio-based initiatives will be concentrated on upgrading the added-value of "traditional", well-established economic sectors, such as those of the aromatic plants. Due to biomass volume restrictions, it seems more likely that such initiatives will concentrate on the production of very high-added value, low-volume bio-based products and chemicals, e.g. for use in the cosmetics or food industry.

Table 5.4.1: SWOT analysis of bio-based industries, products and markets in Albania.

Strengths Close proximity to other European markets Biodiversity, which results in a wide range of potential biomass feedstocks	Weaknesses Small internal market Lack of knowledge on establishing bio-based value chains Limited interactions / participations in European R&I actions
Opportunities Emphasis on increasing the added value of Albanian exports Sustainability is of increased importance to several European markets targeted by Albanian firms	Threats Absence of state policies / support Limited funds for establishing new bio-based value chains

6 Infrastructure, logistics and energy sector

6.1 Existing industrial hubs

Industrial activities in Albania are mostly concentrated in Tirana, Durres and Elbasan, as well as in areas active in mining: Bulqiza, Puka and Kukes[65].

In order to stimulate investments, the Albanian government voted in 2008 a law for the creation of 8 Economic Zones/ Industrial parks in Koplik, Shengjin, Elbasan, Durres, Vlora, Shkoder, Lezha and Tirana and 1 free zone in Vlora. Several of these were located in former industrial sites. However, due to various issues with land ownership, infrastructure, ineffective promotional campaign and lack of enforcement of contracts and inventive packages those announced zones were not successful[66].

Finally, the first project of its kind in Albania is the Tirana Industrial Park, which is set to combine the logistics park concept with an administration hub. The park covers an area of 136,000 m^2, of which 75,000 m2 is construction surface: 20,000 m^2 for showrooms and 55,000 m^2 for warehouses[67].

6.2 Harbours

The major ports of Albania are Durrës, Vlorë, Shëngjin and Sarandë, serving both freight and passengers. There are also petroleum ports at Petrolifera[68] and Romano Port[69], close to Vlorë and Durrës respectively.

Undoubtedly, the most important port in Albania is Durrës which handles about 78% of the country's seaborne cargo in tonnage terms and 75% of all export and import trade of the country. The port of Durrës serves container ships, ferry boats, Ro-Ro vessels, general cargo vessels, bulk cargo and a few fuel vessels. It is located about 36 km to the west of Tirana and serves as the entry way for Corridor VIII[70]. In 2019, Durrës processed 4.72 million tonnes of cargo, an increase of 13% compared to the previous year. About 3.2 million tonnes were carried by cargo ships, while 916,000 tonnes were transported by ferries[71].

In the future, major development of infrastructure is expected at the port of Shëngjin, close to the border with Montenegro. At the moment, Shëngjin handles only ships with a lower capacity than 5,000 tons. Investments promise to upgrade its operational capacity up to 60 million tons per year, surpassing Durrës as the main industrial port of Albania and upgrading into a major transportation hub for the whole region.

6.3 Existing railways

The Albanian railway network started development from 1947 onwards. It consists of around 420 km of railways[72]:

- 350 km belong to a flat area with a slope 9 m / 1000 m
- 30 km located in a hilly area with a slope 13 m/1000 m
- 40 km in a mountainous area with slope 18 m / 1000 m

[65] www.pwc.com/al/en/assets/doing_business_in_albania_pwc2012.pdf
[66] Ç. Sherifi, G. Turan (2018) Albanian Model of Free Zones: Implementation and Implications. International Journal of Economics and Finance; Vol. 10 No. 5. DOI: 10.5539/ijef.v10n5p57
[67] http://concordinvestment.al/wp-content/uploads/2017/10/Concord-Tirana-Industrial-Park.pdf
[68] www.gruppopir.com/en/la-petroliera-italo-albanese
[69] www.romanoport.com.al
[70] O. Metalla, E. Vata, S. Pupa, B. Kacadej (2018) Privatization of Bulk Terminal Operations and its Efficiency: The Case of Durres Port. International Review of Management and Business Research Vol. 7 Issue.2. DOI: 10.30543/7-2(2018)-16
[71] https://seenews.com/news/albanias-durres-port-cargo-traffic-up-13-in-2019-684446
[72] www.unece.org/fileadmin/DAM/trans/doc/2019/TEM/10_Oct_2019_P2_Eneida_Elezi_2.pdf

The Albanian railway system is administered by Hekurudha Shqiptare (HSH). The only international connection is with Montenegro through the Podgorica–Shkodër railway, which has only been used for freight transportation. There is a freight connection between the prot of Durrës and the oil refinery at Ballsh and mixed trains servicing the Tirana-Shkodër and the Durrës-Elbasan lines.

Figure 6.3.1: The Albanian railway system (Source: Hekurudha Shqiptare).

In 2019, a tender for the rehabilitation of the Durrës – Tirana line was launched. The total cost of the project is EUR 92 million and it will be co-financed by the Western Balkan Investment Fund (EUR 38 million), EBRD (EUR 36.9 million) and the Albanian government (EUR 16 million)[73]. The Tirana – Durrës line is the northern part of Tirana – Durres – Elbasan – Pogradec mainline, which forms the TEN-T Corridor VIII on Albanian territory.

Feasibility studies for the interconnection of Albania and Greece via train (Kapshtica to Krystallopigi / Florina) are financed by INTERREG Albania - Greece Regional Cooperation Program; the aim is to connect the Albania railway system with the the TEN-T Orient/East Med Rail Corridor to Greece.

6.4 Existing road infrastructure

The overall road network of Albania extends over 18,300 km; of these 3,945 km are managed by the Albanian Roads Authority: 1,184 km of primary roads, 359 km of main secondary roads, 2,058 km of secondary roads and 244 km of Albanian Defense Force roads included in the national network[74].

[73] www.railwaypro.com/wp/tender-begins-for-albanias-most-important-rail-project
[74] www.unece.org/fileadmin/DAM/trans/doc/2018/UNDA/I_Road__Safety__Management__in_Albania.pdf

The main components of the Albania road network are the motorways (Albanian: *Autostrada*, short: A) and the expressways (Albanian: *Rruga Shtetërore*, short SH). The main ones, especially in terms of international connections are the following:

- A1 connects the port of Durrës with Morinë at the Albanian Alps. It will form part of the Adriatic-Ionian motorwar and Pan-European Corridor X. A1 is currently the only toll-road in Albania.
- A2 connects Fir with Vlorë. It will form part of the Adriatic–Ionian motorway.
- A3 connects Tirana with Elbasan. It will form part of the Pan-European Corridor VIII.
- SH 1 connects Montenegro to Tirana. It will form part of the Adriatic–Ionian motorway.
- SH 2 connects Tirana with the port city of Durrës.
- SH3 connects Greece with Tirana, passing through Elbasan and Korçë.
- SH4 connects Durrës to Greece, passing through Elbasan and Korçë. It will form part of the Adriatic–Ionian motorway.
- SH 7 connects Rogozhina to Elbasan. It is part of the Pan-European Corridor VIII.
- SH 8 connects Fier to Sarandë.
- SH 9 connects connects Qafë Thanë in Elbasan to North Macedonia.

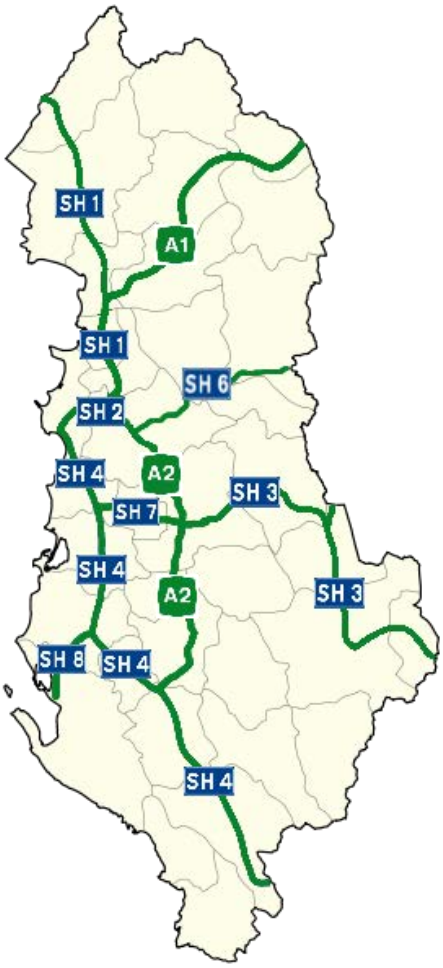


Figure 6.4.1: Highways in Albania[75].

[75] Source: MK-CH1 / CC BY-SA (https://creativecommons.org/licenses/by-sa/3.0)

6.5 Energy sector

Albania has a quite distinct energy sector compared both to its neighbouring countries as well as to the EU-average. The electricity production of Albania is relying almost exclusively on hydropower. As a result, the country's dependency on electricity imports varies depending on the level of precipitation. On the other hand, the per capita level of GHG emissions is much lower compared to the EU-average. The following table provides a short overview of the energy sector in Albania, in comparison with the EU average.

Table 6.5.1: Overview of the energy sector in Albania and comparison with the EU-average.

Category	Albania	EU-28	Unit	Source / Year
Primary energy consumption	0.81	3.03	toe/capita	2018 / [1]
Energy dependence	21.1	55.7	%	2018 / [1]
Renewable energy share	34.9	18.0	%	2018 / [1]
GHG emissions	1.60	8.57	ton CO_2-eq/capita	2018 / [1], [2]
Bioenergy in RE	29	69	%	2017 / [3]
Bioenergy in total energy	10.0	10.6	%	2017 / [3], [4]
Biofuels prod. Capacity	-	0.051	ton/capita	2018 / [3]
CHP	-	11.27%	% gross electricity generation	2017/ [1]

Sources:
[1] Eurostat
[2] www.globalcarbonatlas.org/en/CO2-emissions (for Albania)
[3] Bioenergy Europe Statistical Report 2019; own calculations for Albania
[4] www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Dec/IRENA_Market_Analysis_SEE_2019.pdf

As aforementioned, the electricity sector of Albania is mostly based on hydropower, with a total of 2,132 MWe of installed capacity[76]; there is also one thermal power plant designed to work with oil / natural gas with a capacity of 98 MWe and very limited capacity of photovoltaics as well as waste-to-energy plants. The Albanian Power Corporation (KESH sh.a., http://kesh.al) owns most of the hydro power plants (1,350 MWe) and is the major electricity producer in the country; other hydro power plants are owned by private companies or are concessions. Hydropower capacity is foreseen to continue to grow in Albania, but it is expected that the future electricity sector will present a more diversified picture, both in terms of installed capacity and in terms of production, with the construction of new plants running on wind, solar, biomass and natural gas[77,78].

Excluding hydropower, biomass is the most important renewable energy resource in Albania, amounting to around 10 PJ or 10 % of the total primary energy supply (TPES). About half of it (5 PJ) is used in the residential sector, covering about 26% of its total final energy consumption (TFEC). Solar thermal energy in Albania covers about 1.2% of the residential energy demand, much better than the 0.2% average of other SEE countries; however considering that the corresponding percentage in neighbouring Greece is 5%, there is still room for improvement. It should be noted that the heating demands of Albanian households are mostly covered by electricity (62%), followed by biomass (20%) and then LPG (8%) and fuel oil (8%)[79]. The use of biomass at the residential level often takes place at inefficient appliances for heating and cooking, therefore contributing to local air pollution.

Biodiesel has been used in increasing quantities in the Albania's transport sector, since 2014; in 2017, 3.2 PJ of imported biodiesel were blended with 31.3 PJ of conventional diesel fuel. However, this amount cannot be

[76] www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Dec/IRENA_Market_Analysis_SEE_2019.pdf
[77] www.iene.gr/articlefiles/working%20paper%20no%2022.pdf
[78] www.energyworldmag.com/electricity-generation-capacity-development-albania/
[79] World Bank (2017) Biomass-Based Heating in the Western Balkans: A Roadmap for Sustainable Development

counted toward the 2020 target since Albania has not introduced yet a sustainability and certification scheme for liquid biofuels, as required by the EC Directives[80].

Not all biomass supply is local; an energy dependency rate of more than 25% is noted for biomass, however this is mostly connected to biodiesel imports. It is also much lower than the import dependency for coal (100%) and similar to the dependency rate for fossil oil.

At the moment, and unlike most other Western Balkan countries, there are no major district heating systems nor CHP plants in Albania.

A final note about the energy sector in Albania: the country has the largest onshore hydrocarbon reserves in Europe, estimated to be in the range of 220 million barrels of oil and 5.7 billion cubic meters of natural gas. The historic peak of Albanian oil production was back in 1974, with a production of 2.25 million metric tons[81]; in recent times, a production peak was observed in 2014 (1.21 million metric tons)and is currently on a decreasing trend. There are two older, refineries at Ballsh and Fier with a refining capacity of 1 million tons and 0.5 million tons respectively, as well as a newer refinery near Elbasan with an annual refining capacity of 250,000 tons[82]. Albania exports most of its crude oil production and imports most of its refined oil consumption.

6.6 Summary and conclusions in relation to SWOT elements

The historical isolation of Albania after the Second World War left the country with fairly outdated infrastructure and limited connections with neighbouring countries. Energy demand has mostly been covered by domestic resources, in particular the large hydropower potential of the country. The transition to a market basis economy has impacted some of the state-owned industrial sectors, but has created new opportunities and investments, set to expand the country's regional role and to further exploit its domestic potential. Investments in transport infrastructure are expected to increase the importance of Albania as a gateway to Western Balkan counties and beyond. In the energy sector, the need to diversify the electricity production as well as the country's oil production basis, might create opportunities for the energetic valorization and upgrade of biomass.

Table 6.6.1: SWOT analysis of Infrastructure, logistics and energy sector of Albania

Strengths Already renewable electricity sector (hydro) Various ports, with increasing importance and potential	Weaknesses Inland transportation network (roads and railways) still not fully developed Numerous non-designated industrial areas / outdated infrastructure in designed ones
Opportunities Investments in new infrastructure (roads, ports, railways) Increased role as gateway of Western Balkan countries to European / world markets Potential to establish industrial zones in various locations of former industrial activities	Threats Lack of sustainability scheme for biofuels Some investments may not materialize

[80] IRENA (2019), ibid.
[81] www.altax.al/en/news/603-1-oil-industry-in-figures-in-albania-2019
[82] www.privacyshield.gov/article?id=Albania-Oil-and-Gas

7 Skills, education, research and innovation potential

7.1 Research infrastructure

The National Agency for Scientific Research and Innovation (www.nasri.gov.al) is the main state advisory body in Albania for national policy for research, technology and innovation. The Ministry of Education, Sports and Youth (www.arsimi.gov.al) and the Ministry for Europe and Foreign Affairs (www.punetejashtme.gov.al) share responsibilities for funding research.

The Research, Development and Innovation Strategy for the 2017-2022 Period aims to strengthen the Albania research system (human capital and infrastructure), conduct research relevant to the needs of the country and make R&D an indispensable tool for the further development of the Albania economy. The main focus of the Strategy is on the following priorities[83]:

- Areas of traditional strength for the country (e.g. tourism, energy)
- Areas of recent successes in terms of critical mass and on-going activities (e.g. IT, engineering, energy)
- Areas of high added value and able to deliver major economic benefit and employment prospects (e.g. energy, nutrition –food sciences)
- Areas of national interest (e.g. food production, archaeology, culture, energy, defence)

The Strategy also aims to increase the percentage of GDP going to research from an average of 0.2% during 2009-2015 to at least 0.6% (in comparison with an EU-28 average of 2% and a target of 3%).

Research institutions in Albania can be classified under the following main categories:

- University research institutes (further information on the following section).
- Ministerial research institutes. One example is the National Agency of Natural Resources – AKBN (www.akbn.gov.al) which includes in its portfolio renewable energy resources (including biomass), hydropower, hydrocarbons and mining.
- Agricultural Technology Transfer Centres under the auspices of the Ministry of Agriculture and Rural Development. There are such centres established in Fushë-Krujë, Lushnjë, Vlorë, Korçë and Shkodër.
- Private research organizations. One example is the Urban Research Institute - URI (www.uri.org.al), established in 1999. Among others, URI focuses on environment, natural and cultural resources and urban and regional development and implements projects related to waste management, ecosystems restoration, biodiversity protection and renewable energies.

7.2 Education infrastructure

The Higher Education sector in Albania was composed at the end of 2015 by 12 public universities and 24 private universities of various types accredited by the Ministry of Education, Sports and Youth. Higher education institutes are the top formers in research in Albania.

Some relevant universities for the bioeconomy sector in Albania are listed below:

- Agricultural University of Tirana (www.ubt.edu.al) was established in 1951. It is a public institution consisting of five faculties (Agriculture and Environment; Economy and Agribusiness; Forest Sciences; Veterinary Medicine; Biotechnology and Food) and the Institute of Plant Genetic Resources. The Agricultural University of Tirana is involved in projects relevant to bioeconomy, such BIOECO-R.D.I. (https://bioecordi.adrioninterreg.eu/) and Agrolabs (www.agrolabs.eu).

[83] https://cdn5.euraxess.org/sites/default/files/focus_on_albania.pdf

- Polytechnic University of Tirana (www.upt.al) was also established in 1951. It is a public institution consisting of seven faculties (Geology and Mining; Electrical Engineering; Mechanical Engineering; Mathematical Engineering and Physics Engineering; Construction Engineering; Architecture and Urban Planning; Information Technology) and the Institute of Geo-sciences and Energy, Water and Environment).
- University of Tirana (www.unitir.edu.al) is the largest university in Albania with more than 23,500 students. Through the Faculty of Natural Sciences, it offers bachelor and MSc. Programmes in biotechnology, industrial and environmental chemisty, food technology and other relevant areas.

7.3 Environment for start-ups

The start-up scene in Albania is considered as new but expanding, concentrated mostly in the capital of Tirana. The low cost of establishing a business in Albania is often quoted as one of the advantages of setting up a start-up, along with the country's geographical position, large number of students and cheap labour market. Disadvantages include the small population and the low purchasing power, as well as the fact that business have to pre-pay taxes based on expected revenues and the lengthy procedures for bankruptcy[84].

Although major emphasis and several events are focusing on the ICT sector, the agribusiness sector and its potential is not overlooked by the start-up scene in Albania.

Main co-working spaces available for start-ups include:

- Dutch Hub (http://dutchhub.al/)
- MyOffice'Al (http://myoffice.al)
- Talent Garden Tirana – TAG (https://talentgarden.org/it/coworking/)
- Tirana Business Part (https://www.tiranabusinesspark.com/en/products/coworking/)
- Innovation Hub, an upcoming project by Minister of Innovation and Public Administration with the goal to create the first hub for start-ups.

Incubators and accelerators in Albania include the following:

- Albanian Innovation Accelerator (www.aianetwork.org) focuses on helping young people from the age of 16-21 to become entrepreneurs.
- Protik Innovation Centre (http://www.protik.org) was established by the Albanian American Development Foundation (AADF), The Government of Albania, USAID, Microsoft, Albtelecom and CISCO. It focuses on catalyzing the development of the ICT sector in Albania.
- Yunus Social Business Balkans - YSB Balkans (www.balkanimpact.com) was initially established as "Yunus Social Business Fund Albania" but has since expanded its scope to cover the non-EU Western Balkan countries. YSB Balkans focuses on social enterprenership and provides both funding opportunities through various programmes but most importantly training, coaching and mentoring services.
- EU for Innovation programme in Albania (http://euforinnovation.al/) is funded by the European Union with additional support from the German Federal Ministry for Economic Cooperation and Development (BMZ) as well as the Swedish International Development Cooperation Agency (Sida) the project aims to strengthen the eco-system for innovation and start-up promotion in Albania. It is implemented by GIZ Albania and the Swedish Embassy at Tirana and a total budget of about 7.5 MEUR. The programme focuses on improving the capacity for innovation among innovation ecosystem actors, building linkages within the Albanian innovation ecosystem and internationally and funding innovative start-ups and innovation support providers.

A 2017 study of the Microfinance Center[85] looked into the Albanian start-up scene, including funding possibilities and overall framework conditions. One observation noted was that there is limited SME growth in Albania and very limited number of large corporations, thus driving establishing of start-ups out of necessity rather than entrepreneurship. Moreover, domestic opportunities for seed funding are limited compared to foreign sources;

[84] https://businessmag.al/tirana-startup-city-guide/
[85] http://mfc.org.pl/wp-content/uploads/2017/09/MFC-case-study-Albania-final-18Sept.pdf

fortunately, Albanian law does not restrict foreign participation in national businesses. Some specific financing tools are further outlined in Section 9 of this report. According to stakeholders' interviewed, several measures are needed for the fostering of the start-up sector, including a formal definition of "start-ups" and their subtypes, tax incentives, focus on providing access to finance for stat-ups less than 6-months old, establishment of guarantee funds, etc.

A gap analysis of the Albanian entrepreneurial ecosystem has been the focus of a 2019 study of the EU for Innovation programme[86]. Several factors limiting the start-up ecosystem to an initial stage are described: limited government funding, distrust towards the government and lack of bilateral cooperation, limited exposure to practical experience and lack of success models, lack of coordination and achievement of long-lasting effects for donor programmes among others. However, positive aspects are also highlighted, including the young age of the population, the growing IT sector and human capital and the prospects offered by the Albanian diaspora.

7.4 Public private partnerships

The main framework for Public Private Partnerships (PPPs) in Albania is Law No.125/2013 on Concessions and Public Private Partnership (PPP Law 2013); Law 182/2014 on public procurement also applies. PPPs are managed by the Public Procurement Agency (http://www.app.gov.al/home/) under the Council of Ministers[87].

The PPP Knowledge Lab (https://pppknowledgelab.org/) evaluates Albania with the following marks in relation to PPPs: preparation 67/100; procurement 80/100; contract management 58/100; unsolicited proposals 75/100[88]. Its website lists 19 PPP projects that have reached financial closure since 1990 of a total investment of 2,563 million USD and 16 active (under construction or operation) projects with a total active investment of 2,555 million USD. Some major projects are related to Albania's hydro power plants and transport infrastructure (Tirana Airport and Durres Port, highways). Two waste management projects have also been implemented as PPPs: the waste-to-energy facilities at Tirana and Elbasan.

Table 7.4.1: Indicative PPP projects in Albania (Source: PPP Knowledge Lab).

Project	Sector	Financial closure year	Investment (million USD)
Tirana Waste-to-energy facility	Integrated MSW	2018	146.94
Tirana International Airport concession	Airports	2005	308.00
Port of Durres	Ports	2013	51.30
Ostrovica Faqekuq I & II SHPPs	Electricity	2012	9.00
Milot - Morine Highway	Roads	2017	284.60
ETEA Lapaj SHPP	Electricity	2012	19.40
Enso Hydro Lengarica HPP	Electricity	2013	19.40
Energo-SAS Sasaj SHPP	Electricity	2012	10.60
Elbasan Waste-to-energy facility	Integrated MSW	2018	31.96
Devoll River Hydro power plants	Electricity	2012	1,370.00
Ble-Klo-Ar Tervol SHPP	Electricity	2012	10.10
Ashta Hydro Power Project	Electricity	2009	272.00

[86] K. Hach, E. Trenkmann (2019) EntrepreneurialEcosystem in Albaniawith Focus on Tirana. http://euforinnovation.al/wp-content/uploads/2019/12/Gap-Analysis_E-Publication.pdf
[87] https://ppp.worldbank.org/public-private-partnership/sites/ppp.worldbank.org/files/documents/PPP_Legal_Framework_Snapshot_Albania_EN_Aug2016.pdf
[88] https://library.pppknowledgelab.org/documents/3941/download?ref_site=kl

7.5 Clusters and associations

Various professional associations and chambers are operative in Albania, aiming to represent their members' interests. Considering the important of agriculture, food processing and textiles in the Albanian economy, several of them are also of relevant to the bioeconomy in general. The paragraphs below present some of the most important such organizations:

- National Economic Council – NEC[89] is the evolution of the Business Advisory Council (established in 2006). A formal body chaired by the Prime Minister and with members from various ministries, enterprises, banks, etc., its main objective is the provision of concrete recommendations for the Government to improve the legal and institutional framework that has a direct impact on the business climate.
- Albanian Network for Rural Development – ANRD (www.anrd.al) is a civil society initiative focused on improving the well-being of rural communities. As of June 2020, it includes 27 civil society organizations as its members, such as the Mountain Areas Development Agency (MADA), Agro PUKA (focusing on the Puka district of Northern Albania), Agritra Vision (operating in Dibër) and AgriNET (with activities in districts of Korce, Elbasan and Peshkopi). The Network is involved in various projects, such as NAGE (Networking and Advocacy for Green Economy) and together with the Agricultural University of Tirana it organized the first Albanian Rural Parliament in 2017. ANRD is a member of the Balkan Network for Rural Development and PREPARE (Partnership for Rural Europe).
- Albania Energy Association – AEA (www.aea-al.org) is a non-profit industry association, established in 2011 to represent Albanian and international energy producers, consumers and promote the use of sustainable energy in Albania and West Balkans. Among others, AEA includes biofuels, biomass and biogas in its areas of activities.
- Association of Collectors, Processors and Exporters of Medical Plants – AMAP (www.amap.org.al) was established in 2016 to bring together actors from the entire value chain of plants, herbs and botanicals: collection, cultivation, processing and exporting industry. The association has about 331 members.
- Union of Chambers of Commerce & Industry of Albania – UCCIAL (www.uccial.al) brings together the Chambers of Commerce and Industry established in each of the 12 Albanian counties. UCCIAL represents the general interest of the business community and coordinates the activities of the county chambers at national level.
- Albanian Agribusiness Council – KASH (www.kashalbania.org) was established in 2000 with the purpose to advocate for and promote Albanian agribusinesses from various sectors. KASH's members include several other associations, such as the Albanian Olive Oil Association, the National Union of Albanian Farmers, the Albanian Flour Millers Union, etc.
- Konfindustria Shqipetare (www.konfindustria.org.al) is the Albanian Industrial Association.
- Foreign Investors Association of Albania - FIAA (www.fiaalbania.al) represents foreign investors in Albania from various third countries and covering a wide range of sectors. The Association, together with Risi Albania, is aiming to attract investors in the agro-processing sector through a dedicated project[90].
- Albanian Local Capacity Development Foundation – ALCDF (www.alcdf.org) is a non-profit organization focusing on supporting local capacity development for agriculture, forestry, tourism, local governance and renewable energies sectors.

The establishment of clusters in the agro-food sector is one of the main activities of various projects in Albania, such as AgroLabs[91] and FOCUS[92].

[89] http://ppd.cipe.org/wp-content/uploads/2014/08/Public-Private-Dialogue-in-Albania.pdf
[90] http://fiaalbania.al/projects/attracting-foreign-investments-in-albania-for-the-sectors-of-agro-processing-tourism-and-ict/
[91] AgroFood Innovation Clusters: www.interreg-balkanmed.eu/approved-project/31
[92] Strengthening competitiveness of agri-food SMEs through transnational Clusters: www.interreg-balkanmed.eu/approved-project/28

7.6 Summary and conclusions in relation to SWOT elements

Lack of funding and limited connections with the European R&I organizations are limiting factors for development of the Albanian innovation sector. The emigration issue is also very pronounced among those Albanians with a tertiary education. 31.3% of tertiary educated people from Albania have emigrated, making the country 15th in the world ranking and exceeded in Europe only by Malta; the willingness to emigrate does not appear to have diminished in recent years as well and despite maintaining links with their homeland, members of the scientific diaspora do not realistically anticipate a return to Albania[93].

However, as Albania develops, progresses and becomes more integrated into the European community, this trend can be expected to return. Already, several ongoing initiatives target the innovation sector in Albania and aim to strength its capacities, as well as provide funding opportunities. At the moment, it seems that the bioeconomy sector is not prioritized compared to others, but considering that agribusiness and other relevant sectors are of a priority for the country development, this trend may change in the future.

Table 7.6.1: SWOT analysis of Skills, education, research and innovation potential of Albania.

Strengths	Weaknesses
Large number of universities Generally good conditions for start-up establishment (young and educated population, ease of establishment, etc.)	Lack of a single entity overlooking the bioeconomy innovation potential in Albania Limited interaction / integration with European R&I Very low government spending on R&D and relatively low on education Lack of cooperation between private and research sectors Small business size with limited focus on R&D
Opportunities	**Threats**
Focus and funding allocated to enhance the innovation potential and capacities Albanian scientific and entrepreneurial diaspora offering possibilities for knowledge transfer or angel investments	Continuation of brain drain

[93] I. Gëdeshi, R. King (2019) The Albanian scientific diaspora: can the brain drain be reversed? Migration and Development https://doi.org/10.1080/21632324.2019.1677072

8 Policy framework: Regulations, legislation, rule of law & taxes and tariffs

8.1 Introduction

As of August 2020, Albania does not have a national bioeconomy strategy.

8.2 National Strategy for Development and Integration

The National Strategy for Development and Integration for the period 2014-2020 (NSDI II)[94] presents the vision for the social and economic development of Albania, aiming to bring the country to the point of European Accession.

"Sustainable Growth through Efficient Use of Resources" is Pillar II of the NSDI II and covers items relevant to energy, transport infrastructure, regional development, agriculture and rural development, tourism, environment, water supply and sewage, integrated waste management, spatial planning.

Specific sector targets for Albania as regards energy and waste management are described in other parts of this report. For the agriculture sector, NSDI II includes as an objective the following: "*promote resource efficiency and the shift towards a low carbon economy and climate sensitive sectors of agriculture, food and forestry*". However, no explicit target is provided. Objectives that may have a relevance for the bioeconomy sector include the increase of the total agricultural area to 500,000 ha, expansion of the average farm size to 2 ha, promote new technologies in the agro-food chain and increase productivity in agricultural and agro-food processing and others.

8.3 Smart Specialization Strategy

Albania registered in the Smart Specialisation Platform (S3P) in November 2017 and currently prepares its smart specialization strategy with assistance from DG NEAR and the Joint Research Centre (JRC)[95].

In 2018, a S3 Working Group was formed, coordinating upcoming steps in preparing the collection of data and the entrepreneurial discovery process (EDP). A roadmap for the process has been drafted. The process will be implemented at the national level, but regional specificities at the county level will also be considered. The S3 process will follow JRC's methodological framework for smart specialisation in the EU enlargement and neighbourhood countries. Considering the challenges identified during the S3 process, it has been suggested to emphasize the qualitative mapping exercise in order to overcome the lack of data for a quantitative mapping, as well as to ensure the participation of regional stakeholders during the EDP. The draft strategy is expected to be finished by the end of 2020.

A National Strategy of Scientific Research, Technology and Innovation 2017-2022 was approved in 2017; it is implemented by the National Agency for Scientific Research and Innovation (NASRI) and the Albanian Investment Development Agency (AIDA).

94 www.oneplanetnetwork.org/sites/default/files/albania_national_strategy_on_development_and_integration.pdf

95 https://s3platform.jrc.ec.europa.eu/albania

8.4 National Energy Strategy

In 2018, Albania presented its National Energy Strategy for 2018-2030, prepared with the assistance of various international donors, including USAID. The Strategy aims to be a comprehensive and integrated approach for meeting Albania's future energy demand, while being in all with regional and international agreements and conventions, including the country's goal of joining the EU[96].

The major goals of the National Energy Strategy are set as follows[97]:

- Reduction of losses in the electricity distribution network to 10% in 2030 compared to 26.4% in 2017
- Increase electricity receipts to 98% in 2030 compared to 90% in 2018
- Increase the contribution of primary energy sources versus total supply of primary sources of energy at the level of 52.5% in 2030
- Fully open electricity market by 2025 while developing a scheme for protection of low-income consumers
- Energy savings equivalent to 15% of total consumption in 2030
- Renewable energy to account for 42% of the energy consumption in 2030
- Reduction of GHG emissions against the total to reach 11.5% in 2030
- Natural gas to reach 20% of total primary energy supplyn in 2030 Penetration of natural gas versus total supply of primary energy sources reach the level

The role of biomass in producing renewable energy for the electricity, heating and transport sectors is recognized by the Strategy. For the electricity sector, no specific targets are set, but the interest of investors is noted as well as the need to set up a support scheme. For the heating sector, the figure below presents the potential contribution of biomass and solar thermal. Firewood will remain the main renewable energy for the heating sector, but its contribution is foreseen to remain stable after 2018; solar thermal, biomass pellets, agricultural residues and biogas are foreseen to expand. For biofuels in transport, the need to harmonize and update legislation based on European Directive and Regulations is noted; the existing biodiesel production facility in Porto Romano is considered as enough to meet the targets by 2025.

96 https://www.usaid.gov/albania/news/albania-unveils-national-energy-strategy-2018-2030

97 https://administrata.al/Documents/strategjia%20doc/23.Strategjia%20Komb%C3%ABtare%20e%20Energjis%C3%AB%20p%C3%ABr%20periudh%C3%ABn%202018%20-%202030.pdf

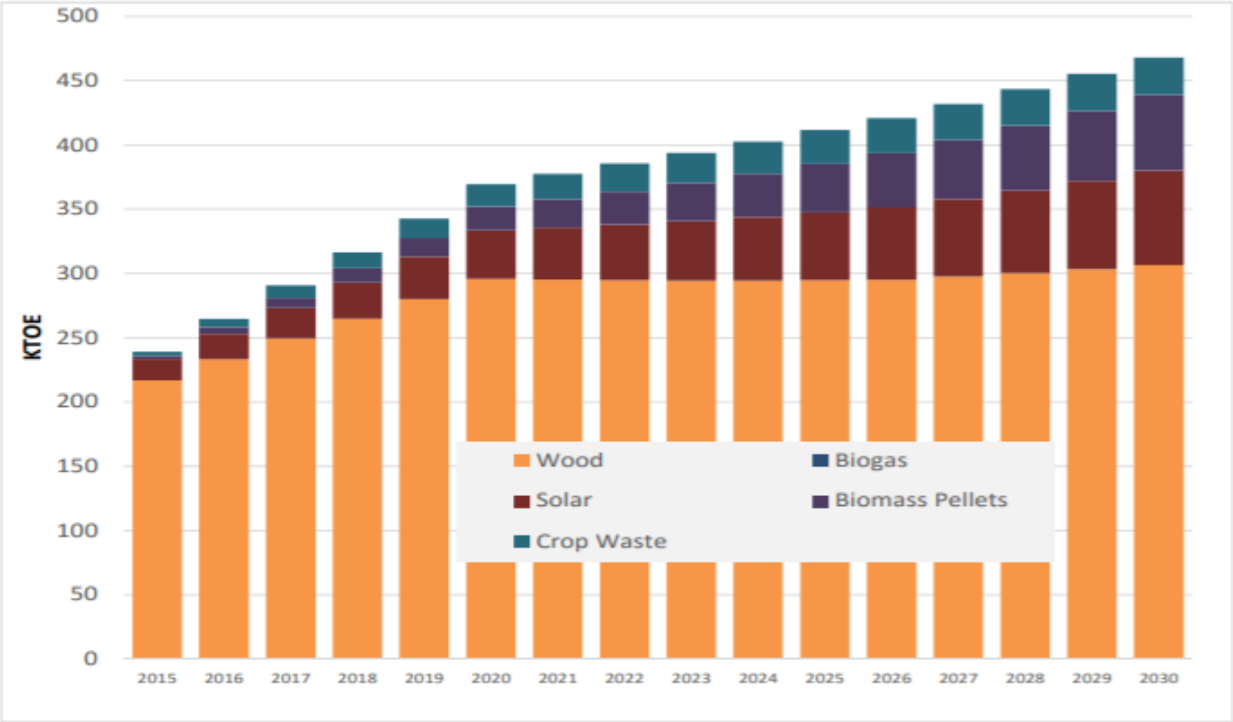


Figure 8.4.1: Role of renewable energy sources in meeting heat demand in Albania (Source: National Energy Strategy 2018-2030).

8.5 Inter-Sectoral Strategy for Agriculture and Rural Development (ISARD)

The Inter-Sectoral Strategy for Agriculture and Rural Development (ISARD) for the period 2014-2020 was developed by the Ministry of Agriculture, Rural Development and Water Administration (MARDWA) with the support of project "Preparation of Inter- sectorial strategy for agriculture and rural development in Albania"[98], funded by the European Union and facilitated by FAO. ISARD was developed in line with the overall EU strategic planning approach for the Common Agriculture Policy (CAP) 2014-2020, while also focusing on the specific needs for the development of agriculture, agro-processing and rural areas in Albania.

ISARD defines the following vision for the agriculture and rural development in Albania:

"*Efficient, innovative and viable agri-food sector capable to sustain the competitive pressure and meeting the requirements of the EU market through a sustainable utilisation of resources, and*
Viable rural areas providing economic activities and employment opportunities, social inclusion and quality of life to rural residents".

The four main priorities outlined by ISARD for the 2014-2020 period are as follows:

1. Enhancing farm viability and competitiveness of agriculture and food-processing, while progressively aligning with Union standards
2. Restoring, preserving and enhancing ecosystems dependent on agriculture and forestry
3. Balanced territorial development of rural areas promoting social inclusion, poverty reduction and balanced economic development in rural areas
4. Transfer of knowledge and innovation in agriculture, forestry and rural areas

[98] www.fao.org/3/I9639EN/i9639en.pdf

In addition, ISARD outlines the following needs:

1. Increase investments in physical assets in agricultural holdings
2. Improve access and quality of advisory services to farmers
3. Improve irrigation and drainage infrastructure
4. Improve competitiveness of food processing industry
5. Upgrade physical capital in food industry to comply with Union standards
6. Enhance cooperation among the main actors in the agri-food chain
7. Improve management of natural resources and resource use efficiency
8. Diversify activities and sources of income for farmers
9. Develop non-agricultural sectors of rural economy
10. Improve rural infrastructure, access and quality of basic services in rural areas
11. Improve local governance and develop capacity for implementation of LEADER approach

8.6 Strategic Investments Law

Attracting investments for development of the country's infrastructure and economy is a major goal of the Albanian government. Law no. 55/2015 "Strategic Investments in the Republic of Albania", in effect since 2016 sets the main legal framework to support foreign and domestic strategic investments in Albania. An amendment voted in 2019 (Law No. 89/2019) extended the deadline for submitting applications for strategic investments until 31st December 2020[99].

Strategic investments are considered as such on the basis of having a relevance to the public interest. The following criteria are considered when evaluating whether public interest exists[100]:

- Investment amount
- Period of investment execution
- Investment productivity and added value
- Creation of jobs
- Priority economic sector
- Regional and local economic development
- Development and improvement of conditions and standards for the production of goods and provision of service
- Introduction of new technologies in order to increase competitiveness and effectiveness of the investment
- Increased overall level of safety and quality of citizens' lives
- Protection of the environment and consumers

The following sectors are considered as being of priority according to the Law:

- Energy and mining
- Transport
- Electronic communications
- Infrastructure
- Urban waste management
- Tourism (tourist structures)
- Agriculture (large farms) and fisheries
- Economic and development priority areas;

[99] https://www.hg.org/legal-articles/strategic-investment-in-albania-54707
[100] https://investmentpolicy.unctad.org/investment-laws/laws/168/albania-law-on-strategic-investments

Depending on the size and other criteria, once considered as "strategic" an investment may be eligible for either the assisted procedure or the special procedure. Benefits of the assisted procedure as follows below[101]:

- Performance of preparatory actions and preparation of administrative documents by the assisting agent, including the necessary documents accompanying the application, when they are issued by a state administration body, at the request of another organ of state administration
- Priority handling and preparation of documentation, issuance of opinions or follow procedures that are included in the activity of state administration bodies represented in the operational group for the preparation and implementation of the strategic investment
- Land consolidation
- Support programs
- Support with ancillary infrastructure
- Access to state-owned immovable property for the purposes of developing and executing strategic investment projects, pursuant to the legislation in force

Additional services to investors eligible for the special procedure include:

- Expropriation of immovable assets owned by private persons, to enable the development and execution of strategic investment projects;
- Approval by the Assembly, when considered by the Council of Ministers, of the relevant strategic investment contracts, upon the request of the strategic investor, in order to increase the safety of regulated legal relationship between it and the Albanian state.

8.7 Taxes and tariffs

The standard VAT rate in Albania is 20%. A reduced VAT rate of 6% applies to certain products and services, e.g. accommodation services, agrotourism services, advertising services and books[102]. Certain goods and services are exempt from VAT; of relevance to the bioeconomy sector is the supply of agricultural machines and of agricultural inputs.

In 2018, Albania introduced a VAT exemption for on the import of qualifying machinery and equipment used in solar energy projects with a contract value of at least ALL 50 million and an installed production capacity of more than 0.5 MW[103].

[101] http://aida.gov.al/en/support-measures/
[102] https://taxsummaries.pwc.com/albania/corporate/other-taxes#
[103] www.orbitax.com/news/archive.php/Albania-Relaxes-VAT-Compliance-31112

8.8 Summary and conclusions in relation to SWOT elements

The development of the policy framework in Albania is geared to a great extend towards harmonization with the European one, in order to support the country's efforts to join the EU. Related sectors, such as renewable energies or waste management are within the priorities of the Albanian government. Regarding "bioeconomy" in itself, no mentions of the term in official documents could be identified. However, this also reflects to a certain extend the European situation: while there may be bioeconomy strategies, there are no directives or regulations targeting the bioeconomy per se, so as to be transposed into the Albanian context. Beyond the transposition of EU legislation, implementation and monitoring continues to be a challenge in Albania that will have to be overcome in order for the sector to take-off.

Table 8.8.1: SWOT analysis of Bioeconomy Policy Framework of Albania

Strengths Policy focus on sectors related to the bioeconomy: agriculture, renewable energy, urban waste management	Weaknesses Lack of a dedicated bio-economy strategy Lack of coordination among policy for different sectors (e.g. agriculture, energy, etc.) Lack of specific financial incentive/ subsidies to foster bioeconomy development Difficulties in implementation and monitoring of regulations
Opportunities Policy goal to harmonization with EU legislation and practices	Threats No clear policy goals for biomass / bioeconomy formulated Limited state resources

9 Financing

9.1 Instrument for Pre-Accession Assistance 2014-2020

The Instrument for Pre-Accession Assistance – IPA is a funding mechanism of the EU targeting candidate countries and potential candidates. IPA was divided into two periods: 2007-2013 (IPA I) and 2014-2020 (IPA II); the budget allocated for Albania was 595 and 639.5 mEUR respectively. In addition to the Country Action Programme, Albania also participates in Cross Border Cooperation (CBC) Programmes with neighboring countries (Greece, Montenegro, etc.) and Multi-Country Programmes.

Table 9.1.1: Priority sectors and budget for IPA II in Albania (Source: EC[104]).

Priority sector	Actions	Indicative budget (mEUR)
Democracy & governance	Strengthening democratic institutions; reforming the civil service and public service delivery; better economic governance; improving public financial management; empowering civil society (e.g. non-state, voluntary organisations)	208.7
Rule of law & fundamental rights	Independent, efficient judiciary; helping police fight organised crime; tackling corruption; respecting human rights conventions.	133.8
Environment & climate action	Alignment with EU law and standards; better treatment of waste and water; controlling air pollution.	30.2
Transport	Better infrastructure and regional connectivity; improved road safety; increased interoperability (cross-border technical compatibility).	24.0
Competitiveness & innovation	Supporting business competitiveness; greater market integration; improving the business environment; developing tourism.	182.2
Agriculture & rural development	More competitive farming and food sector; application of food safety standards; better quality of life in rural areas.	
Education, employment & social policies	Providing effective vocational training; better employment services and labour market policy; inclusion of vulnerable people; efficient health and social services.	60.0
Regional & territorial cooperation	Promoting regional networks, reconciliation and good neighbourly relations; encouraging sustainable local development in border areas.	-

9.2 Rural Development Programme

IPARD (Instrument for Pre-accession for Rural Development) is currently the main tool for supporting rural development in Albania; it has an indicative budget of 94 mEUR, of which 71 mEUR (75%) are provided by the EU, while the Albanian government contributes the remaining 23 mEUR (25%).

IPARD II is managed by the Agency of Agriculture and Rural Development – ARDA (www.ipard.gov.al), a state agency under Minister of Agriculture, Food and Consumer Protection.

At the moment, three IPARD II measures are operational in Albania; details can be found on the table below. Two calls for applications have been published so far.

[104] https://ec.europa.eu/neighbourhood-enlargement/instruments/funding-by-country/albania_en

This project received funding from the BBI JU under the EU Horizon 2020 research and innovation programme under grant agreement No.838087

Table 9.2.1: Operational measures for IPARD II in Albania (Source: ARDA).

Measure	Focus sector(s)	Eligible expenditures amount (EUR) Min.	Max.	Max.
Measure 1: Investments in Physical Assets of Agricultural Holdings	• Milk • Meat • Fruit • Vegetable • Vineyard	10,000	500,000	60% (standard rate) 65% (young farmers < 40 years old) 70% (investments in mountainous areas)
Measure 3: Investments in Physical Assets Concerning Processing and Marketing of Agricultural, livestock and Fishery Products	• Milk and milk processing • Meat processing • Processing of fruits and vegetables • Wine	25,000	2,000,000	50%
Measure 7: Farm Diversification and Business Development	• Production of medicinal herbs, mushrooms, honey, ornamental plants and snails • Processing and marketing of wild and cultivated medicinal and aromatic herbs, fungi and honey • Processing at farm level and trading of agricultural products • Aquaculture • Nature and Rural Tourism • Services for the population and rural businesses • Handicrafts industry and production facilities • Production and use of renewable energy	10,000	400,000	65%

It is clear that the operational measures are of relevance to the development of the bioeconomy sector in Albania. For example, one of the priorities of Measure 3 is to "*improve treatment and handling of waste and utilisation of by-products*".

9.3 International and third country financing sources

Various donor programmes and support from third countries have been active in Albania, assisting the country in implementing structural reforms. Such programmes have been critical to alleviate critical circumstances, e.g. the aftermath of the 2019 earthquakes, but many have a more permanent presence in the country. Apart from the EU, major donors for Albania are Germany, USA, Italy and various international organizations, such as the World Bank and UN agencies. Some important programmes and cooperations are listed below:

- KfW Development Bank has committed about 1.2 billion EUR in Albania. Initially focused on directly alleviating poverty, the main priorities for now are the energy sector (electricity transmission / distribution, energy efficiency, renewable energy sources), municipal infrastructure (water, sanitation, solid waste) and sustainable economic development (promotion of SMEs, vocational education and training)[105].
- Italian Development Cooperation (IDC) has a strong focus on Albania due to multiple historical, cultural and business ties. IDC focuses on Albanian sustainable socio-economic development and EU integration process. The current IDC portfolio of planned and ongoing projects for Albania amounts to 304.7 mEUR, of which nearly 255.2 mEUR are soft loans, 29.5 mEUR are grants and 20 mEUR are disbursed under the Debt for Development Swap Initiative. According to OpenAid Italia[106], in 2016 69 Italian development programmes were active, committing 3.0 mEUR of funds and using 9.2 mEUR.
- World Bank Group activities in Albania are guided by the Country Partnership Framework (CPF) for 2015-2020; about 80% of the programme has been delivered. The World Bank is active in 12 projects, providing a total lending of 738 million USD and 10 grants with a total value of 24 million USD. A key engagement is the enhancement of Albania's "blue economy"[107].

9.4 Venture Capital

The Western Balkans Enterprise Development & Innovation Facility – WB EDIF (www.wbedif.eu) aims to support and enhance the private sector development of the West Balkans region by providing both improved access to finance and access to support measures aimed at both SMEs as well as policy makers in the region. WB EDIF provides financing in Albania through its "Guarantee Facility" instrument; a first round was deployed via Procredit Bank, with a second round was signed with Raiffeisen Bank Albania. WB EDIF manages two types of venture capital funds, both providing equity and quasi equity financing:

- Enterprise Innovation Fund – ENIF focuses on innovative SMEs at various stages of business development, from the seed to expansion phase. ENIF has a target fund size of € 40 million, supporting SMEs to obtain investments ranging from € 100 000 up to € 1.5 million. At the moment, no ENIF investments in Albania are indicated.
- Enterprise Expansion Fund – ENEF finances established SMEs with high growth potential to support the development and expansion of their businesses. ENEF has a target fund size of up to € 97 million, from which eligible SMEs can obtain investments ranging from € 1m up to € 7 million on average. ENEF has one listed investment in Albania: APM, a manufacturer of fabricated metal products serving both the domestic and export markets.

According to the WB EDIF website (www.wbedif.eu/wbedif-in-your-country/albania/), the fund has been active in Albania by providing 36.9 m€ of finance to 561 SMEs. In addition, WB EDIF implements various support services, e.g. advice for small businesses, supporting the Small Business Act (SBA) assessment of OECD, developing and disseminating an IP toolkit, etc.

The Albanian-American Development Foundation – AADF (www.aadf.org) was established in 2009 by the Albanian-American Enterprise Fund (www.aaef.com) with the support and encouragement of the United States Agency for International Development (USAID) and the United States Government. AADF has four main areas of operation: Education for Sustainable Development; Leadership Development; Entrepreneurship; Support for Cultural and Eco-Tourism. According to its 2019 annual report[108], AADF has assisted more than 950 businesses through its entrepreneurial programme; it has committed $ 69 million to 58 projects (of which 31 are active), while mobilizing more than $ 100 million by partners and achieving an overall economic impact of more than $ 270 million.

[105] www.kfw-entwicklungsbank.de/International-financing/KfW-Development-Bank/Local-presence/Europe/Albania/
[106] http://openaid.esteri.it/en/code-lists/recipients/71/?year=2016
[107] http://pubdocs.worldbank.org/en/392601587075676027/Albania-Snapshot-Apr2020.pdf
[108] http://aadf.org/wp-content/uploads/2020/07/AADF_Annual-Report-2019_.pdf

Although it does not provide venture capital by itself, the Foreign Investors Association of Albania - FIAA (www.fiaalbania.al) represents foreign investors in Albania from various third countries.

9.5 Financial institutions

The Bank of Albania (www.bankofalbania.org) is the authority responsible for the licensing, regulation and supervision of banks and other non-bank financial institutions that carry out financial activities in the country. Its website lists 12 banks with domestic and foreign capital operating in Albania as well as 30 non-bank financial institutions offering various services such as lending, microcredit, factoring, financial leasing, payment services and money transfer, issuance of electronic money, foreign exchange, etc.

The Albanian Association of Banks – AAB (www.aab.al), established originally as the Albanian Bankers Club in March 1999, represents the banking sector of Albania. AAB is a member of various international and national organizations, such as the European Banking Federation – EBF, the Interbalkan Forum of Banking Associations, the Banking Association for Central and Eastern Europe – BACEE and others.

The Albania Agribusiness Support Facility – AASF (www.aasf.com.al) was established in 2016 as a financing framework developed by the European Bank for Reconstruction and Development (EBRD) in cooperation and with support from the Government of Albania. It aims to provide both financial and technical support to financing institutions in Albania in order to encourage lending to the whole agribusiness value chain. Ultimately, AASF aims to close the financing gap in the agribusiness sector (estimated to be in the range of USD 750 million) by alleviating bottlenecks both on the financing side (conservative with agricultural lending, higher risks and operational costs, lack of specific skills) and on the agribusiness side (lack of collateral, absence of licenses and business plans, high level of informality). The AASF partners are the Agricultural and Rural Development Agency (ARDA), a national state agency, and financial institutions: Intesa Sanpaolo Bank Albania, OTP Bank, ProCredit Bank, Raiffeisen Bank Albania, Fondi Besa. Among the AASF activities are: training and consultancy services; publication of value chain studies and factsheets; agribusiness credit lines and risk sharing facilities, etc.

Agro& Social Fund (www.asf.al) is a microcredit, non-bank financial institution licensed by the Bank of Albania. As its name implies, it offers various loan products with an emphasis on agribusinesses and social performance, e.g. by supporting financing of women, youth and unserved groups.

9.6 Summary and conclusions in relation to SWOT elements

International financing in Albania mostly aims to assist the country in its path to become a full member of the EU, by upgrading its infrastructure, enhancing rule of law, alleviating poverty and promoting social inclusion and entrepreneurship. Almost never are there any references to the "bioeconomy" in the various funding instruments; however, the Albanian rural / agricultural sector are among those priority sectors targeted. Private financing in Albania also places an increasing focus on agriculture, through the development of specific products as well as by expanding its technical capacities to deal with the peculiarities of agri-business investments.

Table 9.6.1: SWOT analysis of Bioeconomy Financing of Albania.

Strengths Access to various funding sourcing (EU, international, donor programmes, etc.)	Weaknesses Limited public financing Limited financing support to bioeconomy activities beyond farming and food processing
Opportunities Emphasis on financing investments in the agricultural sector	Threats Uncertainties on risk level of bioeconomy investments Reallocation of funds for more pressing issues (e.g. COVID-19 response and recovery)

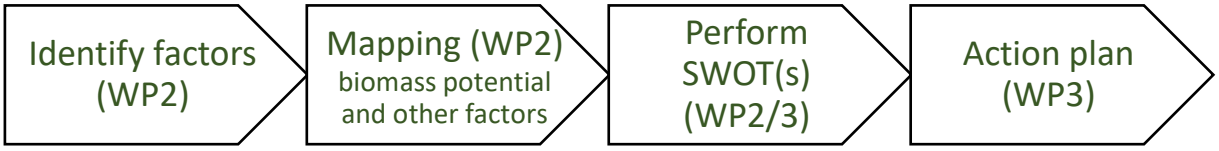
Annex 1 Approach guiding the structure and contents of this report

Identification of factors that are important for establishing bio-based production chains in a country

One of the objectives of the CELEBio project is to map opportunities in the target countries for setting up bio-based business activities. This includes the mapping of the biomass feedstock potentials, and other key success factors for establishing bio-based production chains, e.g. business activities, what bio-based products can be generated, and what is the market demand of these products.

The BBI is focused on the next bio-based products and markets: Chemicals, Plastics (polymers, materials, packaging), Specialties (surfactants, lubricants, pharmaceuticals, nutraceuticals, cosmetics), Textiles, Food ingredients and feed, Advanced biofuels.

To be able to perform SWOT(s) and generate action plans, the first step is to identify which factors are important. These factors should be determined based on the perspective of both entrepreneurs/business developers and governments. The identified factors should be mapped and will be the basis for performing a SWOT (Strength, Weakness, Opportunity and Threat) analysis for development of biobased production chains.



Based on input from industry and business developers a logical set of factors was identified that guide the choice of investing in the bio-based economy and location of conversion plants (Van Dam et al., 2014). This set is expanded/updated (amongst others based on the BBI project BIOFOREVER (bioforever.org)). Via an interview sheet, different stakeholders (15) from different countries (the Netherlands, Croatia, Czech Republic, Hungary, and Slovenia) were asked to comment on the factors and rank them.

Highest ranked factors:

- Feedstock supply: price, security of supply, quality
- Product market: price, off-take security
- Regulations, legislation, and rule of law

Medium raked factors:

- Financing: investors, subsidies, guarantees, risk minimization options
- Taxes and Tariffs
- By-product valorization: heat, CO_2, fodder, lignin

Lowest ranked factors:

- Infrastructure: what part of the chain is already available (harbor, industries)
- Logistics: cost, reliable
- Technology: TRL, robustness, yield, CAPEX, OPEX
- Sustainability: economical, environmental, and social aspects

Overall, the ranking of the factors only differed slightly. Most of the experts mentioned that all the identified factors are important and that a system approach is key in developing biobased initiatives. If one link in the chain is missing, the biobased initiative will not succeed.

According the experts the most important stakeholders for establishing biobased production chains are:

- Producers/suppliers of biomass
- Chemical industry
- Energy industry
- R&D organizations
- Regulatory authority
- Environmental organizations
- Public

Annex 2 Explanation of the S2BIOM approach to assessing lignocellulosic biomass potentials from agriculture, forestry and waste

In S2BIOM project the core biomass cost supply data was generated in WP1 for 37 European countries at regional level. Lignocellulosic biomass assessed by S2BIOM includes biomass originating from the following:

- Primary residues from agriculture
- Dedicated cropping of lignocellulos biomass on agricultural area
- Wood production and primary residues from forests
- Other land use
- Secondary residues from wood industry
- Secondary residues of industry utilising agricultural products
- Waste collection/ tertiary residues

Data have been assessed for 2012, 2020 and 2030. They are provided for several 'potentials' including: a technical potential; a base potential considering currently applied sustainability practises; and further potential levels that are determined considering changing sustainability restrictions, mobilisation measures and different constraints to account for competing use.

The technical potential represents the absolute maximum amount of lignocellulosic biomass potentially available for energy use assuming the absolute minimum of technical constraints and the absolute minimum constraints by competing uses. This potential is provided to illustrate the maximum that would be available without consideration of sustainability constraints.

The base potential can be defined as the technical potential considering agreed sustainability standards for agricultural forestry and land management. The base potential is thus considered as the sustainable technical potential, considering agreed sustainability standards in CAP (Common Agricultural Policy) for agricultural farming practices and land management and in agreed (national and regional) forestry management plans for forests (equivalent to current potentials described in EFSOS II). This also includes the consideration of legal restrictions such as restrictions from management plans in protected areas and sustainability restrictions from current legislation. Further restrictions resulting from RED (Renewable Energy Directive) and CAP are considered as restrictions in the base potential as well. CAP sustainable agricultural farming practices include applying conservation of Soil Organic Carbon (SOC) (e.g. Cross Compliance issues of 'maintaining agricultural land in good farming and management condition' and avoiding soil erosion).

The user-defined potentials vary in terms of type and number of considerations per biomass type. Following the general nomenclature of potentials the user defined potentials can also be considered as sustainable technical potentials but differ in the constraints considered vs the base potential and among each other. The user can choose the type of biomass and the considerations he would like to employ and calculate the respective potential accordingly. This flexibility is meant to help the user to understand the effect on the total biomass potential of one type of consideration against the other. These can include both increased potentials (e.g. because of enhanced biomass production) or more strongly constrained potentials (e.g. because of selection of stricter sustainability constraints).

Technical, base and one user defined (UD) potential has been assessed for all biomass groups. For forest biomass many more user defined potentials were quantified. See underneath:

Table A2.1: Overview of agricultural residual biomass potential types and considerations in S2BIOM.

	Area/ Basis	Yield, Growth	Technical & environmental constraints on the biomass retrieval (per area)	Consideration of competing use	Mobilisation
Technical (straw & stubbles)	Area in 2012, 2020, 2030 with cereals, rice, sunflower, rape, corn maize	Growth based on regional growing conditions & management. Yield according to regional averages including expected developments in yield towards 2020 and 2030	Maximum volume of straw and stubbles that could be harvested in 2012, 2020 and 2030	None	None
Technical (prunings permanent crops)	Area in 2012, 2020, 2030 with fruit trees, vineyards, olive & citrus	Growth based on regional growing conditions & management. Yield according to regional averages including expected developments in yield towards 2020 and 2030	Maximum volume of prunings and cuttings that could be harvested in 2012, 2020 and 2030	None	None
Technical (sugarbeet leaves & tops)	Area in 2012, 2020, 2030 with sugar beet	Growth based on regional growing conditions & management. Yield according to regional averages including expected developments in yield towards 2020 and 2030	Maximum volume of sugarbeet leaves and tops that could be harvested in 2012, 2020 and 2030	None	None
Base (straw & stubbles)	As for technical potential	As for technical potential	Only the biomass part can be removed that is not needed to keep the SOC stable. This is assessed according to carbon content that is removed with the residue and the SOC level in the soil that has to be maintained.	None	None
Base (prunings permanent crops)	As for technical potential	As for technical potential		None	None
Base (sugar beet leaves & tops)	As for technical potential	As for technical potential	Removal of leaves and tops from field is only allowed in Nitrate vulnerable zones where nitrogen surplus needs to be declined through removal of nitrogen rich biomass.	None	None
User potential (straw & stubbles)	As for technical potential	As for technical potential	As in base	In cereal straw a subtraction is applied according to demand for straw for animal bedding & feed . For rice straw, corn stover and sunflower and rape stubbles no competing uses are assumed.	None
User potential (prunings & cuttings)	As for technical potential	As for technical potential	All pruned material is available that is currently according to real practices NOT used to maintain the SOC and fertility of the soil. So the part that is now removed to the side of the field for energy uses or that is burned with & without energy recovery is seen as potential and can be removed. This follows the common treatment practices of prunings as assessed in the EUROpruning project.	None	The potential that is NOT used for SOC and fertility maintenance according to current practices needs to be mobilised gradually as it requires a change in management. It is therefore assumed; it becomes available from 50% in 2012 to 60% in 2020 and 70% in 2030.

This project received funding from the BBI JU under the EU Horizon 2020 research and innovation programme under grant agreement No.838087

Table A2.2: Overview of woody biomass potential types used in S2BIOM.

	Area/ Basis	Yield, Growth	Technical & environmental constraints on the biomass retrieval (per area)	Consideration of competing use	Mobilisation
Technical	Forest area available for wood supply. This excludes protected and protective areas, where harvesting is not allowed according to protection purpose.	Growth based on regional to national growing conditions, including changes in biomass increment due to climate change. Yield according to regional management guidelines for age limits for thinnings and final fellings.	Maximum volume of stemwood that could be harvested annually during 50-year periods. Technical constraints on residue and stump extraction (recovery rate)	None	None
High	As for technical potential	As for technical potential	As for technical potential, but considering additional less stringent constraints (compared with base potential) for residue and stump extraction: Site productivity -Soil and water protection: ruggedness, soil depth, soil surface texture, soil compaction risk -Biodiversity (protected forest areas) -Soil bearing capacity.	None	None
Base	As for technical potential	As for technical potential	As for technical potential, but considering additional constraints for residue and stump extraction: -Site productivity -Soil and water protection: ruggedness, soil depth, soil surface texture, soil compaction risk -Biodiversity (protected forest areas) -Soil bearing capacity.	None	None
User potential - option 1	Reduction of FAWS by 5%	As for technical potential	Equivalent to increase of protected forest area by 5%.	None	None
User potential - option 2	Reduction of FAWS by 5%	As for technical potential	Increase of protected forest area by 5% and increase in retained trees by 5%.	None	Reduction in harvest by 5%
User potential - option 3	As for technical potential	As for technical potential	No stump extraction.	None	None
User potential - option 4	Reduction of FAWS by 5%	As for technical potential	Increase in protected forest by 5% plus increase in retained trees by 5% plus no stump extraction	None	Reduction in potentials by 5%
User potential - option 5	As for base potential	As for base potential	As for base potential	Roundwood production for material use (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Pulpwood, Round & Split + Other Industrial Roundwood) in period 2010-2014) subtracted from BP.	None
User potential - option 6	As for base potential	As for base potential	As for base potential	Roundwood production for material use excl. for pulp and paper and board industry (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Other Industrial Roundwood) in period 2010-2014) subtracted from UP4.	None
User potential - option 7	As for user potential - option 4	As for user potential - option 4	As for user potential - option 4	Roundwood production for material use (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Pulpwood, Round & Split + Other Industrial Roundwood) in period 2010-2014 subtracted from BP.	As for user potential - option 4

	Area/ Basis	Yield, Growth	Technical & environmental constraints on the biomass retrieval (per area)	Consideration of competing use	Mobilisation
User potential - option 8	As for user potential - option 4	As for user potential - option 4	As for user potential - option 4	Roundwood production for material use excl. for pulp and paper and board industry (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Other Industrial Roundwood in period 2010-2014) subtracted from UP4.	As for user potential - option 4

Table A2.3: Overview of potentials calculated for biowaste and wood waste.

Technical potential The Technical potential represents the amount of biomass assuming only technical constraints and a minimum of constraints by competing uses. In case of biowaste no constraints are considered in the technical potential. In case of post-consumer wood, the technical potential assumes that 5% of all wood waste cannot be recovered and used for energy application for technical reasons. Competing uses (current material application of the wood) are not taken into account.
Base potential This is the sustainable technical potential, considering currently agreed sustainability standards. In case of biowaste the base potential equals the technical potential. In case of post-consumer wood, the base potential takes into account the current material application of recovered wood, and assumes that this material application remains constant in 2020 and 2030
User defined potential The user-defined potentials vary in terms of type and number of considerations per biomass type. The user can choose the type of biomass and the considerations he would like to add and calculate the respective potential. This flexibility is meant to help the user to understand the effect on the total biomass potential of one type of consideration against the other. In case of biowaste no user-defined potentials have been developed. In case of post-consumer wood, one user-defined potential has been developed. This user defined potential on cascading use of post-consumer wood takes into account the current material application of post-consumer wood in 2012, and assumes that the material application of non-hazardous post-consumer wood will increase to 49.2% in 2020 and 61.5% in 2030, or remain stable if current (2012) material use is higher.

Primary agricultural residual biomass assessments

For the assessment in S2BIOM (like for Biomass Policies) land-use and livestock production levels are used based on the most recent CAPRI baseline run 2008-2050, providing intermediate results for 2010, 2020, 2030 and 2050.

The potential supply of agricultural residues was estimated for the period from 2012, 2020 and 2030. It uses as main input the cultivated land and main crop production and yield combinations made for these years by the CAPRI model. Residual biomass covered in S2BIOM from agriculture comes from primary residues from arable crops (straw and stubbles) and pruning, cutting and harvesting residues from permanent crops.

The assessment of residues from arable crops builds on methodologies and assessments already done in Biomass Policies and Bioboost. The assessment for vineyards, olive groves and fruit plantation residues bases builds on work done in EuroPruning project.

The aim of S2BIOM was to identify the part of the residues that can be removed from the field without adversely affecting the SOC content in the soil.

It is the carbon balance module in the MITERRA-Europe that has been further adapted in S2BIOM (and Biomass Policies) to take account of removal of straw (and also prunings, see next). This was done by incorporating the RothC model (Coleman and Jenkinson, 1999) into MITERRA-Europe. RothC (version 26.3) is a model of the turnover of organic carbon in non-waterlogged soils that allows for the effects of soil type, temperature, moisture

content and plant cover on the turnover process. It uses a monthly time step to calculate total organic carbon (ton C ha-1), microbial biomass carbon (ton C ha-1) and Δ14C (from which the radiocarbon age of the soil can be calculated) on a years to centuries timescale (Coleman and Jenkinson, 1999). For this study RothC was only used to calculate the current SOC balance based on the current carbon inputs to assess taking account of soil types (including Soil C levels) the sustainable crop residue removal rates at which the carbon C in the soil remains constant.

Primary forest biomass potential assessment

The potential supply of woody biomass was estimated for the period from 2012 to 2030 for stemwood; branches and harvest losses (further: 'logging residues'); and stumps and coarse roots (further: 'stumps') (Table 20). First, we estimated the theoretical potential of forest biomass supply in Europe based on detailed forest inventory data. This theoretical potential was defined as the overall, maximum amount of forest biomass that could be harvested annually within fundamental bio-physical limits (adapted from Vis and Dees 2011, Dees et al. 2012), taking into account increment, the age-structure and stocking level of the forests. Second, multiple environmental and technical constraints were defined and quantified that reduce the amount of biomass that can be extracted from forests for different biomass potential types. Third, the theoretical potentials from the first step were combined with the constraints for the biomass potential types.

This sequence of steps is based on the approach developed and applied within the EUwood and EFSOS II studies (Verkerk et al. 2011; UNECE et al. 2011; Verkerk 2015). The approach in S2BIOM differs from previous studies in several ways, with the main difference being that that woody biomass potentials have been estimated using a typology of potentials developed within S2BIOM. Other changes include (i) an updated of the forest inventory data used as a basis to estimate biomass potentials; (ii) extension of the geographical scope to include all 37 S2Biom countries; (iii) improvements to set the of constraints; and (iv) improve the potential estimates at regional level by spatially disaggregating estimated biomass potentials. All improvements are described below.

The large-scale European Forest Information SCENario model was applied (EFISCEN) (Sallnäs, 1990) to assess the theoretical potential of forest biomass at regional to national level. Versions 3.1.3 (Schelhaas et al. 2007) and 4.1 (Verkerk et al. 2016a) were used because the former version is included in a script to estimated biomass potentials Verkerk et al. (2011), while the latter version has the ability to directly store results in a database, which is used to run the EFISCEN disaggregation tool (Verkerk et al. 2016b). EFISCEN describes the state of the forest as an area distribution over age- and volume-classes in matrices, based on data on the forest area available for wood supply (FAWS), average growing stock and net annual increment collected from NFIs. Forest development is determined by different natural processes (e.g. increment) and is influenced by human actions (e.g. management). A detailed model description is given by Schelhaas et al. (2007; 2016).
National forest inventory data on area, growing stock and net annual increment are used to initialize the EFISCEN model.

The amount of wood that can be felled in a time-step is controlled by a basic management regime that defines the period during which thinnings can take place and a minimum age for final harvest. Age-limits for thinnings and final fellings were based on conventional forest management according to handbooks at regional to national level (Nabuurs et al. 2007) and by consulting national correspondents (UNECE-FAO 2011). The amount of stemwood potential removed as logs was estimated by subtracting harvest losses from the stemwood felling potential. Harvest losses were estimated using the ratio between fellings and removals as reported by UNECE-FAO (2000) for coniferous and broadleaved species separately.

Branches together with harvest losses represent logging residues that can be potentially extracted as well. In addition, stumps could potentially be extracted, separately from logging residues. The volume of branches, stumps and coarse roots was estimated from stemwood volume (incl. harvest losses) using age-dependent, species-specific biomass distribution functions (Vilén et al., 2005; Romano et al., 2009; Mokany et al., 2006; Anderl et al. 2009). We assumed no difference in basic wood density between stems and other tree compartments, due to lack of information.

Climate change is accounted using results from LPJmL (Sitch et al. 2003, Bondeau et al. 2007). Data are an average for several climate models for the A1b SRES scenario. Annual tree Net Primary Production (NPP) in gC/m2 for 3 individual years (2010, 2020, 2030) was calculated with LPJmL and used to scale the increment functions used in EFISCEN.

Secondary biomass potentials from agro-food industry

For an overview of the calculation methods and assumptions of secondary biomass sources from agro-food industries see the table below.

Table A2.4: Overview of assessment rules applied in S2BIOM to assess potentials for olive stones, rice husk, pressed grapes residues and cereal bran.

Biomass type	Area / Source	Residue factor	Technical & Environmental constraints
Olive-stones	CAPRI & national statistics: Area with all olive trees (table=oil olives) 2012, 2020, 2030	Olive pits make up between 10%-12.5% of the weight of olive according to Garcia et al. (2012) and Pattarra et al., (2010)	Base= pits from all oil olives + 30% of table olives
Rice husk	CAPRI & national statistics: Area with rice in Europe 2012, 2020, 2030	Rice husk is approximately 20% of the processed rice, with average moisture content of 10% ((Nikolaou, 2002)). It is assumed that all rice produced in the S2BIOM countries is locally processed	None
Pressed grapes residues (pressing residues & stalks)	CAPRI & national statistics: Area with vineyards in Europe 2012, 2020, 2030	Of the processed grapes 4.6% consists of dregs and 1.5% of stalks (FABbiogas (2015)- Italian country report)	None
Cereal bran	CAPRI total estimate of tons processed cereals per EU country	In wheat processing 20% to 25% wheat offals (Kent et al., 1994). Wheat bran represents roughly 50% of wheat offals and about 10 to 19% of the kernel, depending on the variety and milling process (WMC, 2008; Prikhodko et al., 2009; Hassan et al., 2008). . So the residue to yield factor used is 10% of cereals processed domestically.	None

For the calculation of the olive stones, rice husk and pressed grapes dregs we assumed that all domestic production would also be processed locally and that is no further processing of imported olives, rice and grapes. This implied that the residues would be available locally and that the regional distribution of the processing residues is a direct outcome of the cropping area distribution over regions in every country.

For cereal bran it is more logical to assume that the basis should be the total amount of cereals processed in every country. This implies that cereal bran needs to be calculated for a total net domestic cereal production and imports:

$$Domestic\ production_{cereals} - export_{cereals} + import_{cereals}$$

The data on total domestic production, exports and imports levels were available from CAPRI for 2010 (extrapolated to 2012), 2020 and 2030 for all S2BIOM countries except for Ukraine.

To come to a regional distribution of the cereal bran potentials in every S2BIOM country 2 assumptions were made:

1) The bran based on the net domestic production (=domestic production – exports) is distributed regionally according to cereal production area share.
2) The cereal bran based on processing of imported biomass is distributed over largest (port) cities per country as it is expected that processing industries are there where imports enter the country and where population is concentrated. The residues were spatially distributed to regions with the large and medium sized cities (>100,000 inh.), every city was equally weighted.

Method used to estimate secondary forest biomass produced in the forest processing industry

The EU-Wood study (Mantau, 2010) projects the demand for material use without considering competition with other sectors in order to explore if the increasing demand for energy will lead to a strong competitive situation where the demand substantially exceeds the supply. The EU-Wood project (Mantau, 2010) has aligned the prediction of the future demand to the real GDP (Gross domestic product) and thus the prediction that utilises the IPCC B2 scenario assumptions shows a strong increase (see figure below).

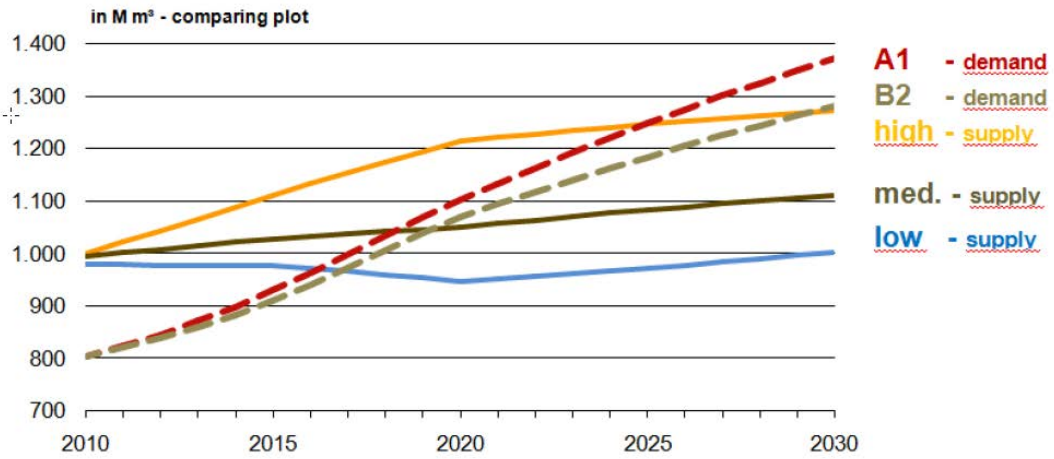


Figure 1-4: Development woody biomass potential demand and potential supply

Source: EUwood 2010

Figure A2.1: Future development of demand and supply as projected by the EU-Wood project for different scenarios (Mantau, 2010).

Thus, to constrain the potentials by such demand projection would constrain the potential with strong preference to material use. The recent trends of the forest products consumption index indicate that the production has changed its relation to the GDP (see figure below).

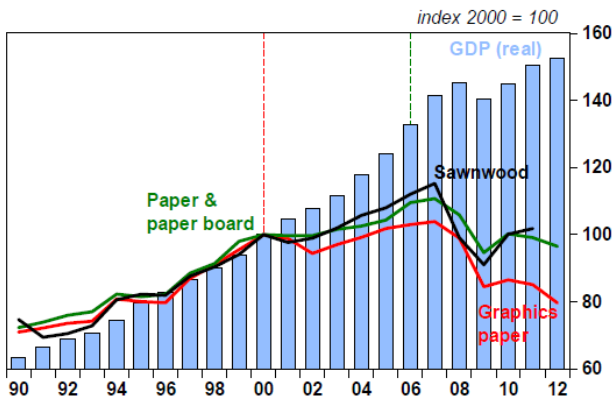


Figure 2.1.2. EU GDP (real) and forest products consumption index over the period 1990-2012 (2000 = 100). (Forest products data from FAO; GDP data from IMF, Gross domestic product based on purchasing-power-parity (PPP) valuation of country GDP).

Figure A2.2 EU GDP and forest products consumption index[109]

[109] Source: Birger Solberg, Lauri Hetemäki, A. Maarit I. Kallio, Alexander Moiseyev and Hanne K. Sjølie (2015) Impacts of forest bioenergy and policies on the forest sector markets in Europe – what do we know?

An alternative to use predict the future industry production results from modelling that considers economic competition. Such estimates are available from the EFSOS II study for 2010, 2020 and 2030. The trends of the EFSOS II study are utilised by S2BIOM. Figures 3 and 4 show for sawn wood and panels that the S2BIOM data for 2012 are close to EFSOS II reference scenario projections 2010.

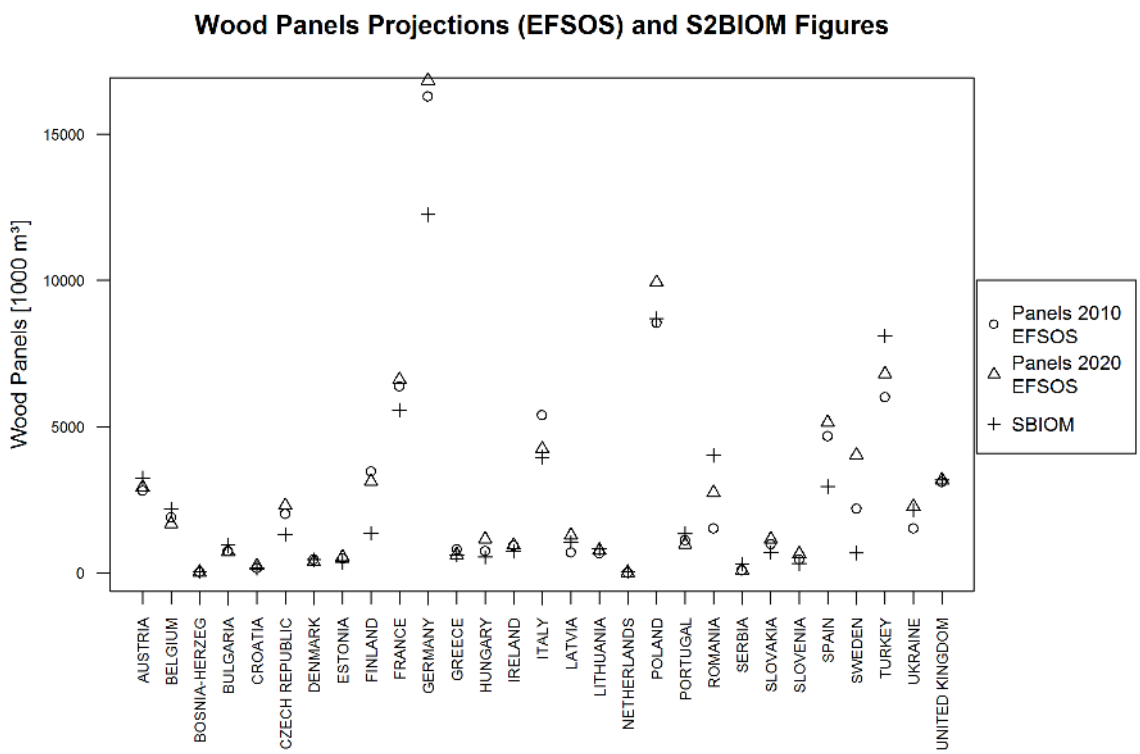


Figure A2.3 Wood panel production, EFSOS 2 reference scenario projections, and S2BIOM 2012 estimates

The S2BIOM residue and production figures of the timber industry were thus projected to the years 2020 and 2030 using the growth rates of the reference scenario of the UNECE European Forest Sector Outlook Study II (EFSOS II) for sawnwood and wood based panel production.

For the pulp and paper sector there was a huge difference between S2BIOM 2012 quantities and the EFOS reference scenario projections.

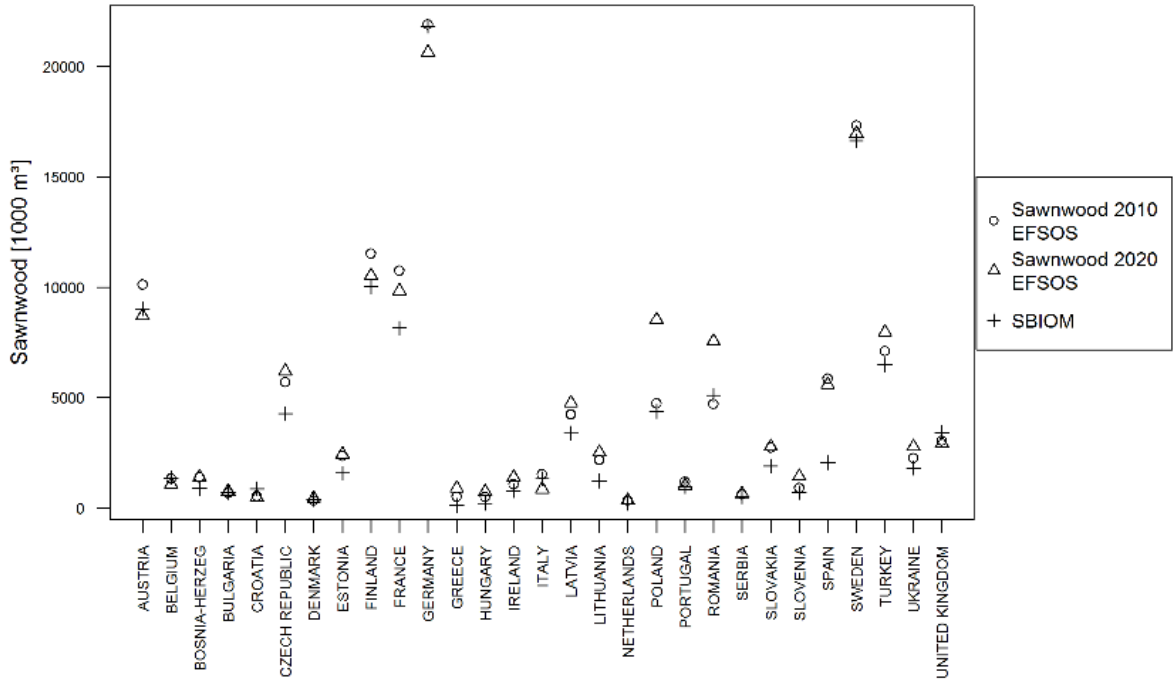


Figure A2.4 Sawnwood production, EFSOS 2 reference scenario projections and S2BIOM 2012 estimates

The visualisation of the figures from the "Historic Statistics" report of CEPI on pulp and paper production are shown in Figure 5. This figure shows the changes of pulp production for the CEPI member states which are: Austria, France, Netherlands, Romania, Sweden, Belgium, Germany, Norway, Slovak Republic United Kingdom, Czech Republic, Hungary, Poland, Slovenia, Finland, Italy, Portugal and Spain. It is for S2BIOM assumed that the changes in production after some bigger fluctuations in the past will be in 2020 and 2030 in the same dimension as in 2012. Hence the production quantities from 2012 are used for 2020 and 2030 as well.

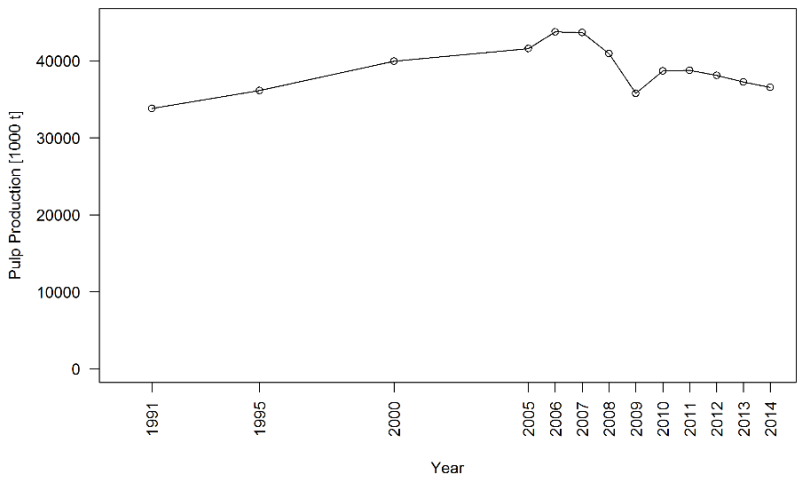


Figure A2.5 Development of Pulp production, CEPI data

The approach used is summarised by category in the table below.

Table A2.5: Approach used to estimate future production amount in the wood industry.

Sector	Approach
Saw mill residues, conifers	EFSOS II sawnwood, reference scenario
Saw mill residues, non-conifers	
Residues from industries producing semi - finished wood based panels	EFSOS II wood based panels production, reference scenario
Residues from further wood processing	EFSOS II sawnwood, reference scenario
Secondary residues from pulp and paper industry	Kept constant

Assessment of biowaste and post-consumer wood potentials

The availability of biowaste in 2012 on NUTS3 level was established as:

MSW generated per capita (kg/capita) x
biowaste fraction (%) x
population of the NUTS3 area (persons).

A further distinction has been made between the separately collected biowaste and biowaste as part of mixed waste.

In Arcadis and Eunomia (2010) projections have been provided of the shares of biowaste going to the different treatment options like landfill, incineration, MBT, composting, backyard composting, anaerobic digestion and others have been made for the years 2008-2020. It has been assumed that all countries meet the requirement of the landfill directive, e.g. that maximally 35% of the amount of biodegradable waste generated in base year 1995 is landfilled in 2020, even if current developments show that diversion from landfill has not been successful yet. Furthermore, the projections are based on policy views and current changes in treatment of biowaste in the member state concerned. For instance, some countries have a strong preference for MBT, others for incineration with energy recovery. For the year 2030 the same shares between treatment options are used as in the year 2020. Currently no policies are known that influence the production of biowaste after 2030, therefore it is assumed that the projected status quo in 2020 will be maintained in 2030.

Projections on the development of the total quantity of biowaste are assumed to be proportional to population growth. The main scenario on population development from Eurostat has been used to predict the population in 2020.

The calculation of the post-consumer wood potential is calculated according to the following formula:

$PCW_{technical\ potential} = PCW_{material} + PCW_{energy} + PCW_{disposed}$
$PCW_{base\ potential} = PCW_{energy} + PCW_{disposed}$

in which:

- $PCW_{recovered}$ = PCW used for materials like panels and chipboards
- PCW_{energy} = PCW used for energy production
- $PCW_{disposed}$ = landfilled and/or incinerated with MSW

Eurostat gives data on "wood waste", but this includes not only post-consumer wood but processing wastes from agriculture forestry and fishing sectors. Because of this mixture of secondary wood processing and tertiary post-consumer wood within one category, Eurostat data could not be used to determine the potential of post-consumer wood. For S2BIOM, data on recovered wood were used from a forest biomass resource assessment

done for the EUwood and EFSOS II studies (Mantau et al. 2010; UN-ECE/FAO 2011[110]). EUwood combines among others Eurostat and COST Action E31 data. The EFSOS II data on demolition wood is based on EU wood, but covers Europe as a whole instead of EU28. In order to determine the base potential PCW available for energy, it is necessary to estimate how much is used for material applications. In the Methodology report of the EUwood project[111], a table is given on the availability of *PCW recovered* [for material recycling] and *PCW energy* for 2007, page 119-120, which have been used in S2BIOM as well.

Assessment of cost levels for different biomass categories in S2BIOM

Because we are still in the early stages of a transition of fossil based feedstock towards bio-based feedstock there is hardly any information of enough quality to conduct a meaningful market analysis. In this light it is important to keep in mind that a distinction needs to be made between different types of cost and price levels specific per biomass type:

- Market prices exist for already traded biomass types (e.g. straw, wood chips and pellets based on primary and secondary forestry residues).
- Road-side-cost for biomass for which markets are (practically) not developed yet (e.g. many agricultural and forestry residues, dedicated crops for ligno-cellulosic and woody biomass and waste streams such as vegetal waste). These may cover the following cost:
    - Production cost (in case of dedicated crops, not for residues or waste)
    - Pre-treatment in field/forest (chipping, baling)
    - Collection up to road side/farm gate
- At-gate-cost which cover the cost at roadside plus transport and pre-treatment cost of biomass until the biomass reaches the conversion plant gate (e.g. bioethanol plant, power plant).

The cost assessed in S2BIOM are limited to the road-side cost. So, the cost from road side for transport and possible in-between treatment to the gate of the conversion installation or the pre-treatment installation are NOT included.

Cost assessment for agricultural biomass potentials

The overall methodology followed to gain insight in the minimum costs of production is the *Activity Based Costing* (ABC). It involves the whole production process of alternative production routes that can be divided in logical organisational units, i.e. activities. The general purpose of this model is to provide minimum cost prices for the primary production of biomass feedstock at the road side. ABC generates the costs of different components based on specific input and output associated with the choice of the means of production, varying with the local conditions and cost of inputs (e.g. labour, energy, fertilisers, lubricants etc.). Since the production of most biomass is spread over several years, often long-term cycles in which cost are incurred continuously while harvest only takes place once in so many years, the Net Present Values (NPV) of the future costs are calculated. This provides for compensating for the time preference of money. To account for the fact that the costs are declining in different periods of time in the future the Net Present Value annuity is applied. In this way annual, perennial crops and forest biomass cost are made comparable (=all expressed in present Euros).

The costs are automatically calculated for all field operations per year in a 60-year cycle in the case of agricultural biomass. The costs of wood production were not considered in this study as these costs need to be allocated to the main product, while here the focus is on the cost of the residues. Cost are presented as NPV per annum and expressed in € per ton dm or per GJ.

[110] UNECE (United Nations Economic Commission for Europe), FAO (Food and Agricultural Organization of the United Nations) 2011: The European Forest Sector Outlook Study II; Geneva

[111] EU Wood (2010) Methodology report, real potential for changes in growth and use of EU forests EUwood. Call for tenders No. TREN/D2/491-2008.

It is also important to note that the costs calculated in here are at the farm level cost. We are aware that the costs for the next link in the value chain might be higher because of rent seeking behaviour. However, in this approach we did not take account of it as we did not include a profit margin.
As explained in the former cost of agricultural biomass are calculated for *Net Present Value annuity* taking a 60-year coverage period. These 60 years are chosen to fit all possible cycles in the cost calculation as 60 is fully synchronizable to 1,3,5,10,15,20,30 and 60 years cycles. Cost differences after that period are negligible. In this way, cost for biomass from residues and from dedicated crops can be assessed with the same model and can be made comparable.

First the Net Present Values of all activities are calculated as follows:

Formula:
$NPv=Fv/(1+i)^n$
Where:

NPv = Net Present value
Fv = Future value
i = the interest rate used for discounting (set to 4%)
n = number of years to discount

Then the Net Present Value annuity is applied, assuming that the sum of NPVs cover the annual capital payments attracted against the same interest rate (4%) as the discount rate used for calculating the NPVs.

Formula:
$NPVa= \Sigma NPv*(1/((1-(1+i)^{-n})/i))$
Where:

NPVa = Net Present Value annuity
ΣNPv = sum of NPVs
n = number of years
i = the interest rate (set to 4%)

The cost also allow for national differentiation of cost according to main inputs having national specific prices levels. This organised through the **'Country inputs'** module in the ABC model. It contains detailed information concerning the prices of various resources needed as input for the production process of biomass specific per country. These are specified, either in absolute price levels or as an index related to the known price level in one or two specific countries (mostly Germany). This is necessary as prices of key production factors differ a lot at national level across Europe. National level price data (ex. VAT) included cover cost/prices for labour (skilled, unskilled and average), fuel, electricity, fertilizers (N, P2O5, K2), machinery, water, crop protection and land. Most of these data were gathered from statistical sources such as FADN (Farm Accountancy Data Network), Eurostat and OECD. Most cost levels were gathered for the year 2012.

The cost data elaboration also requires a feedstock specific approach. If costs are estimated for biomass that is specifically produced for energy or biobased products, i.e. in the case of dedicated crops the cost structure is clear and all cost can be allocated to the final product. All cost should include the fixed and variable cost of producing the biomass including land, machinery, seeds, input costs and on field harvesting costs. If the biomass is a waste, i.e. cuttings of landscape elements or grass from road side verges, the cost could be zero, as cutting and removing these cutting is part of normal management. However, bringing the biomass to the conversion installation requires some pre-treatment costs, e.g. for drying or densifying and then transport costs have to be made to bring it to the conversion installation. These costs will not be assessed here however as we concentrate on the road side cost.

Crop residues also require a separate approach as harvesting cost can usually be allocated to the main products, i.e. grain in the case of cereal straw, and not to the residue. However, the baling of the straw and the collection up to the roadside can be included in the costs.

For the elaboration of cost levels account also needs to be taken of the local circumstances and type of systems used for the production and harvesting of the biomass. This is particularly complex in the case of dedicated

crops for which cost estimates are mostly and/or only available from pilot plots and practically no commercial plantations. Costs vary strongly per type of management, soil and climate zone. Furthermore, cost need to be allocated per ton harvested mass over the whole life-time of a plantation as harvest levels are very low in the first years and increase in time.
The costs are determined for 2012, the reference year and are kept constant in the future years 2020 and 2030. The reason for keeping cost constant in time has several advantages:

1) Estimations of future changes in prices for (fossil) energy (fuel & electricity), labour, and machinery are difficult to predict. If predictions are used this implies automatically adding additional uncertainties in the cost assessment.
2) If cost levels do not alter in time the uses of the cost-supply data in other models in and outside S2BIOM (e.g. Resolve and BeWhere) deliver results that can only be explained from the internal logic of the models and not by differences in cost level increases based on a large number of uncertainties.
3) The cost levels presented in S2BIOM can still be further adapted by other users applying their own assumptions on future cost level changes. This enables them to use the S2BIOM cost-supply data consistently with their own modelling assumptions.

Cost assessment for forest biomass

The estimation of harvesting and comminution costs is following the approach presented earlier by Ranta (2002, 2005), Ilavský et al. (2007), Anttila et al. (2011) and Laitila et al. (2015). In contrast to the cost estimates for energy crops, the production costs are not considered in the cost estimates.
The data are mostly determined by the S2Biom project. A survey of cost factors related to forest harvesting operations was carried out in cooperation with INFRES project (Dees et al. 2015).
The methodology can be divided into two main components: 1) the estimation of hourly machine costs, and 2) the estimation of productivity. All the cost estimations pertain to current cost level (year 2012).

The general work flow is illustrated in the figure below.

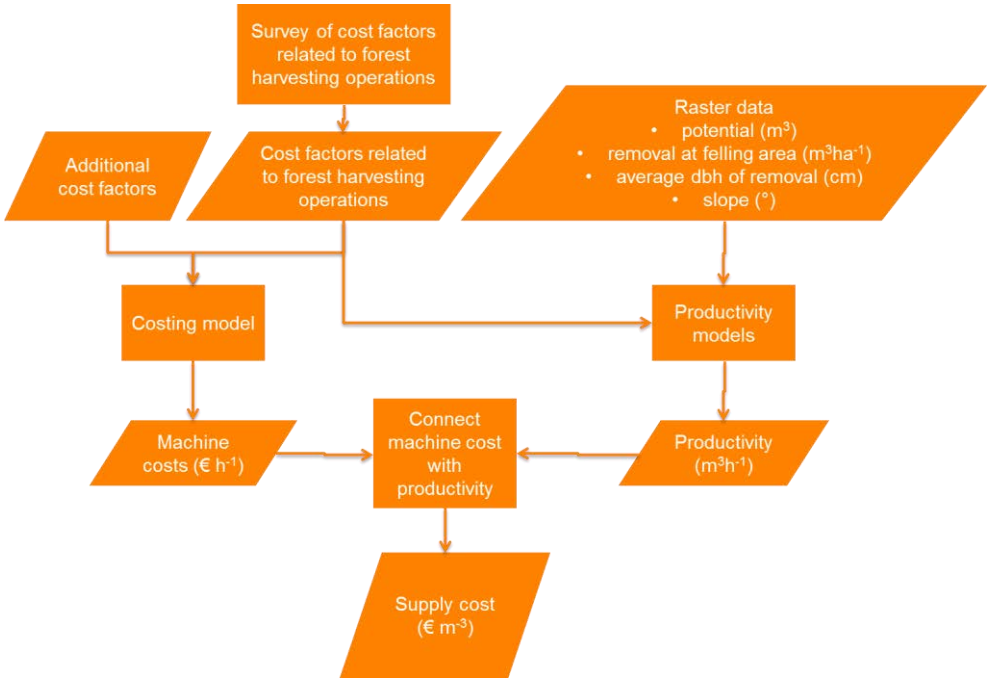


Figure A2.6 General work flow of the forest biomass cost calculations

Cost estimates for biowaste and post-consumer wood

This study follows the activity-based costing approach. In principle, the costs of harvesting collection and forwarding to the roadside need to be considered. The cost to put the biowaste in a container at roadside is assumed to be zero. The cost of further collection and processing is covered by the households and organisations that need to discard the biowaste, regardless its possible further application for energy production. Waste collection and treatment is part of the public tasks and the cost for it cannot be allocated to the processor of the waste. In case of biowaste we could define the municipal collection point as "at roadside". From this municipal collection point, the municipality can select which waste treatment option is preferred, within the framework of European and national policy, considering costs and sustainability of the treatment methods.

The cost of discarding post-consumer wood in a container at roadside is regarded zero. For instance, demolition activities are performed to make space for another building, and not with the purpose to generate wood waste. Demolition activities will follow legal instruction, i.e. put waste wood fractions in separate containers if this is required by law. For other sources of post-consumer wood such as packaging materials or household waste a similar approach can be applied. Packaging waste is of no value to organisations. Consumers bring wooden furniture to a central collection point, or put it at roadside for pick-up, not the sake of providing energy wood. Once collected and sorted, waste wood fractions have an economic value, which can be considerable if there is sufficient demand. However, as said, S2BIOM follows an activity based costing approach, considering the costs, not the economic value of the material. The roadside cost of demolition wood is therefore assumed zero.

Horizon 2020
European Union Funding
for Research & Innovation

BBI JU

Bio-based Industries Consortium

CELEBio

D.2.2

Country report: Bosnia and Herzegovina

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 838087

Author(s): Petar M. Gvero

RCISD
smart. flexible. innovative.

This project received funding from the BBI JU under the EU Horizon 2020 research and innovation programme under grant agreement No.838087

EXECUTIVE SUMMARY

Work package	2
Activity	A.2.1 – Sustainable Biomass Assessment
Task	n/a
Deliverable No	D.2.2
Deliverable Title	Country report: Bosnia and Herzegovina
Responsible partner	RCISD
Author(s)	Petar Gvero
Editor(s)	Berien Elbersen & Julien Voogt
Quality reviewer(s)	n/a
Due date of deliverable	M14
Actual submission date	M15
Level of dissemination	PU
Publishable executive summary in English	This report is organized in 9 chapters. In chapter 1 a first description is given of the key characteristics of the country of Bosnia and Herzegovina. In the chapters 2, 3, and 4 the biomass production including their current uses and opportunities for what biomass can be additionally mobilised, is summarized for respectively the agricultural, forest, and waste sectors. In Chapter 5 a description is given of the current biobased industries and markets, in Chapter 6 the infrastructure, logistics, and energy sector are described. Chapter 7 focusses on the innovation potential. Chapter 8 focusses on the policy framework, in chapter 9 potential financing options related to the development of biobased production chains are discussed. The chapters are closed by swot analysis.
Publishable executive summary in national language	Ovaj izvještaj je napravljen u 9 poglavlja, U poglalvju 1 data je prvi opis ključnih karakteristika zemlje Bosne i Hercegovina. U poglavljima 2, 3 i 4 opisana je proizvodnja biomase, njeno trenutno korišćenje, kao i mogućnosti za koje se biomasa može dodatno mobilizovati iz sektora poljoprivrede, šumarstva i otpada. U poglavlju 5 dat je opis bio-baziranih industrija i tržišta. U poglavlju 6 opisana je infrastruktura, logistika i energetski sektor. Poglavlje 7 je fokusirnao na inovacijski potencijal. Poglavlje 8 fokusira se na okvire politika. Poglavlje 9 obrađuje opcije finansiranja vezane za razvoj bio-baziranih proizvodnih lanaca. Svako poglavlje je zaključeno SWOT analizom.

This project received funding from the BBI JU under the EU Horizon 2020 research and innovation programme under grant agreement No.838087

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SUMMARY

Bosnia and Herzegovina is among the most forest rich states in Europe. Forest and forest land cover about 48,3% of the territory of the country, and 50.3% of the total area is agricultural land (of which 62% is arable land). The most significant resource among RES is wooden biomass. Out of the total area of Bosnia and Herzegovina, approximately 2.200 million ha is arable land, of which less than 1% is irrigated, 0.7 ha per capita. The agriculture sector covers about 4-5 % of Bosnia and Herzegovina's GDP, but it is difficult to say precisely because this share decreasing every year. But from the other side the large share of agriculture in the structure of GDP, the high level of employment and considerable share in the foreign trade deficit are the three main characteristics of agriculture and its importance for BiH economy. Residues from crops production has as significant potential and it is practically unexploited. Significant percentage of the land is abounded, which gives opportunity for dedicated crops production, for energy purposes. Residues from food processing industries, represent an excellent opportunity to improve energy efficiency and economic viability, which can make these industries more competitive on the market. Unfortunately, in Bosnia and Herzegovina, there are not too many examples of food processing residual uses. The latest data from the second National Forest Inventory in Bosnia and Herzegovina (2006–2009) shows a total figure of 3,231 million ha of forest and other woodland out of which 1,652 million ha are high forests and 1,252 million ha are coppice forest. Mainly the wood is exported as a roundwood, pellet and firewood. Significant potential laying in charcoal export, but only a little fragment is exported as added-value products such as chemicals, and wood final products. According to some research it is estimated that around 2.8 kg of food waste is disposed of by the average household in Bosnia and Herzegovina, every week. The main treatment option available in the country is landfilling of waste. Large potential in waste recycling industry exist as well as possibilities of energy recovery. The food and food processing industry make a significant contribution to overall GDP. According to future biomass valorisation the bio-refining is much of an interest as is the other surrounding countries, but is important to find its own model of the future bio-refinery adequate to business and natural environment of the country, Priority of Bosnia and Herzegovina is to increase the supply of energy from renewable sources and thus strives to replace outdated technologies with more efficient and environment-friendly technologies for using renewable sources. Regarding to R&D, entities and state investment in R&D is small, but research programs are oriented towards the development of new technologies and products. Some initiatives for start-ups creation and incubators already exist. Legal framework for PPP already exists in both entities and some PPP projects in bioenergy sector are active (mainly DHS). As in most surrounding countries bioeconomy is not the central topic of any specific Bosnia and Herzegovina's framework or policy. There are, however, several entity and national frameworks that touch on the topic of bioeconomy. It is also important to emphasize that new strategies and action plans for energy, agriculture and renewable energy sources has adopted. Bosnia and Herzegovina has a great and unexploited potential for bioenergy projects and bioeconomy development in general. This development ultimately depends on the financing. There are not special investment incentives pushing activities on bioeconomy and bioenergy on more serious level.

1. Introduction

This chapter gives an overview of the objectives and approach of the CELEBIO Project and will directly pinpoint to the key and most typical characteristics of the country.

1.1. Objectives and approach

The main objective of CELEBio is to contribute to strengthening Bioeconomy-related activities in Bulgaria, Czech Republic, Croatia, Hungary, Slovak Republic, Slovenia and the neighbouring countries. To this end one of the key activities is to develop seven comprehensive reports for the target countries and the wider neighbouring region on the availability of sustainable biomass, logistics, costs and biomass business opportunities assessed through an analysis of the Strengths, Weaknesses Opportunities and Threats The main objective of CELEBio is to contribute to the strengthening bioeconomy-related activities in Bulgaria, Czech Republic, Croatia, Hungary, Slovak Republic, Slovenia and neighbouring countries of Greece, Albania, North-Macedonia, Bosnia and Herzegovina, Serbia and Montenegro. To this end, one of the key activities is to develop seven comprehensive reports for the target countries and the wider neighbouring region on the availability of sustainable biomass, logistics, costs and biomass business opportunities assessed through an analysis of the Strengths, Weaknesses Opportunities and Threats (SWOT).

This report aims to provide the necessary background information needed to evaluate the possibilities for setting up bio-based production chains in BOSNIA AND HERZEGOVINA.

The information structure and analysis presented in this report was developed by building on the method designed and applied by Van Dam et al. (2014) and was further refined through the execution of interviews with bio-based business developers and other experts. In these interviews further information was obtained on key factors that guide the choice of setting up bio-based activities in countries. Most of the experts stressed that all the identified factors are important and that a system approach is key in developing bio-based initiatives. If one link in the chain is missing, the bio-based initiative will not succeed. The identified factors are mapped in this report and will be the basis for performing a SWOT analysis for development of bio-based production chains.

1.1.1. SHORT CHARACTERISATION

Bosnia and Herzegovina has common borders with the Republic of Croatia (931km), the Republic of Serbia (375 km) and the Republic of Montenegro (249 km). The border with Croatia on the Adriatic sea is 23,5 km long, which is shown on figure 1.3.2. (Figure 1). According to the Constitution of Bosnia and Herzegovina is consists from two entities: Republic of Srpska (RS), Federation of Bosnia and Herzegovina (FBiH), and third administrative unit, Brcko District (BD). Energy sector, forestry, environmental and climate changes related issues are under their jurisdiction. The Federation of Bosnia and Herzegovina itself has a federal structure and consists of 10 autonomous cantons.

Bosnia and Herzegovina has a surface of 51,000 km^2. With 3.53 million inhabitants its corresponding population density is given in Table 1. The average income level is relatively low in comparison to the average of the EU. Bosnia and Herzegovina (BiH) is among the most forest rich states in Europe. Forest and forest land cover about 48,3% of the territory of the country, and 50.3% of the total area is agricultural land (of which 62% is arable land). The main land cover distribution is presented on Figure 2. Bosnia and Herzegovina is one of the most rural countries in Europe. Around 60% of the population live in rural areas, whether defined as villages or as scarcely populated municipalities. The population density in Bosnia and Herzegovina is 64 per km2, and 52.3 % of the population is urban. The GDP and purchasing power in Bosnia and Herzegovina are below the European average.

Table 1 Main population, land surface, GDP and trade characteristics of Hungary benchmarked against EU average[1,2]

Category	Bosnia and Herzegovina	EU	Unit
Population	3.53	512.4	million (2018)
Area (total)	5.1	447	million ha (2018)
% population in urban areas	39%	44.9%	% of total population (2018)
% territory predominantly rural	40%	43.8%	% of total territory (2018)
% territory predominantly urban	20%	10.7%	% of total territory (2018)
Agricultural Area	2.57	173.3	million ha (2016)
Forest area	3.23	164.8	million ha (2016)
Population density	74	115	n°/km² (2018)
Agricultural Area per capita	0.53	0.34	ha/capita(2016)
Forest area per capita	0.92	0.32	ha/capita(2016)
GDP/capita	4,200	30,956	at current prices in 2018
	-	30,956	GDP at purchasing power in 2018
GVA by Agriculture, forestry and fishing	6.1	1.6%	% of total GVA (for EU: 2018), for BiH 2019 (source Worldbank)

GDP = Gross Domestic Product; PPS = Purchasing Power Standard; GVA = Gross Value Added; UAA = Utilised Agricultural Area

[1] *Source: "Analysis of the Forest Sector in Bosnia and Herzegovina EU funded project "Preparation of IPARD Forest and Fisheries Sector Reviews in Bosnia and Herzegovina"," FAO, 2015.*

[2] *Source: Eurostat most recent statistical data sources (Accessed August/September 2019) (https://ec.europa.eu/eurostat/data/database) and statistical factsheets (https://ec.europa.eu/agriculture/statistics/factsheets_en)*

Figure 1 Bosnia and Herzegovina and its bordering countries[3]

[3] *Source:https://en.wikipedia.org," [Online]. [Accessed 06 2020].*

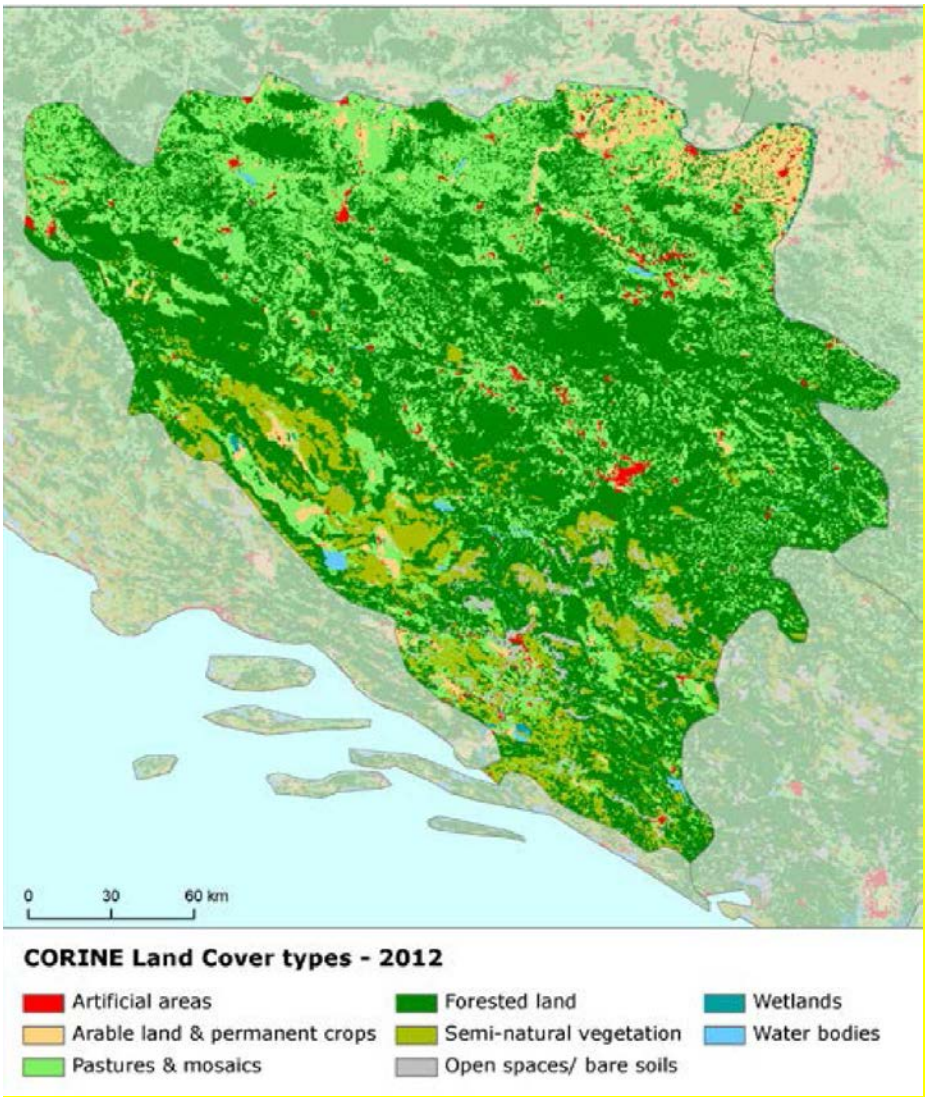

Figure 2 Main land cover distribution over Bosnia and Herzegovina[4]

According to the available data, the total length of the road network in Bosnia and Herzegovina is 22,609.11 km, out of which is 69,60 km of motorways, 3,772.88 km of trunk roads, 4,566.63 km of regional roads, and approximately 14,200 km of local roads. In the case of railway, the rail network of BiH consists of 1,031 km of railways, of which 426 km are in the RS (Institute for statistics of RS) and 615 in FBiH. Although the density of the railway network in BiH is comparable with that of Western European countries, the volume of transport of goods and passengers per kilometer of railways is far below the European average. Figure 3 shows the position of Bosnia and Herzegovina in the Trans-Europe Transportation network.

[4] *Source:"https://www.eea.europa.eu/data-and-maps/figures/land-cover-2006-and-changes/bosnia-herzegovina," [Online]. [Accessed 2020].*

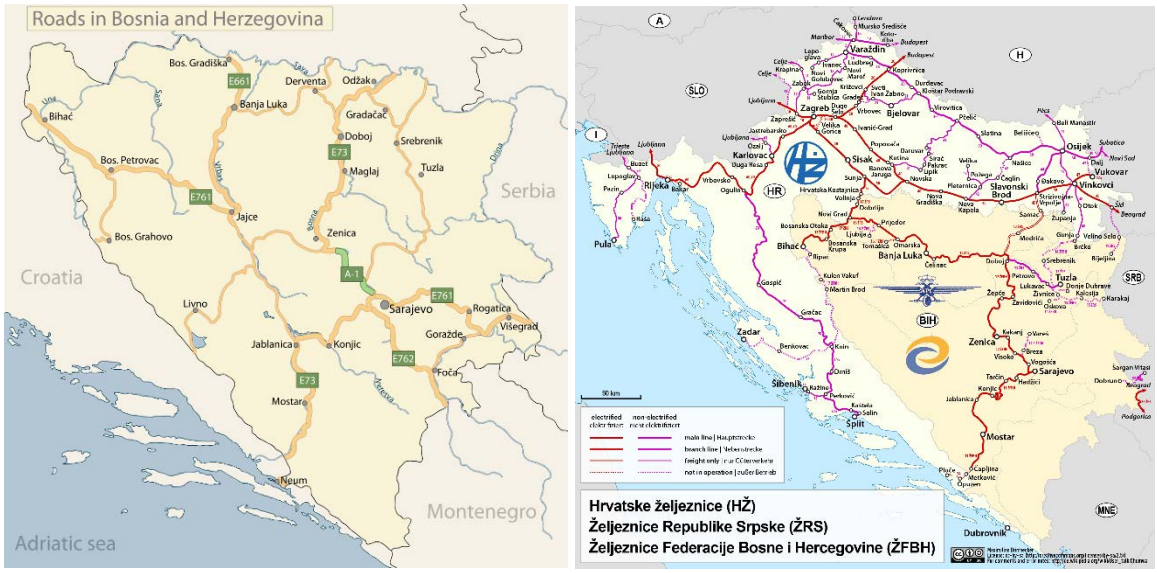

Figure 3 Road and Railway Transportation Network in Bosnia and Herzegovina[5][6]

Figure 4 gives Sankey diagrams as an insight into biomass flows in Bosnia and Herzegovina (top) maximum and minimum scenarios.

General conclusions from the Sankey diagram for Bosnia and Herzegovina (Figure 1.3.4) (quantities below are all expressed in million tons of dry matter) are that the biomass potential in Bosnia and Herzegovina in 2015 was between minimum value of 10.3 tonnes and maximum value of 10.4 million tonnes of dry matter and could in theory, (not considering the lower heating values/net calorific values and conversion related factors and depending on the mobilisation), cover up to 24 per cent of the total primary energy supply of Bosnia and Herzegovina. The 2.0 million tonnes of dry matter currently 'not used' translates to a potential share of 716 to 907 ktoe of the total primary energy supply (when assuming a lower heating value from 15 to 19 GJ/tdm) , which equals a share of 12 to 15 % of the total primary energy supply in BiH. Considering the current share of the total primary energy supply for renewable energy sources is 9.1 % a total share of 21 to 24 % is possible[7].

Percentages presented below have to be considered carefully because unofficial non-registered wood consumption is currently not captured in the monitoring system, especially when referring to the potential for annual forest increment and waste wood. According to the rough estimate it is shown that current monitoring system show the limitations, and need to be improved in aspect of reporting on wood consumption. This results in 'not used' biomass potential of between 89 and 823 ktoe, provides more information on the fuel wood consumption and its recording in general.

[5] *Source: "https://en.wikipedia.org/wiki/Rail_transport_in_Bosnia_and_Herzegovina," [Online]. [Accessed 06 2020].*

[6] *Source: "https://en.wikipedia.org/wiki/Transport_in_Bosnia_and_Herzegovina," [Online]. [Accessed 06 2020].*

[7] *Source: A. Pfeiffer, T. Krause, T. Horschig, M. Avdibegović, H. Ćustović, M. Ljuša, D. Čomoć, A. Mrkobrada , T. Mitschke, S. Mutabdžija Bećitović, M. Ponjavić, A. Karabegović and A. Brosowski, "Biomass Potential Monitoring Bosnia and Heregovina," GIZ, 2019.*

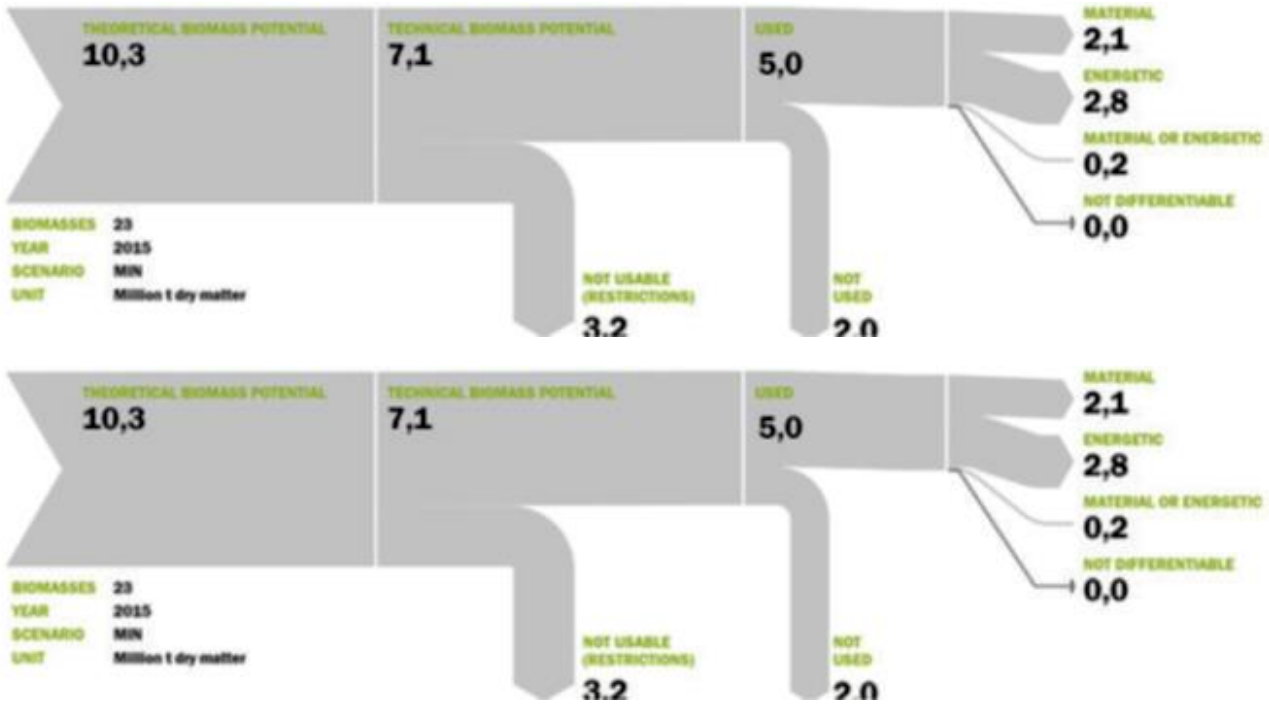

Figure 4 Biomass flows in Bosnia and Herzegovina[8]

Group of the authors in 2017 published research results, related to wood fuels consumption in households in Bosnia and Herzegovina and according to that results show that in 2015, 5.4 million m^3 of firewood, 81,656 tons of wood pellets, and 6,780 tons of wood briquettes were consumed in the households in Bosnia and Herzegovina. Total expenses of households necessary for the supply of wood fuels in Bosnia and Herzegovina in 2015 were 239.8 M€, with the largest share of firewood (226.8 M€), followed by wood pellets (11.6 M€), and wood briquettes (720.9 thousand €). Average firewood consumption per household in Bosnia and Herzegovina is 6.43 m^3. Compared to the surrounding countries it is on the level of Slovenia (6.5 m3 per household), less than in Serbia (7.3 m^3 per household) and more than in Montenegro (5.49 m3 per household)[9].

Regarding to district heating systems and according to present situation, the most significant RES is the wood biomass the use of which in the district heating systems has been growing rapidly in recent years. In the period from 2008 to 2017, seven district heating systems powered by wood chips were constructed[10].

[8] *Source: A. Pfeiffer, T. Krause, T. Horschig, M. Avdibegović, H. Ćustović, M. Ljuša, D. Čomoć, A. Mrkobrada , T. Mitschke, S. Mutabdžija Bećitović, M. Ponjavić, A. Karabegović and A. Brosowski, "Biomass Potential Monitoring Bosnia and Heregovina," GIZ, 2019.*

[9] *Source: B. D. Glavonjić, L. Oblak, D. Čomiić, A. Lazarević and M. Kalem, "Wood fuels consumption in households in Bosnia and Herzegovina," Thermal Science , vol. 21, no. 5, pp. 1881-1892, 2017.*

[10] *Source:" The Study of renewable energy sources with focus on biomass, geothermal energy and solar energy in Bosnia and Herzegovina," UNDP and Italian Ministry of Environment, Land and See Protection, 2019.*

2. Biomass supply: Agriculture

2.1. INTRODUCTION

In this chapter the agricultural biomass production and main uses is described. A distinction will be made between the main economic products produced and their main process chains and residual biomass potentials from primary production and available as by-products of food processing industries. The residual biomass sources, certainly the ones from primary sources are largely not used as already became clear from Section 1.2. In addition to presenting the main biomass production attention will also be paid to the importance and the structure of the agricultural sector and to the main environmental challenges associated with agriculture in Bosnia and Herzegovina.

2.1.1 CHARACTERISATION OF CURRENT AGRICULTURAL SECTOR

Agriculture and the food industry are important branches of the economy of Bosnia and Herzegovina (BiH), its Entities and Brcko District (BD), both in terms of their contribution to the economy and overall employment and socio-economic development.

Out of the total area of Bosnia and Herzegovina, approximately 2.200 million ha is arable land, of which less than 1% is irrigated, 0.7 ha per capita[11]. According to Strategic plan for rural development of Bosnia and Herzegovina 2018-2021, Federation of BiH has 1,181,000 ha, Republic of Srpska 983,000 ha and Brcko Dictrict 36,000. Structure of arable land in Bosnia and Herzegovina is shown in Table 2[12]. There is approximately 0.56 ha of agricultural land per capita, of which 0.36 ha is arable land and vegetable gardens. 45% of agricultural land is hilly (300 to 700 meters above sea level), of moderate quality and suitable for semi-intensive cattle breeding through grazing and fodder production. Mountainous regions (above 700 meters above sea level) represent an additional 35% of farmland. However, high altitude, slopes and aridity limit the use of this land for pastures only to spring and summer months. Less than 20% of agricultural land (half of all arable land) is suitable for intensive agriculture and it is mainly located in lowland areas in the north of the country, in

[11] *Source: Analysis of the Forest Sector in Bosnia and Herzegovina EU funded project "Preparation of IPARD Forest and Fisheries Sector Reviews in Bosnia and Herzegovina"," FAO, 2015*

[12] *Source: "Strategic Plan for Rural Development of Bosnia and Herzegovina (2018-2020) – Framework Document".*

the river valleys. The Hydrological map of BiH is composed of rivers and natural and artificial lakes. With average precipitation of 1.250 mm BiH is one of the water abundant areas of Europe, in particular, southern Europe.

Natural water resources are abundant, with many unpolluted rivers and available groundwater. Despite the abundance of water, water supply is a limiting factor for production in many areas. About 10,000 hectares (0.1 percent of arable land) was irrigated before the war. The area that is now being irrigated is even much less[13].

According to BiH Agency for Statistics, in Bosnia and Herzegovina Gross Added Value (GAV) of agriculture (together with forestry and fishing), has varied over the last period in absolute terms (EUR 0.8-0.9 billion), but generally has been increasing. However, in relative terms it has been decreasing due to the faster growth in the GAV of other, non-agricultural sectors (from 8.1% in 2006 to 6.2% in 2015). At the same time, agriculture is of bigger importance for Republic of Srpska, than for BiH Federation.

In 2015 the share of agricultural and food sector in BiH foreign trade is substantial, with imports having a larger share (EUR 1.4 billion; 18.1%; 2015) than exports (EUR 420 million; 9.4%; 2015). The import to export ratio of agricultural and food products is still very low and was at 29.4% in 2015. Total trade balance in agricultural and food products was negative in 2015 (BAM -2,022.5 million) and accounted for 29.5% of total BiH trade deficit[14].

The share of agriculture in country's GDP is constantly decreasing (11% in 2003 to 7% in 2013)[15]. In Federation of BiH participation of agriculture in FBiH GDP is falling, being 4.6% in 2015, while in Republic of Srpska participation of agriculture in RS GDP is falling, amounting to 9.3% in 2015, and in Brcko District participation in BD BiH GDP has fallen from 14% in 2006, to 10% in 2015. The large share of agriculture in the structure of GDP, the high level of employment and considerable share in the foreign trade deficit are the three main characteristics of agriculture and its importance for BiH economy.

[13] *Source: "Third National Communication and Second Biennial Update Report on Greenhouse Gas Emissions of Bosnia and Herzegovina under the United Nations Framework Convention on Climate Change," UNDP , 2017.*

[14] *Source: "Strategic Plan for Rural Development of Bosnia and Herzegovina (2018-2020) – Framework Document".*

[15] *Source: O. Zurovec, P. O. Vedeld and B. K. Sitaula, "Agricultural Sector of Bosnia and Heryegocina and Climate Change - Challanges and Opportunities," Agriculture , vol. 5, pp. 245-266, 2015.*

Regarding to labour force, it is important to say that the share of agricultural population has decreased 76% in a 40-year period (1948–1981), but 61% still lives in rural areas[16]. It is also important to know that during the war between 1992 and 1995, over half of the pre-war population of the country has been displaced from their homes. The employment in agriculture was at 17.9% at the end of 2015, though the sector accounted for less than 1% of formal registered employment. In BiH, 147 thousand people are working in agricultural production, on a full-time or part-time basis.Long-term trends indicate a decrease in the number of people engaged in agriculture in BiH. However, this decrease is slow and indicates agrarian over-employment compared to the importance and share of this sector in creating social wealth.

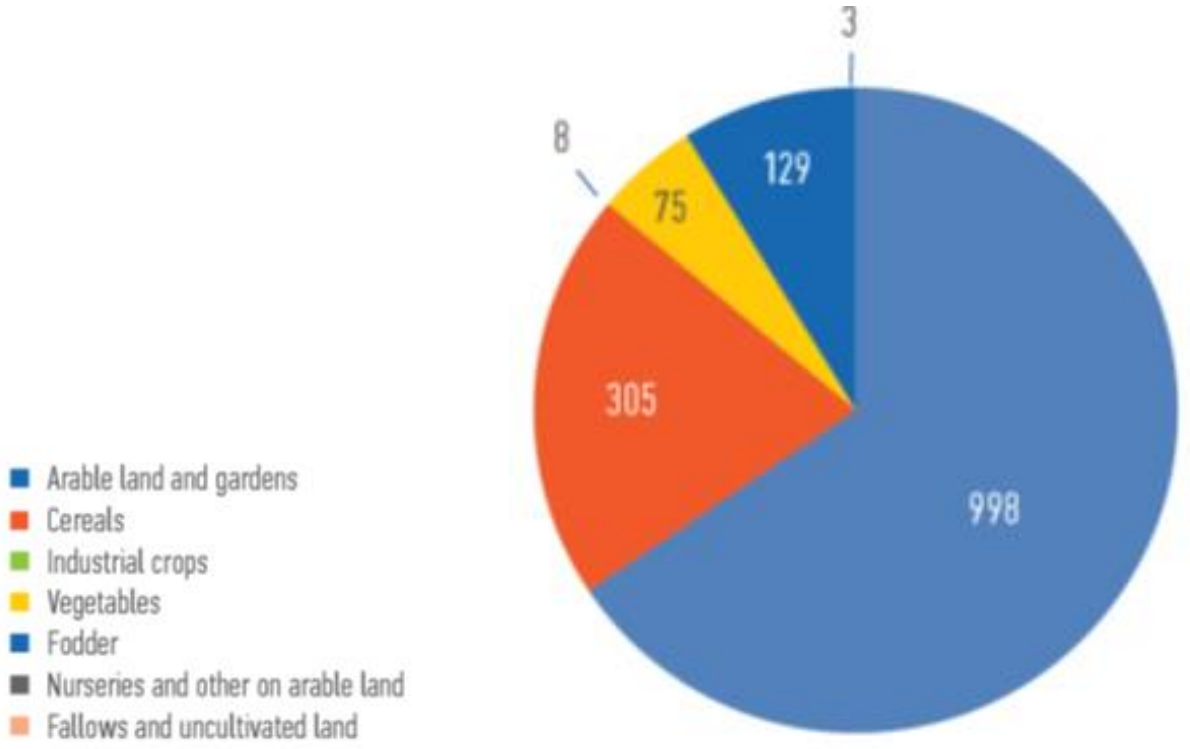

Figure 2 Arable land, by land utilization in thousands ha in 2013[17]

Figure 6 shows land use/land cover situation in Bosnia and Herzegovina in 2002.

[16] *Source: O. Zurovec, P. O. Vedeld and B. K. Sitaula, "Agricultural Sector of Bosnia and Heryegocina and Climate Change - Challanges and Opportunities," Agriculture , vol. 5, pp. 245-266, 2015.*

[17] *Source: "Third National Communication and Second Biennial Update Report on Greenhouse Gas Emissions of Bosnia and Herzegovina under the United Nations Framework Convention on Climate Change," UNDP , 2017.*

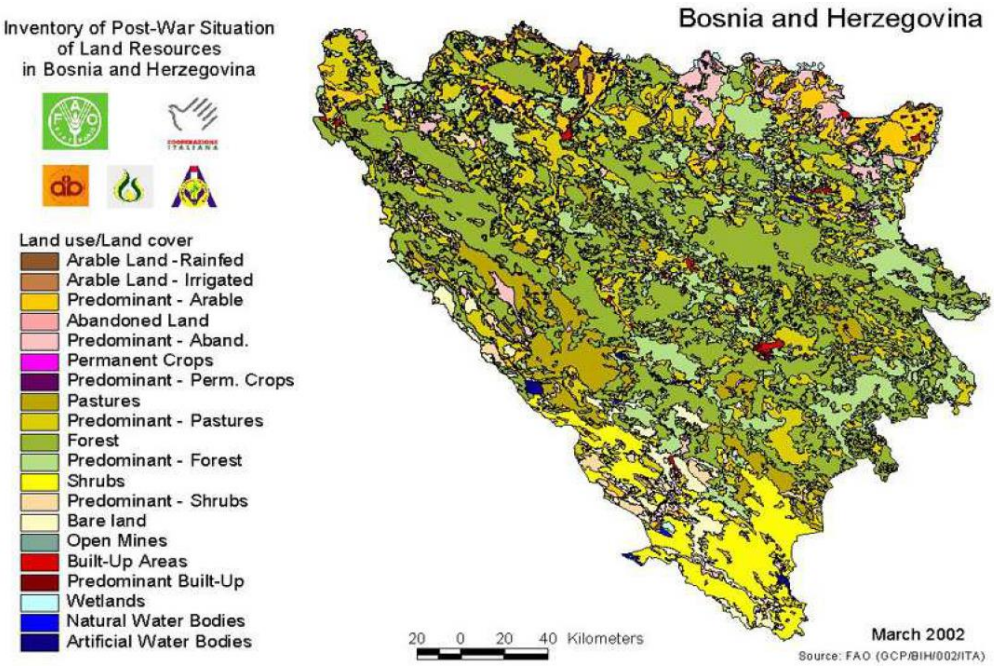

Figure 6 Main crops and land uses in Bosnia and Herzegovina[18].

Structure of arable land is given in Table 2.

Table 2 Structure of arable land (in 1000 hectares) in Bosnia and Herzegovina[19]

Agricultural land		Arable areas (in 1000 ha)						
		Total	Plow land and gardens	Orchards	Vineyards	Meadows	Pastures	Marshes reeds and ponds
BiH	2,200	1,598	1,035	101	5	457	599	3
FBiH	1,181	747	428	45	5	269	432	2
RS	983	816	577	52	0	187	166	1
BD	36	35	30	4	0	1	1	0

Note: BiH – Bosnia and Herzegovina, FBiH – Federation BiH, RS – Republic of Srpska, BD – Brcko District

18 Source: FAO

[19] *Source: "Strategic Plan for Rural Development of Bosnia and Herzegovina (2018-2020) – Framework Document".*

2.1.1.1 CROP PRODUCTION

According to the data available from the 2012 BiH, total area covered by cereal crops was 304,000 ha, by fodder crops – 137,000 ha, by vegetable crops – 78,000 ha, and by industrial crops – 8,000 ha. Total achieved production in 2011 was as follows: 1,077,387 tons of cereals, 771,999 tons of fodder crops, 676,109 tons of vegetable crops, and 10,113 tons of industrial crops.

In Federation BiH, in the period from 2006 – 2015 on average 194,000 ha or 48.6% of total arable land area was planted on, while more than half (205,000 ha) was fallow land. With respect to planting on arable land, the most common crop, on a ten year average for the 2006 – 2015 period, was cereal which with 85 thousand ha makes up 43.6% of total planted area. In Republic of Srpska in the period from 2006 – 2015, 324,000 ha or 55.4% of arable land was used for planting some crops while 44.6% or 261,000 were not used. With regards to arable land use structure in RS, cereals dominated (maize was planted on 2/3 of cereals planted land area), which in ten-year average for the 2006 – 2015 period comes to about two thirds (65.4%) of planted arable land. In Brcko District BiH the most prevalent planted crop is wheat (on average 10 thousand ha).

According to available sources, the major impact on land use is due to some mechanisms, a large scale migration of the population within the country resulting in intensified urbanization which is resulted with the appearance of abandoned land. Secondly, there is a trend of land abandonment following the trend of urbanization that affects the amount and management of forest land. A significant land use change between 1998 and 2006 in terms of agricultural land being transformed to artificial areas, discontinuous urban areas, semi-natural areas, water surface area, and into complex cultivation patterns. In addition, land mine contamination is still a relevant factor for land use change in BiH. In 2008, 3.4 percent of the territory of BiH was reported to be mined, today is 1,97% or 965 km[20].Land areas which are still full of mines face less land utilization and are subject to non-management and re-wilding as well.

Table 3 shows comparative overview of average yields in BiH Entities, neighbouring countries and the EU (2006-2014 average). Generally for the almost all crops, this is related to soil degradation and poor fertility, mainly because of less favourable physical and chemical properties[21].

[20] *Source: "http://www.bhmac.org/?page_id=747&lang=en," [Online]. [Accessed 06 2020].*

[21] *Source: W. L. filho, G. Trbić and D. Filipović, Climate Change Adaptation in Eastern Eutope: Managing Risks and Building Resilience to Climate Change, Springer , 2019.*

Table 3 Comparative overview of average yields in Bosnia and Herzegovina's entities, neighbouring countries and EU (2006-2014 average [22]

Product	Unit of measurement	Federation of Boania and Herzegovina	Republic of Srpska	Serbia	Croatia	EU
Maze	t/ha	4.7	4.8	5.2	8.1	6.9
Wheat	t/ha	3.6	3.4	3.8	4.8	5.3
Oat	t/ha	2.6	2.5	2.2	2.8	2.9
Barlay	t/ha	2.8	3.3	3.3	3.9	4.4
Rye	t/ha	3.3	2.6	2.4	2.7	3.4
Soya	t/ha	2.1	1.8	2.6	2.5	2.7
Tobacco	t/ha	0.9	1.6	1.6	2.0	2.3
Oilseed rape	t/ha	2.2	2.3	2.5	2.7	3.1
Sunflower	t/ha	0.9	0.9	2.3	2.8	1.8
Potato	t/ha	9.6	10.7	11.4	16.4	29.9
Beans	t/ha	1.3	1.4	1.6	1.2	1,6
Cabbage and kale	t/ha	13.2	13.7	18.5	21.4	30.0
Tomato	t/ha	11.3	10.9	11.5	32.3	57.4

2.1.1.2 LIVESTOCK PRODUCTION

Taking into account the availability of natural resources and the number of farmers engaged in cattle breeding, this production is of great importance for BiH agriculture, especially in the Federation BiH. The dominant portion of meadows and pastures in the BiH Federation (60.6%, 2006-2015 average), and the significant share in Republic of Srpska (35.1%, 2006-2015 average) in the agricultural areas is a resource which makes a solid basis for its further development. When analysing the production of livestock products, the starting point is the number of livestock by type and category, which is shown in Table 4.

Table 4 Number of livestock units in Bosnia and Herzegovina, Federation BiH and Republic of Srpska, 2015 (in 000 heads)[23]

	Catle		Pigs		Sheep			Horses			
	Total	Dairy cows	Total	Sows/ gilts	Total	Breeding ewes	Goats	Total	Mares/ filies	Poultry	Hives
BiH	455	247	564	77	1,001	592	72	17	6	22,248	393
FBiH	216	136	89	9	525	404	42	6	1	9,818	229
RS	229	108	452	61	486	272	30	11	5	11,011	164
BD	7.0	1.9	`19.4	2.1	7.2	4.6	0.9	0.03		1,004	9.9

[22] *Source: "Strategic Plan for Rural Development of Bosnia and Herzegovina (2018-2020) – Framework Document"*

[23] *Source: "Strategic Plan for Rural Development of Bosnia and Herzegovina (2018-2020) – Framework Document"*

2.2. BIOMASS POTENTIALS FROM AGRICULTURAL RESIDUES AND UNUSED LANDS

According to methodology developed for biomass potential estimation in Bosnia and Herzegovina, authors used terms theoretical and technical potential and gave formulae for potential calculation for each type of biomass. According to available data and findings of project "Biomass Potential Monitoring Bosnia and Herzegovina" (2019) theoretical potential of primary biomass residues is presented in Table 5.

Detailed explanation of the methodology as well as interpretations of the terms "theoretical" and "technical" for each biomass source is presented in above mentioned document. Some short explanations are given below the tables in this sub-chapter. Data are given for the state level and for the level of entities (Federation BiH, Republic of Srspka and Brcko District).

Table 5 Theoretical potential of primary agricultural residues (ton dry mass, average value) in Bosnia and Herzegovina[24]

	Federation BiH	Republic of Srpska	Brcko District	Bosna and Herzegovina
Cereal straw	80,180	178,365	5,536	204,107
Maze straw	133,166	422,826	15,074	571.079
Corn cobs	26.633	84.575	3,009	114.218

Note: The theoretical potential is the mathematical product of the grain production, straw-to-grain/corn-to-cob ratio, the dry matter content and the bandwidth.

Technical potential of primary biomass residues is presented in Table 6. Data are given for the state level and for the level of entities (Federation BiH, Republic of Srspka and Brcko District).

Table 6 Technical potential of primary agricultural residues in Bosnia and Herzegovina (ton dry mass, average value) in Bosnia and Herzegovina [25]

	Federation BiH	Republic of Srpska	Brcko District	Bosna and Herzegovina
Cereal straw	16.036	35.673	1.113	52.821
Maize straw (stover)	26.633	84.575	3.009	114.218

Theoretical potential of pruning residues is presented in Table 7. Data are given for the state level and for the level of entities (Federation BiH, Republic of Srspka and Brcko District).

[24] *Source: http://atlasbm.bhas.gov.ba/," [Online]. [Accessed 06 2020].*

[25] *Source: http://atlasbm.bhas.gov.ba/," [Online]. [Accessed 06 2020].*

Table 7 Theoretical potential of pruning residues in Bosnia and Herzegovina (ton dry mass, average value)[26]

	Federation BiH	Republic of Srpska	Brcko District	Bosna and Herzegovina
Pruning residues from raspberries	7.676	3.770	4	11.449
Pruning residues from orchards	17.241	13.043	1.115	31.399
Pruning residues from vineyards	4.950	456	0	5.407

Note: The theoretical potential for pruning residues for orchards, vineyards and raspberries is the mathematical product of the orchard/vineyard/raspberry plantation area and pruning yield per hectare. If the orchard/vineyard/ raspberry plantation area is not readily available (which it should be in the case of Bosnia and Herzegovina) then it can be calculated using information on the total number of plants per plantation and plants per hectare. Hence, this is indicated in the calculation flowcharts[27].

Technical potential of pruning residues is presented in Table 8. Data are given for the state level and for the level of entities (Federation BiH, Republic of Srspka and Brcko District).[28]

Table 8 Technical potential of pruning residues in Bosnia and Herzegovina (ton dry mass, average value)[29]

	Federation BiH	Republic of Srpska	Brcko District	Bosna and Herzegovina
Pruning residues from raspberries	6.141	3.016	3	9.159
Pruning residues from orchards	13.793	10.434	892	23.119
Pruning residues from vineyards	3.960	365	0	4.325

Theoretical potential of manure from livestock production is presented in Table 9. Data are given for the state level and for the level of entities (Federation BiH, Republic of Srspka and Brcko District).

[26] *Source: http://atlasbm.bhas.gov.ba/," [Online]. [Accessed 06 2020].*

[27] *Source: A. Pfeiffer, T. Krause, T. Horschig, M. Avdibegović, H. Ćustović, M. Ljuša, D. Čomoć, A. Mrkobrada , T. Mitschke, S. Mutabdžija Bećitović, M. Ponjavić, A. Karabegović and A. Brosowski, "Biomass Potential Monitoring Bosnia and Heregovina," GIZ, 2019.*

[28] *Source: http://atlasbm.bhas.gov.ba/," [Online]. [Accessed 06 2020].*

[29] *Source: http://atlasbm.bhas.gov.ba/," [Online]. [Accessed 06 2020].*

Table 9 Theoretical potential of of manure from livestock production in Bosnia and Herzegovina (ton dry mass, average value)[30]

	Federation BiH	Republic of Srpska	Brcko District	Bosna and Herzegovina
Cattle manure	500.142	588.337	22.485	948.535
Pig manure	306.601	489.715	33.705	162.428
Poultry manure	362.875	431.708	29.676	667.593
Sheep manure	83.388	70.538	2.740	156.666
Goat manure	15.016	5.734	82	20.832

Note: The theoretical potential was the mathematical product of the livestock numbers, specific excretion rate per animal and the dry matter content. Livestock numbers were listed in the official statistical yearbooks in both entities.

Technical potential of manure from livestock production is presented in Table 10. Data are given for the state level and for the level of entities (Federation BiH, Republic of Srspka and Brcko District).

Table 10 Technical potential of of manure from livestock production in Bosnia and Herzegovina (ton dry mass, average value)[31]

	Federation BiH	Republic of Srpska	Brcko District	Bosna and Herzegovina
Cattle manure	9.021	16.192	2.587	27.800
Pig manure	10.513	32.731	5.590	21.034
Poultry manure	12.002	69.583	26.509	108.193
Sheep manure	0	0	0	0
Goat manure	0	0	0	0

Theoretical potential of slurry from livestock production is presented in Table 11. Data are given for the state level and for the level of entities (Federation BiH, Republic of Srspka and Brcko District).

Table 11 Theoretical potential of slurry from livestock production in Bosnia and Herzegovina (ton dry mass, average value)[32]

	Federation BiH	Republic of Srpska	Brcko District	Bosna and Herzegovina
Cattle slurry	352.026	342.051	11.688	705.766
Pig slurry	18.478	87.598	4.613	110.689

Note: The theoretical potential was the mathematical product of the livestock numbers, specific excretion rate per animal and the dry matter content. Livestock numbers were listed in the official statistical yearbooks in both entities.

[30] *Source: http://atlasbm.bhas.gov.ba/," [Online]. [Accessed 06 2020].*
[31] *Source: http://atlasbm.bhas.gov.ba/," [Online]. [Accessed 06 2020].*
[32] *Source: http://atlasbm.bhas.gov.ba/," [Online]. [Accessed 06 2020].*

Technical potential of slurry from livestock production is presented in Table 12. Data are given for the state level and for the level of entities (Federation BiH, Republic of Srspka and Brcko District).

Table 12 Technical potential of slurry from livestock production in Bosnia and Herzegovina (ton dry mass, average value)[33]

	Federation BiH	Republic of Srpska	Brcko District	Bosna and Herzegovina
Cattle slurry	6.713	12.045	1.924	20.683
Pig slurry	1.017	11.271	2.046	14.334

Note: The technical potential was the mathematical product of theoretical potential, animals in farms with the minimum requirement (in percent) and 1- fee range husbandry (in percent).

An estimate of the technical biomass potential to be used for heat or CHP generation in the wood processing and agricultural sectors is shown in Table 13.

Table 13 Estimated technical biomass primary energy potential wood processing and agricultural sectors in BiH in 2014[34]

Biomass type	Technical potential (PJ)	Technical potential (GWh)
Woody biomass	7.44	2066.7
Field crop residues	4.69	1302.8
Livestock residues	1.62	450.0
TOTAL	13.75	3819.5

Box 2.2: Methodology of Pfeiffer, et al., 2019 to calculate the crop residues potentials.

According to this methodology agricultural biomass can be placed in two sub-categories: livestock based and plant based biomass. The following livestock based biomasses were considered for the purposes of the study made by Pfeiffer, et al., 2019: 1) cattle slurry, 2) pig slurry, 3) cattle manure, 4) pig manure, 5) poultry manure, 6) sheep manure and 7) goat manure.

*theoretical potential [tDM] = (number of cows and heifers [-] * specific excretion rate [tFM] + number of other cattle [-] * specific excretion rate [tFM]) * dry matter content [%] / 100*

*technical potential [tDM] = theoretical potential [tFM] * animals in farms with the minimum requirement [%] / 100 * (1 - pasture grazing [%] / 100)*

*theoretical potential [tDM] = (number of sows [-] * specific excretion rate [tFM] + number of other pigs [-] * specific excretion rate [tFM]) * dry matter content [%] / 100*

[33] *Source: http://atlasbm.bhas.gov.ba/," [Online]. [Accessed 06 2020].*

[34] *"Source: Investing in energy sector EIA-USAID Project," USAID, 2016.*

*technical potential [tDM] = theoretical potential [tFM] * animals in farms with the minimum requirement [%] / 100 * (1 - free range husbandry [%] / 100)*

*theoretical potential [tDM] = number of poultry [-] * specific excretion rate [tFM] * dry matter content [%] / 100*

*technical potential [tDM] = theoretical potential [tFM] * animals in farms with the minimum requirement [%] / 100 * (1 - free range husbandry [%] / 100)*

*theoretical potential [tDM] = (number of ewes for breeding [-] * specific excretion rate [tFM] + number of other sheep [-] * specific excretion rate [tFM]) * dry matter content [%] / 100*

*technical potential [tDM] = theoretical potential [tFM] * (1 - fertilisation [%] / 100)*

*theoretical potential [tDM] = number of goats [-] * specific excretion rate [tFM] * dry matter content [%] / 100*

*technical potential [tDM] = theoretical potential [tFM] * (1 - fertilisation [%] / 100*

The sub-category plant based biomass consists of 1) cereal straw, 2) maize straw, 3) corncob and pruning residues, which are subdivided into 4) orchard, 5) vineyard and 6) raspberry.

theoretical potential [tDM] = (wheat production [tFM] * straw-to-grain ratio [-] + rye production [tFM] * straw-to-grain ratio [-] + barley production [tFM] * straw-to-grain ratio [-] + oat production [tFM] * straw-to-grain ratio [-]) * dry matter content [%] / 100 * bandwidth [%] / 100

technical potential [tDM] = theoretical potential [tDM] * unused material [%] / 100

theoretical potential [tDM] = maize production [tFM] * straw-to-grain ratio [-] * dry matter content [%] / 100 * bandwidth [%] / 100

technical potential [tDM] = theoretical potential [tDM] * unused material [%] / 100

theoretical potential [tDM] = technical potential [tDM] = maize production [tFM] * corn-to-cob ratio [-] * dry matter content [%] / 100 * bandwidth [%] / 100

theoretical potential [tDM] = vineyard area [ha] * pruning yield [tDM/ha]

technical potential [tDM] = theoretical potential [tDM] * technical recovery rate [%] / 100

theoretical potential [tDM] = (orchard area apple [ha] + orchard area plum [ha] + orchard area pear [ha] + orchard area cherry [ha] + orchard area

sour cherry [ha] + orchard area apricot [ha] + orchard area quince [ha] + orchard area peach [ha] + orchard area walnut [ha]) * pruning yield for all fruits [tDM/ha]

technical potential [tDM] = theoretical potential [tDM] * technical recovery rate [%] / 100

theoretical potential [tDM] = raspberry plantation area [ha] * pruning yield [tDM/ha]

technical potential [tDM] = theoretical potential [tDM] * technical recovery rate [%] / 100

2.3. DEDICATED CROP POTENTIALS FROM UNUSED/ABANDONED LANDS

There is no official or exact data on abandoned or unused agricultural land areas in Bosnia and Herzegovina. One of the most relevant data sources is the Coordination of Information on the Environment (CORINE)39 land cover database.

The war and post-war developments have strongly affected the land use pattern in Bosnia and Herzegovina. The war 1992-1995 caused the displacement of more than half of the pre-war population of Bosnia and Herzegovina from their homes. In many cases rural populations did not return to their pre-war settlements, and many villages remain abandoned (due to several reasons, security at the beginning, but after that lack of infrastructure, which was destroyed durung the war, and lack of jobs). The large-scale migration of the population within the country also resulted in intensified urbanisation and transformation of the traditional and cultural land use. More importantly for forests, the trend of abandoning land followed the trend of urbanisation and this has had a combined effect on the amount and management of forestland.

The trend of land abandonment began in the 1960s and found its peak during the war (1992–1995). Consequently, land previously used for agriculture (pastures, orchards, ploughed fields etc.) has now naturally reforested and turned into unmanaged forests of pioneer species and/or shrubs and former managed coppice forests (mainly small-scale and largely fragmented) are no longer cared for. This has resulted in an increase in wood biomass but a decline in active forest management and the production of quality timber. This shift toward lower value forest types of primary successions has severe implications for the economic potential and value creation of forestland. Yet these 'new forests', either unmanaged coppice or associations of pioneer species on what was formerly agriculture land, have significant potential as a source of wood biomass.

Some estimations of biomass potential related to dedicated crops from unused lands, in the last period were made by S2Biom H2020 project, these estimations show significant potential of 7621.78 Kton of dry matter. More detailed results are presented in Table 14.

Table 14 Biomass potentials from dedicated crops from unused lands 2020 in Kton d.m. (=S2BIOM base potential)[35]

	Mischantus	Switchgrass	Perrenial grasses	Total
Bosnia and Herzregovina	2188.95	1622.02	3810.81	7621.78

In the scope of Energy Community project under the title " SYNENERGY – Biomass in Bosnia and Herzegovina, Action 1: Renewable Energy Assessment" in 2010 some estimations regarding to potential for energy crops were done. In theory, potential is large. It is also highly dependent on which crops are deemed to be most likely to be grown, what type of

[35] *Source: "S2Biom H2020 Project data base"*

land is converted to their cultivation, and the areas of land used. The estimations were based on two reasonably scenarios[36]:

A. 10% of land currently used for grazing/pasture plus 5% of fallow land are used to grow perennial grasses, and

B. 10% of land currently used for grazing/pasture plus 25% of fallow land are used to grow perennial grasses.

Total available land is 95.791 ha and 147.118 ha under scenarios A and B, respectively. 72% of the available land is found in the Federation of Bosnia and Herzegovina. Table 15 shows results of the estimations according to presented scenarios for perennial grasses and short rotation coppice.

Table 15 Energy crops potential for biofuels[37]

Crop	End use	Energu potential (Pj)	
		Scenario A	Scenario B
Perennial grasses	2nd gen bioethanol	7,76	11,92
	Heat and electricity	15,33	21,54
Short rotation coppice	2nd gen bioethanol	6,21	9.53
	Heat abd llectricity	12,26	18,83

2.4. SECONDARY AGRICULTURAL RESIDUES FROM PROCESSING INDUSTRIES

Residues from food processing industries, represent an excellent opportunity to improve energy efficiency and economic viability, which can make these industries more competitive on the market. Unfortunately, in Bosnia and Herzegovina, there are not too many examples of food processing residual uses. Not even for energy generation purposes. There are some reasons for that, as lack of knowledge, and initial financial sources to invest in such applications are scarce.

In Table 16, an overview is given of secondary residual biomass sources from the wine, olive oil and cereal processing industries (how these potential estimates were assessed is explained in Box 2.3.)

[36] *Source: "SYNENERGY – Biomass in Bosnia and Herzegovina, Action 1: Renewable Energy Assessment, USAID HELLENIC AID ENERGY COOPERATION," CRES Greece, 2010.*

[37] *Source: "SYNENERGY – Biomass in Bosnia and Herzegovina, Action 1: Renewable Energy Assessment, USAID HELLENIC AID ENERGY COOPERATION," CRES Greece, 2010.*

Some of food processing companies, which already use their own residues for energy purposes, are:

"Bimal Group" Brcko - is a leading company in Oilseeds, Grains, and Edible Oils (http://bimal-group.com/en/),

"Prijedorcanka AD" Prijedor - produces high quality fruit distillates and brandy, concentrated fruit and vegetable juices, aseptic pasta, frozen and dried fruits, vegetables and forest fruits (http://prijedorcanka.com/en/home-2/#o-nama).

Box 2.3: Methodology of S2BIOM to calculate the secondary residue potentials from food processing

All the secondary agricultural residues presented refer to residues of crops that are mostly grown and processed in the same country. Their assessment can therefore be based on production information (area and/or yield information) derived from national agricultural statistics.

For further details on the whole assessment of biomass potentials in S2BOM consult Dees et al (2017) and a summary is given in Annex 2.

Table 16 Biomass potentials from agro-food processing industries 2020 in Ton d.m. (=S2BIOM base potential (see also Annex 2)[38]

	Olive stones	Cereal bran	Total
Bosnia and Herzegovina	75,432	146`	75,578

[38] *Source: "S2Biom H2020 Project data base"*

2.5. COST OF MAIN BIOMASS SOURCE

Since for most agricultural residues no commodity market has developed yet it is very difficult to provide figures on prices. Instead cost estimates can be presented building on the S2BOM methodology and assessment. The cost refers to Roadside cost and these cover all biomass production collection and pre-treatment cost up to the road where the biomass is located. The roadside cost are only a fraction of the total 'at-gate-cost.' The road side costs are presented in Table 17 below; for further details on the cost calculation in S2BOM see Annex 2.

Table 17 Road side cost levels (€/ton d.m.) for agricultural biomass sources based on S2BIOM cost calculations[39]

Road side cost for agricultural biomass	**Average (€ ton** dm)
	(2020 cost level)
Maize stover	21
Residues from vineyards	290
Residues from fruit tree plantations (apples, pears and soft fruit)	131
SRC unused lands	64
Dedicated crops on unused lands	64

According to World Bank Study findings, the production cost of biomass for heating in the Western Balkans is in the range of EUR 9.2–27.4 per MWh, for transport distances up to 50 km. This reveals that biomass is relatively cheaper compared to traditional fuels, whose cost is in the range of EUR 10.4–131.7 per MWh[40]. Figure 7 shows structure of production costs of biomass for heating with transport less than 50 km.

Also some findings from Western Balkans (Serbia as an example) shows that The price of transport of straw bales at distance of 85 km, with one ship and one barge cost around 38 EUR/t (price is 15,000 EUR, carrying 393 tons of straw bales), while transport with truck costs around 90 EUR/t. In this example, the cost of waterway transport is 60% lower compared to the cost of truck transport[41].

[39] *Source: "S2Biom H2020 Project data base"*

[40] *Source: "Biomass-Based Heating in the Western Balkans – A Roadmap for Sustainable Development, International Bank for Reconstruction and Development," The World Bank, 2017.*

[41] *Source: "Sector Study on Biomass-Based Heating in the Western Balkans," WBIF, 2017.*

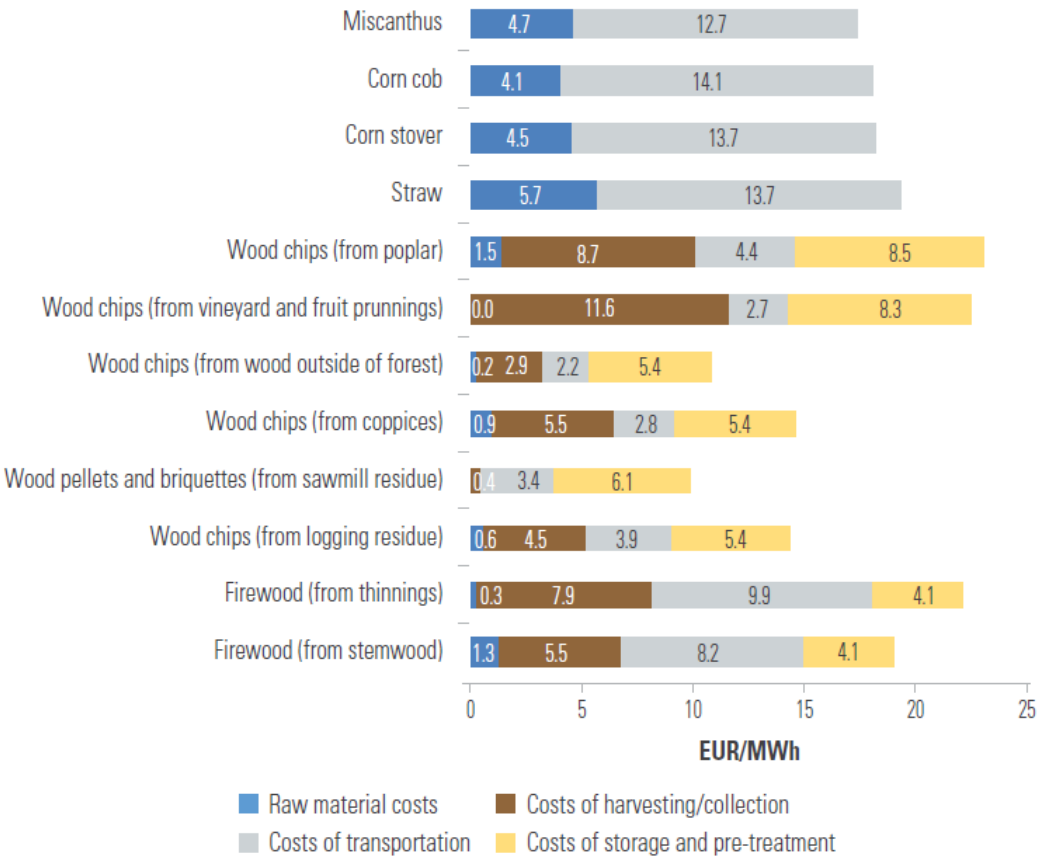

Figure 7 Structure of Production Costs of Biomass for Heating in BiH, with Transport <50 km[42]

2.6. SUMMARY AND CONCLUSIONS IN RELATION TO SWOT ELEMENTS

The percentage of people living in rural area is around 61%, which is well above the EU average of 18.9 %. Despite this fact, agriculture in Bosnia and Herzegovina is behind the EU average in terms of structural changes. The agriculture sector covers about 4-5 % of Bosnia and Herzegovina's GDP, but it is difficult to say precisely because this share decreasing every year. Farms in Bosnia and Herzegovina are on average still very small, dispersed and not specialized. Crop production is below the EU average because quality of soil, lack of irrigation, and adequate technical measures. Taking into account the availability of natural resources and the number of farmers engaged in cattle breeding, Different agro-climate zones, allows diversity in agricultural production. The potential for residual biomass that can be sustainably removed is significant, but tis potential is mainly untapped. In Bosnia and Herzegovina substantial areas of uncultivated land exists, which gives the possibility for production of fast growing perennial biomass crops. Unfortunately, abandoned arable land

[42] *Source: "Biomass-Based Heating in the Western Balkans – A Roadmap for Sustainable Development, International Bank for Reconstruction and Development," The World Bank, 2017.*

are still increasing. Livestock manure biomass potential is significant due to a relatively well developed livestock production, but only several biogas plants exists. The food processing industry is generally well-adapted, but weak spots of food residue processing exists in almost all industries from this branch.

Table 18 SWOT factors regarding biomass feedstock

Strengths	Weaknesses
Different agro-climate zones, facilitating diverse agricultural production	Low level of average yields in most agriculture sectors comparing to EU average
Available water resources for irrigation in many areas of BiH	Low level of usage of agricultural waste for energy purposes
Substantial areas of uncultivated land	Agriculture in general is not very attractive to younger generations, and has a poor image as a line of business
Substantial grassland areas suitable for expansion of livestock production	Insufficient utilization of natural resources (agriculture, tourism, entrepreneurship aspects)
Existence of tradition in different branches agriculture	Inefficiency of the system of management of land, forest and water resources
R&D and consulting capacities exists	Frequent damages on crops and plantations as a consequence of natural disasters (droughts, floods, hail, frost)
Educational institutions on different levels exist	Disorganized land registries and cadastres
Improved assortment in plant production and breed composition in animal production	Pronounced fragmentation of land property
Pronounced trend of increase in the number of registered farms	Low share of irrigated area in the total arable areas
Enhancement of competitiveness in some sectors of agriculture (wine, berries, fish, vegetables)	Low level of specialization and marketability of production
Favorable environmental conditions for development of rural tourism	Low yields lagging behind surrounding countries and EU averages
	Low added value of most agricultural products
	Poor technical and technological equipment level of a large number of farms
	Instability and market prices oscillations most of agricultural sectors
	Low redemption prices

	Low productivity in all sectors of agricultural production Insufficient production of local seed and planting material Low level of organization and needed post-harvest/picking infrastructure Low level of farmers' knowledge about technologies, marketing and management
Opportunities Promoting access to specialized advisory services Use of agricultural residues, concentrated in the north and northeast part of Bosnia and Herzegovina, along the Sava River The potential for growing biomass crops on currently unused/abandoned lands is large Increasing demand for sustainably produced local products of higher quality and products from above standard breeding Natural predispositions for development of bio-refinery concept Promotion of organic farming Development and promotion of more niche market, higher value agriculture products Transfer of knowledge and technologies in agricultural production Technical and technological modernization of agricultural production possible	Threats Too slow restructuring due to lack of own resources to co-finance investments Lack of interest in taking over the farm and continuing farming in the younger generations High dependence of agricultural producers on direct budgetary support; Increased share of abandoned arable land Undeveloped land market Outstanding issue of land restitution Negative trends in livestock numbers and size of sawn plowed land Further property fragmentation Natural disasters Plant diseases and pests.

3. Biomass supply: Forestry

3.1. INTRODUCTION

Bosnia and Herzegovina has particularly rich biodiversity due to its location in distinct geological and climatic regions: the Mediterranean region, on the south and continental region on the north. BiH is one of the countries with the greatest diversity of species of plants and animals in Europe. Flora in Bosnia and Herzegovina accounts for about 4,500 species of high plants, 600 moss taxa and about 80 ferns. Currently in BiH there are around 250 forest tree species and bushes. Over 200 fauna species are living in the forest. As much as 30% of the total endemic flora in the Balkans (1,800 species) is contained within the flora of Bosnia and Herzegovina[43].

Fauna inventories indicate richness and diversity, particularly in comparison to other countries in the Balkans and in Europe, but this rich biodiversity is endangered. It is important to emphasize that only about 1% of the BiH territory is protected (three national parks and two wildlife parks), which is a devastating fact considering the richness of biodiversity and natural resource potential that is also coming increasingly under threat of processes like intensification in agriculture and forestry and urbanisation. Given the size of the country and the number of registered geological rarities, Bosnia and Herzegovina is one of the countries with the greatest diversity, both in Europe and in the world.[44]

The latest data from the second National Forest Inventory in Bosnia and Herzegovina (2006–2009) shows a total figure of 3,231 million ha of forest and other woodland out of which 1,652 million ha are high forests and 1,252 million ha are coppice forest. The rest is characterised as 'other wooded land' that comprises of shrub, barren forestland and other forest areas. In total, these new figures imply that around 63 % of the total territory of Bosnia and Herzegovina is covered with forest and other woodland, which is one of the highest values in Europe[45].

Compared to the first National Forest Inventory that dates back to the 1960s, which reported a total forest and other wooded land area at a magnitude of 2,734 million ha, it is clear that a significant increase in the forest area has occurred in all categories. The main reason for this is the factual increase in forest area resulting from natural reforestation mainly on abandoned private agriculture land, particularly in rural areas, which is related with population migration and other factors mentioned in chapters before. The war and post-war developments have strongly affected the land use pattern in Bosnia and Herzegovina. These changes have resulted into a significant increase in the share of private forests. Example of private forests in Republic of Srpska shows that according the Cadastre for 2015, for example, private forests cover 300,328.63 ha and yet according to data from the second

[43] *Source: "Third National Communication and Second Biennial Update Report on Greenhouse Gas Emissions of Bosnia and Herzegovina under the United Nations Framework Convention on Climate Change," UNDP , 2017.*

[44] *Source: "Third National Communication and Second Biennial Update Report on Greenhouse Gas Emissions of Bosnia and Herzegovina under the United Nations Framework Convention on Climate Change," UNDP , 2017.*

[45] *Source: A. Pfeiffer, T. Krause, T. Horschig, M. Avdibegović, H. Ćustović, M. Ljuša, D. Čomoć, A. Mrkobrada , T. Mitschke, S. Mutabdžija Bećitović, M. Ponjavić, A. Karabegović and A. Brosowski, "Biomass Potential Monitoring Bosnia and Heregovina," GIZ, 2019.*

National Forest Inventory private forests in Republic of Srpska cover 501,600 ha and therefore 201,271.37 ha more than the documented area of private forests.

Forests and forest land occupy a surface area of approximately 27,100 km², or about 53% of the territory of BiH: about 23,000 km² of this land is comprised of forests and about 4,000 km² is forest land. The annual increment in the forests is relatively low, because so-called economic forests (forests that can be managed on an economic basis) cover only about 13,000 km² (approximately 25% of the BiH territory), and even these forests have low timber reserves (as low as 216 m3/ha with an incremental increase of timber of almost 5.5 m³/ha from half of the potential of the habitat). There are about 9,000 km² (approximately 17%) of low and degraded forests with a very low incremental increase (approximately 1 m3/ha) and with no economic value from the timber production perspective. Based on this increment, about 7,000,000 m³ per year was cut in BiH before the war and this potential should be the basis for the strategic development of the wood-processing industry. Legal and institutional framework governing forestry is structured through the two Entities.

Total production of forest assortments in Bosnia and Herzegovina in the fourth quarter of 2012 increased by 3.04% compared to the same period of 2011. Production of coniferous (softwood) assortments recorded a slight increase of 11.75%, while production of broadleaf (hardwood) assortments in the same period recorded a significant decrease of 3.83%. The production increase is recorded in category of coniferous logs by 9.30 %, while production of broadleaf logs recorded a drop of 4.74%. The drop in production of 2.84% is recorded with broadleaf firewood in relation to the fourth quarter of 2011. The largest increase in production is in the coniferous cordwood of 32.40%. The biggest drop was recorded in the production of other coniferous long wood of 36.23% and other rough-cut wood of 92.42%.

Table 19 summarizes the main characteristics of Bosnia and Herzegovina forests.

Table 19 Bosnia and Herzegovina forests in numbers, 2017[46]

Forrest area	3,231,500 ha
Growing stock (public owned)	334,440,000 m3 or 228 m3/ha
Growing stock (private owned)	100,380,000 m3 or 143 m3/ha
Annual increment	>11,000,000 m3
Harvesting	5,700,000 m3
Length of forest roads (Republic of Srpska)	6 732 km
Length of forest roads (Federation BiH)	10 499 km

The forest resource is poorly served in terms of road infrastructure (World Bank, 2012). In 2012, the total length of forest roads in the FBiH, without data from Hercegovačko-Neretvanski Canton, was 10,499 km (FBiH Ministry of Agriculture, Water Management and Forestry, 2013). In 2012, total length of roads in public forests in Republika Srpska was 9,825 km of which ,732 km were forest roads and 3,093 were public roads (Institute for Statistics of RS, 2013)[47].

[46] *Source: "Analysis of the Forest Sector in Bosnia and Herzegovina EU funded project "Preparation of IPARD Forest and Fisheries Sector Reviews in Bosnia and Herzegovina"," FAO, 2015.*

[47] *Source: "Analysis of the Forest Sector in Bosnia and Herzegovina EU funded project "Preparation of IPARD Forest and Fisheries Sector Reviews in Bosnia and Herzegovina"," FAO, 2015.*

The average road density in different cantons in the FBiH varies between 7 and 14 m per ha (FBiH Ministry of Agriculture, Water Management and Forestry, 2013). In total, average road density in the FBiH is 10.9 m per ha (FBiH Ministry of Agriculture, Water Management and Forestry, 2013) and 9.05 m per ha in RS (World Bank, 2012). Therefore, average road density in BiH is 9.97 m per ha. These densities are significantly below other European countries with broadly similar topography (Austria 36 m per ha, Switzerland 40 m per ha, France 26m per ha, Germany 35 m per ha) but somewhat better than Romania (6.5m per ha) (World Bank, 2012). A study undertaken as part of the Forest Programme (FP) preparation in the FBiH called for a minimum density of 15 m per ha (Sokolović et al 2011 cited in World Bank, 2012)[48].

Main performance indicators of the wood processing industry in 2011 are presented in Table 20.

Table 20. Main performance indicators of the wood processing industry[49]

	Sales (in million EURO)	Percent share	Exports (in million EURO)	Percent share	Employment	Percent share
Sawmill products	236.7	6.6	142.1	3.3		
Veneer	47.0	1.3	12.9	0.3		
Joinery	24.7	0.7	24.9	0.6		
Other wood products	29.2	0.8	7.9	0.2		
Furniture	172.6	4.8	178.5	4.1	7,942	5.9
Prefabricated houses	0.8	0.1		0.3		
Total Wood Processing Industry	514.3	14.3	15.0	8.9	7,942	5.9
Total Manufacturing Industry	3,597.5	100	4,323.3	100	133,707	100

Currently about 2.5 million m3 of round wood goes into local sawmills for further processing. Since the sawmilling process produces more than 30% residue wood in the form of sawdust, cuttings and bark an additional 0.75 million m3 of sawmilling residue is also available. Residues from furniture and joinery production in B&H, also exists. Thus, according to various estimates, in total there is more than 1 million m3 of wood processing industry residue available annually50. According to some available data approximately 1.500 wood processing companies are now operative in Bosnia and Herzegovina. Ineffective wood work leads to a 30% capacity loss of raw material. Wood residues are left in the forest without

[48] *Source: "Analysis of the Forest Sector in Bosnia and Herzegovina EU funded project "Preparation of IPARD Forest and Fisheries Sector Reviews in Bosnia and Herzegovina"," FAO, 2015.*

[49] *Source: "Analysis of the Forest Sector in Bosnia and Herzegovina EU funded project "Preparation of IPARD Forest and Fisheries Sector Reviews in Bosnia and Herzegovina"," FAO, 2015.*

[50] *Source: " The Study of renewable energy sources with focus on biomass, geothermal energy and solar energy in Bosnia and Herzegovina," UNDP and Italian Ministry of Environment, Land and See Protection, 2019.*

any usage. Raw material for pellet production factories come mainly from wood processing industry.

3.2. PRIMARY BIOMASS RESOURCES FROM FORESTRY

Table 21 describes the primary biomass potential from forests in 2020. Data was obtained during the S2Biom project. It should be noted that biomass potential is expressed in thousands of tons (Kton) of dry matter (d.m.). Taken this into consideration, volumetric results above (expressed in m3) coincide relatively well with estimated data for 2020 (expressed in Kton d.m.).

Table 21 Primary biomass potential from forests in Kton d.m. (S2Biom Base 2020 potential)[51]

	Final fellings [Kton]	Thinnings [Kton]	Logging residues from final fellings [Kton]	Logging residues from thinnings [Kton]	Total [Kton]
Bosnia and Herzegovina	1438	1414	161	77	3090

Beside S2Biom project, data collected from online biomass Atlas, which is result of the project Biomass Potential Monitoring Bosnia and Herzegovina from 2019 is presented in Table 22. as theoretical potential and in Table 23 as technical potential. Problem with this data is that there are no data for Federation BiH and Brcko District, due to some administrative problems which authors of the study had in FBiH and BD.[52]

Table 22 Theoretical potential of primary forests in Bosnia and Herzegovina[53]

tones, dry mass, average value	Federation BiH	Republic of Srpska	Brcko District	Bosna and Herzegovina
Industrial wood coniferous	0	285.521	0	285.521
Final wood coniferous	0	0	22	22
Industrial wood deciduous	0	282.647	2.329	284.976
Final wood deciduous	0	371.743	2.060	373.794

[51] *Source: "S2Biom H2020 Project data base"*

[52] *Source: A. Pfeiffer, T. Krause, T. Horschig, M. Avdibegović, H. Ćustović, M. Ljuša, D. Čomoć, A. Mrkobrada , T. Mitschke, S. Mutabdžija Bećitović, M. Ponjavić, A. Karabegović and A. Brosowski, "Biomass Potential Monitoring Bosnia and Heregovina," GIZ, 2019.*

53 Source: "http://atlasbm.bhas.gov.ba/," [Online]. [Accessed 06 2020].

Table 23 Technical potential of primary forests in Bosnia and Herzegovina[54]

tones, dry mass, average value	Federation BiH	Republic of Srpska	Brcko District	Bosna and Herzegovina
Industrial wood coniferous	0	285.521	0	285.521
Final wood coniferous	0	0	22	22
Industrial wood deciduous	0	282.647	2.329	284.976
Final wood deciduous	0	371.743	2.060	373.794

Box 3.1: Methodology of Pfeiffer, et al., 2019 to calculate the crop residues potentials.

According to this methodology Forestry biomass in this study consists of six categories: 1) annual increment, 2) fuel wood, 3) industrial wood, 4), waste wood, 5) by products from the wood processing industry and 6) black liquor. The input data for the calculation of biomasses 1 to 4 is the amount of trees felled in m³. This already considers the technical recovery rate and hence the only calculation element necessary is the m³ to tonnes of dry matter conversation ratio. If the conversion factor is from m³ to tonnes of fresh matter then only the dry matter content needs to be considered.

*theoretical potential [tDM] = technical potential [tDM] = annual allowed felling [m³] * conversion factor [tDM/m³]*

*theoretical potential [tDM] = technical potential [tDM] = tree felling for energetic utilisation [m³] * conversion factor [tDM/m³]*

*theoretical potential [tDM] = technical potential [tDM] = tree felling for material utilisation [m³] * conversion factor [tDM/m³]*

*theoretical potential [tDM] = technical potential [tDM] = waste wood [m³] * conversion factor for waste wood [tDM/m³]*

*theoretical potential [tDM] = technical potential [tDM] = input from IWC, IWD, FWC, FWD [tDM] * (sawdust [%] + bark [%] + splinters, cuttings, slabs [%]) / 100*

*theoretical potential [tDM] = technical potential [tDM] = annual pulp production [tDM] * ratio pulp to black liquor [%] / 100*

According to UNDP project "Possibilities of using biomass from forestry and wood industry in Bosnia and Herzegovina, Table 24 summarizing available quantities of wood biomass for energy production.

[54] *Source: "http://atlasbm.bhas.gov.ba/," [Online]. [Accessed 06 2020].*

Table 24 Available quantities of wood biomass for energy production[55]

Sources	Conifers m3	Deciduous trees m3	Total m3
Cordwood for energy	1711	1228441	1230152
Residues after cutting and production of wood products	342181	261154	603335
Small branches	314848	401432	716280
Residues and waste after production of sawn timber, veneer and furniture	354857	200843	555700
Stumps	314848	334527	649375
Total (m3/year)	1328446	2426396	3754842
Total (t/year)	557947	1747005	2304952
Total (tce)	298866	840422	1139288
Total (toe)	209223	588343	797567

The production of wood pellets started only in 2008 in Bosnia and Herzegovina. In the beginning of 2011 there were about 142,000 tons/year of installed production capacity for pellets. Wood pellet production and biomass based heat production is recognized as one of the major areas for future investment. According to available data in 2016 in Bosnia and Herzegovina there were active 31 companies dealing with pellet production, with total production capacity of 350,000 t/year, out of which in 2015, 52% of total production was exported[56].

Data from the project "Analysis of the Forest Sector in Bosnia and Herzegovina" suggests that 5.7 million m³ is harvested from forests per year as a 10-years average. As compared to an annual increment of more than 11 million m³ .This means that only around 50% of the annual increment is used for wood production, which is low value. Comparing to the values from most of the EU countries presented in Table 3.2.5., the harvesting rate in coppice forests is at a rate of 43 %, even more marginal and is lower than EU average[57].

3.3. SECONDARY BIOMASS RESOURCES FROM WOOD PROCESSING INDUSTRIES

Unfortunately, there are no to many sources which can give adequate picture about secondary biomass resources and Table 25 provides estimations made by S2Biom H2020 project, regarding to this resource.

[55] *Source: "Possibilities of using biomass from forestry and wood industry in Bosnia and Herzegovina," UNDP, 2014.*

[56] *Source: B. D. Glavonjić, L. Oblak, D. Čomiić, A. Lazarević and M. Kalem, "Wood fuels consumption in households in Bosnia and Herzegovina," Thermal Science , vol. 21, no. 5, pp. 1881-1892, 2017.*

[57] *Source: Analysis of the Forest Sector in Bosnia and Herzegovina EU funded project "Preparation of IPARD Forest and Fisheries Sector Reviews in Bosnia and Herzegovina"," FAO, 2015.*

Table 25 Secondary biomass potential from forests in Kton d.m. (S2BIOM Base potential 2020)[58]

	Saw-dust (conifers)	Other residues (conifers)	Residues from industries producing semi finished wood based panels	Residues from further wood processing	Bark	Black liquor	Total
Bosnia and Herzegovina	170	314	137	11	81	11	723

Beside S2Biom project, data collected from online biomass Atlas, which is result of the project Biomass Potential Monitoring Bosnia and Herzegovina from 2019 is presented in Table 26. Problem with this data is that there are no data for Federation BiH, due to administrative problems with which authors were faced.

Table 26 Secondary biomass potential from forests in ton d.m. (AVG 2017)[59]

	By products of wood processing industries	Black liquor
Federation BiH	0	135,000
Republic of Srpska	449,273	0
Brcko District	4,595	0

According to information obtained from the public forestry companies in B&H, the price of firewood ranges from 25-50 Euros per m^3. The price of bark and sawdust from sawmills is even lower, dependent on availability and location. Although, according to pellet producers in B&H, the price range is quite wide, the cost of raw material wood inputs is 50 - 60 Euros per ton of produced pellets (Wood Pellet Produciton in Bosnia and Herzegovina, 2014).
Diagram presented on Figure 3 shows comparison of biomass and conventional fuels market prices in Western Balkan Countries. From this diagram, it can be concluded that Straw and wood chips most competitive heating fuels (electricity by far the most expensive option). Several biomass fuel types not traded yet (prunings, thinning, corn stover, energy crops). Most processed fuels are exported (60-70%), particularly pellet, but situation in Bosnia is changing and share of pellet sold on domestic market increase every year. The one of the characteristics of biomass market in Bosnia and Herzegovina is non-transparency, which means that buyers have difficulties in finding the right quantity and quality biomass. It is a problem to achieve long-term biomass contracts. The other problem in the last time related to pellet market are volatile prices (e.g. winter season 2016/17 –price of pellets rose 50% season start to mid-season), this year situation is even worst. One of the crucial problems is lack of knowledge and experience related to complexity of biomass fuels storage and logistics. Need for development of biomass logistics & trade centers exists.

[58] *Source: "S2Biom H2020 Project data base"*

[59] *Source: "http://atlasbm.bhas.gov.ba/," [Online]. [Accessed 06 2020]*

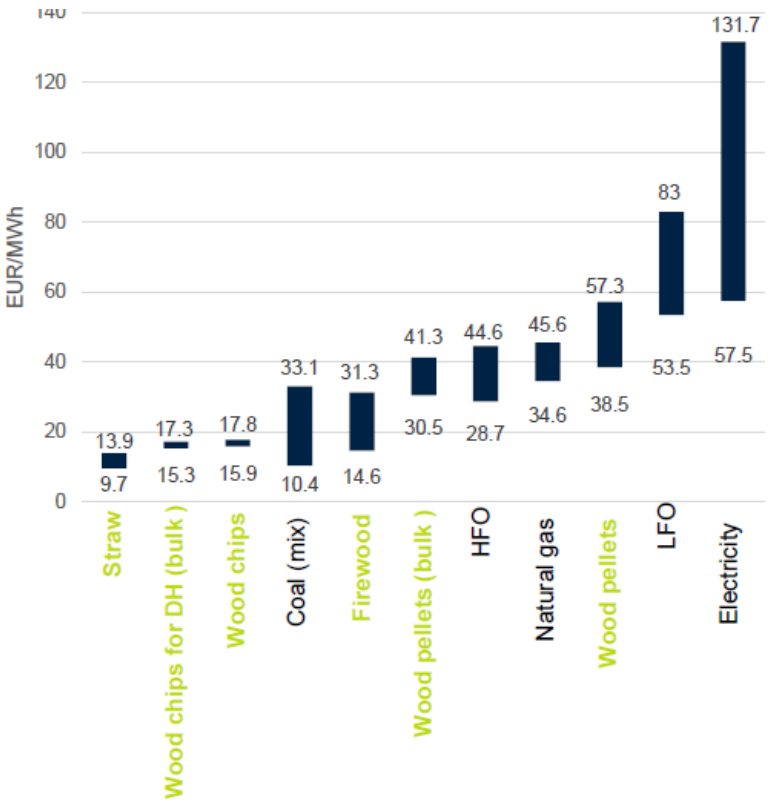

Figure 8 Market prices of biomass and conventional fuels in WB region (WBIF, 2017)[60]

3.4. SUMMARY AND CONCLUSIONS IN RELATION TO SWOT ELEMENTS

In total, these new figures imply that around 63 % of the total territory of Bosnia and Herzegovina is covered with forest and other woodland, which is one of the highest values in Europe. The latest data from the second National Forest Inventory in Bosnia and Herzegovina (2006–2009) shows a total figure of 3,231 million ha of forest and other woodland out of which 1,652 million ha are high forests and 1,252 million ha are coppice forest. 20.324 km length of forest roads offers a good accessibility to this highly abundant biomass resource. According to 2015 data currently about 2.5 million m3 of round wood goes into local sawmills for further processing. Large unused forest biomass potential that can be removed without reaching the forest increment level exist, which allows new employment possibilities, through development of whole bioenergy chains. One of the challenging issues is logistics for collecting and transporting biomass to pre-processing centres.

Mainly the wood is exported as a roundwood, pellet and firewood. Significant potential laying in charcoal export, but only a little fragment is exported as added-value products

[60] *Souce: "Biomass-Based Heating in the Western Balkans – A Roadmap for Sustainable Development, International Bank for Reconstruction and Development," The World Bank, 2017.*

such as chemicals, and wood final products. Table 27 summarises SWOT elements in relation to biomass supply from forestry.

Table 27 SWOT factors regarding biomass feedstock

Strengths	Weaknesses
Continuity of resources Forestry abundance Large unused forest biomass potential that can be removed without reaching the forest increment level Competitive advantages for exploitations of biomass (land, forest, climate, etc) Relatively good accessibility (forest roads) Very close perspective of promotional measures for bioenergy production and use.	Lack of cross-sectoral communication Professional education Good accessibility (forest roads) Non-adequate system of actual data management regarding to forests and forestry Non-adequate forest management Lack of transparency in biomass market Challenging logistics for collecting and transporting biomass to pre-processing centres Large unmanaged forest area Ownership of forest land unclear
Opportunities	**Threats**
Development of innovative and high-added value products Rural development Employment, through development of whole bioenergy chains Consolidation of local markets Increased competitiveness of the country Development of ESCO companies or other forms of the PPP Options to create biomass logistics and trade centers Transfer of knowledge and technologies in agricultural production Technical and technological modernization of agricultural production possible	Unsystematic and unsustainable exploitation of forests and land, especially forest residues (wastes) Lacking investment in rural areas Non-implementation of legislation Missing communication with other sectors Lack of owners' willingness to mobilise forest feedstock Low level of R&D and technological development Some big biomass consumers (DHS) appears in last couple years and made disturbance on the market

4. Biomass supply: Waste

4.1. INTRODUCTION

According to some research it is estimated that around 2.8 kg of food waste is disposed of by the average household in Bosnia and Herzegovina, every week. Global warming potential associated with household food waste is on average, 3.49 kg CO2e/week, Also it is important to emphasize that households in Bosnia and Herzegovina, discard over 80 different pieces of food packaging waste weekly, where plastic packaging is the most dominant packing type.

Based on the latest national statistics report published by Agency of Statistics BiH in 2016, the situation in waste sector in BiH can be described with the following indicators[61]:

- average waste generation rate is 0.89 kg/head/day (2015),
- the total amount of municipal waste generated annually is around 1.3 million tons (2015),
- 74 % of waste generated is collected with waste collection services (2016),
- 66 % of population is covered with solid waste collection service (entity average) (2015),
- 33 % of the waste collected is disposed on sanitary landfills, while 67 % is disposed on uncontrolled municipal landfills (2015),
- only 1 % of waste is recovered (2015)
- waste contribute 5% to total CO2 emission in Bosna and Herzegovina.

The total quantity of waste collected is comprised of municipal mixed waste (86.5%), collected municipal waste separated at the source (7.3%), waste from gardens and parks (4.8%), and packaging waste (1.4%)[62].

Limited amounts of industrial and hazardous waste are recovered or reused; it is estimated that only 10 % or less of the total volume of industrial waste is used as secondary raw material[63].

4.2. WASTE FROM BIOLOGICAL RESOURCES

According to the available data from the newest studies, organic waste is the dominant fraction and varies from 25 % (cantonal average) up to 50 % (municipal average). The dry recyclables (plastic, glass, paper, metals, Al. cans, PET) accounts for 24 to 38 % of the total waste. More precisely, the dry recyclables in Federation BiH (plastic, glass, paper, metals,

[61] *Source: M. Cero, I. Silajdzic and S. M. Kurtagic, "Waste Management in Bosnia and Herzegovina – Current Situation and Perspectives," Waste Management, 2018.*

[62] *Source: "Third National Communication and Second Biennial Update Report on Greenhouse Gas Emissions of Bosnia and Herzegovina under the United Nations Framework Convention on Climate Change," UNDP , 2017.*

[63] *Source: "Municipal waste management – Country fact sheet Bosnia and Herzegovina, EEA European Topic Centre on Waste Materials in a Green Economy," EEA, 2018.*

aluminium cans, PET) accounts for 24-38% of the total waste, while in Republic of Srpska total ercentage of dry recyclables in generated waste will thus be 32%[64] [65].

Some estimations related to biowaste were given in S2Biom project and presented in Table 28.

Table 28 Biowaste separately collected Kton d.m. (S2BIOM Base potential 2020)

	Biowaste unseparately collected	Biowaste separately collected	Total
	13	367	380

4.3. CURRENT WASTE TREATMENT AND UNUSED POTENTIALS ESTIMATES

Waste management responsibilities in Bosnia and Herzegovina (BiH) are distributed between a number of institutions at various levels. According to the Constitution, environment is not a core competence of the state of BiH. Development and implementation of the waste management policy in Bosnia and Herzegovina is at the entity level and level of Brcko District (BD).

The main treatment option available in the country is landfilling of waste. The entity Waste Management Strategies recommend the implementation of regional landfills serving a certain geographical area. Currently, Bosnia and Herzegovina has 6 active regional sanitary landfills and 2 under construction. In Bosnia and Herzegovina, around 75 % of the population is covered by a waste collection service, with coverage more or less complete in larger cities but dropping to very low levels in rural areas. Of all landfills, only six meet the required EU standards, while at the same time several others are being planned[66].

Figure 9 shows current status of waste disposal in Bosnia and Herzegovina.

[64] *Source: "Municipal Solid Waste Management Sector Review Strategic Directions and Investment Planning up to 2025, Part A Federation BiH" The World Bank/ Swedish Assistance, 2018.*

[65] *Source: "Municipal Solid Waste Management Sector Review Strategic Directions and Investment Planning up to 2025, Part B Republic of Srpska" The World Bank/ Swedish Assistance, 2018.*

[66] *Source: "Municipal waste management – Country fact sheet Bosnia and Herzegovina, EEA European Topic Centre on Waste Materials in a Green Economy," EEA, 2018.*

Figure 9 Current status of waste disposal in each region in Bosna and Herzegovina[67]

According to latest studies estimations for Republic of Srpska, during the period 2013 and 2025, the average annual growth rate is 0.76%. The average waste generation is expected to increase from 0.76 kg/cap/day to 0.83 kg/cap/day It is also assumed that It is assumed that dry recyclables fraction will grow 50% faster than the overall waste generation per capita. Estimations for Federation BiH shows that in the period 2013 to 2025, waste volumes will increase by 21% with average annual growth rate of 1.8%. The average waste generation rate is expected to increase from 0.8 kg/cap/day in 2013 to 1.02 kg/cap/day in 2025, and it is also assumed that recyclables fraction will grow 50% faster than the overall waste generation per capita[68][69].

Actual Waste Management Strategy for Republic of Srpska predicts significant increase of separation and recycling of waste (up to 23% until 2026). But, considering the current baseline (64% collection coverage, almost no separation and recycling, poor basic service level, lack of regional landfills) such transformation of the waste management system in RS

[67] *M. Cero, I. Silajdzic and S. M. Kurtagic, "Waste Management in Bosnia and Herzegovina – Current Situation and Perspectives," Waste Management, 2018.*

[68] *Source: "Municipal Solid Waste Management Sector Review Strategic Directions and Investment Planning up to 2025, Part B Republic of Srpska" The World Bank/ Swedish Assistance, 2018.*

[69] *Source: "Municipal Solid Waste Management Sector Review Strategic Directions and Investment Planning up to 2025, Part A Federation BiH" The World Bank/ Swedish Assistance, 2018.*

will require a coordinated effort at all administrative levels, significant development of human resources, increased public participation and quite important financial resources[70].

In Federation BiH is the similar situation. Taking in to consideration the current baseline (68% collection coverage, almost no separation and recycling, poor basic service level) such transformation of the waste management system in Federation of BiH will require a coordinated effort at all administrative levels, significant development of human resources, increased public participation and significant financial resources[71].

4.4. Summary and conclusions in relation to SWOT elements

Bosnia and Herzegovina is a country with the low number of separately collected waste and management of recycling. The average waste generation rate is 0.89 kg/head/day (2015), There are not any waste to energy plants in Bosnia and Herzegovina. 74 % of waste generated is collected with waste collection services (2016), Waste was disposed of in 6 regional landfill sites, only 1 % of waste is recovered (2015). Waste contribute 5% to total CO2 emission in Bosna and Herzegovina. Large potential in waste recycling industry exist as well as possibilities of energy recovery. Significant percentage of waste still is not covered by landfills, particularly in rural areas. Limited amounts of industrial and hazardous waste are recovered or reused and systematic monitoring of the parameters for environmental assessment does not exist on satisfying level.

Table 29 summarises SWOT elements in relation to waste sector in Bosnia and Herzegovina.

[70] *Source: "Municipal Solid Waste Management Sector Review Strategic Directions and Investment Planning up to 2025, Part B Republic of Srpska" The World Bank/ Swedish Assistance, 2018.*

[71] *Source: "Municipal Solid Waste Management Sector Review Strategic Directions and Investment Planning up to 2025, Part A Federation BiH" The World Bank/ Swedish Assistance, 2018.*

Table 29 SWOT analysis in relation to waste sector in Bosnia and Herzegovina

Strengths	Weaknesses
System of regional landfills which is suitable to development waste-to –energy projects Some waste separation activities in the process of collection and in landfills Modern and adequate waste management legal framework exist	Low level of separation and recycling of waste Significant percentage of population which is still not covered by landfills Limited amounts of industrial and hazardous waste are recovered or reused Low level of awareness and willingness of citizens to separately collecting waste Lack of capabilities to treat broader spectrum of waste Lack of capacities for adequate disposal of hazardous waste Non-systematic monitoring of the parameters for environmental assessment Cost recovery problems relared to unpaid fees
Opportunities	**Threats**
Large potential in waste recycling industry exist Possibility of energy recovery Development of innovative and high-added value products Job creation Increased competitiveness of the country Reduction of landfill costs Extension of landfill's lifetime Option to introduce polluter pays principles	Waste accumulation Significant percentage of waste in rural areas which is not covered by waste collection system No separate collection system for hazardous materials, so everything ends up in landfills or dumpsites Environmental and health risks related to non-adequate disposal of certain hazardous wastes Increased GHG emissions from waste sector

5. Bio-based industries, products and markets

5.1. CURRENT BIO-BASED INDUSTRIES

5.1.1. FOOD AND FEED INGREDIENTS INDUSTRIES

The food and food processing industry makes a significant contribution to overall GDP. Food and drink processing gross output in 2004 was 1,035 million KM and in 2005 1,283, million KM. The sector's estimated contribution to overall GDP increased from 7% in 2004 to 8% in 2005. Value of production in 2005 increased by 24% compared to 2004, which suggest some recovery of industry, particularly by privatized companies benefiting from Foreign Direct Investment (FDI) or partnership (e.g. Meggle, Dukat, Vegafruit, Klas Sarajevo, Coca-Cola, Vitaminka Banja Luka, Mira Prijedor, Mljekoprodukt, Bimal Brčko and Lijanovići).

According to the available data for Federation BiH, insufficient use of installed capacities continues to pose one of the bigger problems for the food industry in FBiH. The highest level of utilization of installed capacities is in fruit and vegetable processing (62%), milk processing (56%) and production of beverages (54%) while quite low level of utilization is found in production of mineral water (16%), wine (16%) and biscuits and waffles (19%)[72].

According to available data for Republic of Srpska food industry situation being unsatisfactory, its value in total sales of RS industry sectors is at 16.5% (additional 1.4% for production of beverages and 0.4% for production of tobacco products). Gross added value of food products produced in RS was BAM 201 million in 2015, and overall business result of this sector was positive. The food industry growth rate was at 121% in 2015, 115% in 2014 and 108% in 2013. At the same time, employment growth was slower indicating that productivity in food industry is increasing. The utilization rate of food industry capacities is low also in RS and ranges between 12% and 60%, depending on the industry branch. Brcko District Bosnia and Herzegovina: In 2015, food industry contributed to the total BD BiH industry with 56.91 %, in GAV with 8.76 % and in GDP with 6.85%[73].

[72] *Source:"Ministry of Foreighn Trade and Economic Relations of Bosnia and Herzegovina – MOFTER, 2016.*

[73] *Source: "Strategic Plan for Rural Development of Bosnia and Herzegovina (2018-2020) – Framework Document".*

5.1.2. COMMERCIAL BIOREFINERIES

Maybe is interesting to mention that one of the first factories which can bring under definition bio-refinery is chemical industry JSC "Destilacija" Teslic, established in 1896, still functioning and by using wood as raw material, and producing charcoal, vinegar, acetic acid, charcoal acid, etc. According to the available information the only commercial refinery, which is built in Bosnia and Herzegovina, is company "System Ecologica" predicted for biodiesel production based on treatment of rapeseed, but in the last year their production was based on recycling of used edible oils imported from abroad[74].

Beside of "Destilacija" Teslic, according to available information, some companies placed in Banja Luka, dealing with production of charcoal from hardwood on industrial scale, by using Twin-Carbo retort technology. Total export value of charcoal in Bosnia and Herzegovina is about 8,6 Mil. Euro[75].

In 2017 Republic of Srpska (RS) government approved a project to build a biorefinery, A statement from the government session in Banja Luka early in December 2017 said that the cabinet discussed a report on cooperation and draft protocol and solutions for the project to build the biorefinery to produce cellulosic ethanol[76]. According to available information this project has stopped.

5.1.3. REGIONAL BIO-BASED INITIATIVES

This is an example of the initiative developed by World Bank in order to establish joint market for agricultural biomass and push technologies related to use of this type of biomass, in the areas belongs to three states[77]. The presented cross-border region of Bosnia and Herzegovina, Croatia and Serbia is the most important area of the Western Balkans from the point of view of agricultural production, and availability of agricultural residues for bioenergy. Thus, integrated efforts on a regional level could play essential role in developing the market, and synergies can be drawn and lessons learnt on how to increase the use of agricultural residues and energy crops for heating and energy purposes. Cross-border regions of Bosnia and Herzegovina, Croatia and Serbia are part of the Pannonian Basin, a large basin in in the south-eastern part of Central Europe, between the Carpathian Mountains, the Alps, the Dinarides and the Balkan Mountains, as presented in Figure 10. The Rivers Danube and Tisza divide the basin roughly in half. Pannonian Basin covers Vojvodina and Mačva regions of Serbia, Central Croatia and Slavonia, and the border regions of northern Bosnia and Herzegovina. Pannonian basin is a major agricultural area; it is sometimes said that these fields of rich loamy loess soil could feed the whole of Europe. The

[74] *Source: "https://systemecologica.com/Srpski/productiontechnology.html," [Online]. [Accessed 06 2020].*

[75] *Source: " https://www.tridge.com/intelligences/charcoal/BA/production," [Online]. [Accessed 06 2020]*

[76] *Source: "https://balkangreenenergynews.com/republika-srpska-government-approves-biorefinery-project/," [Online]. [Accessed 06 2020].*

[77] *Source: "Sector Study on Biomass-Based Heating in the Western Balkans – Case Studies," International Bank for Reconstruction and Development / The World Bank, 2017.*

cross-border region of BIH/CRO/SER assessed in this study comprises the following administrative units:

1. In Bosnia and Herzegovina - six municipalities in the Republika Srpska – Bijeljina, Gradiska, Laktasi, Lopare, Srbac, and Ugljevik; District Brčko; Posavski Canton of the Federation of BIH;
2. In Croatia - Osijek-baranja and Vukovar-syrmia County;
3. In Serbia – Autonomous Province of Vojvodina and Mačva County.

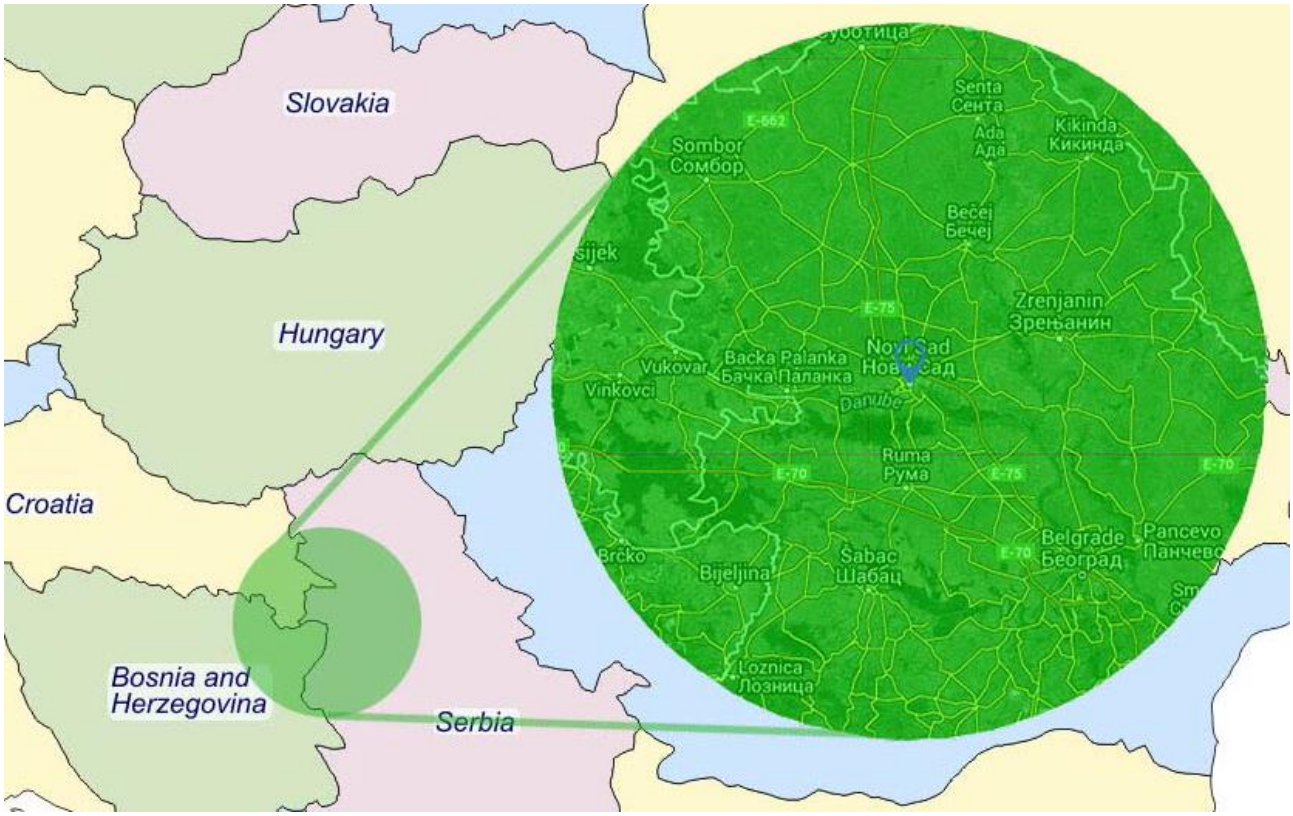

Figure 10 Cross-border region of Bosnia and Herzegovina, Croatia and Serbia[78]

Table 30 presents general information on the cross-border region of Bosnia and Herzegovina, Croatia and Serbia.

[78] *Source: "Sector Study on Biomass-Based Heating in the Western Balkans – Case Studies," International Bank for Reconstruction and Development / The World Bank, 2017.*

Table 30 General information on the cross-border region of Bosnia and Herzegovina, Croatia and Serbia[79]

Region	Area (km2)	Population	Population density per km^2	Number of administrative units/ municipalities	Number of households	Rural household	Urban households
Semberija/ Lijevce polje (BiH-RS)	2,794	234,020	84	6	78,646	51,304	27,526
Brcko District (BD)	493	83,516	169	1	27,341	17,836	9,569
Posavski Canton (BiH-FBiH)	325	43,453	134	3	13,313	8,685	4,660
Osijek-baranja County (CRO)	4,155	305,032	73	35	110,009	52,605	57,404
Vukovar-syrmia County (CRO)	2,454	179,521	73	26	61,094	29,088	32,006
Vojvodina Province (SER)	21,506	1,931,809	90	45	696,157	272,147	424,010
Macva County (SER)	3,268	329,625	101	8	100,136	68,599	31,537
Total	34,995	3,106,976	89	124	1,086,696	500,263 (46%)	586,712 (56%)

Current heat demand in the cross-border region of of Bosnia and Herzegovina, Croatia and Serbia is estimated at 82772 ktoe, Main fuel for heating is firewood, followed by natural gas, coal, electricity, and LFO. Agriculture's contribution to the economies of Bosnia and Herzegovina, Croatia and Serbia, measured as a share of GDP in the period 2011-2014, is in the range from 3.8% in Croatia, to 6.7% in Bosnia and Herzegovina, and 8% in Serbia. In Bosnia and Herzegovina, 45% of agricultural land is hilly (300-700 m above sea level), of medium quality and is suitable mainly for semi-intensive livestock production. Mountainous areas (above 700 m above sea level) account for 35 % of agricultural land. High altitudes, slope and poor soil fertility limit the use of these areas for agricultural production. Thus, it is mainly used for livestock grazing during the spring and summer[80].

Yields of cereals and oil crops (grains) in the cross-border region of Bosnia and Herzegovina, Croatia and Serbia, for the period 2013-2015 is presented in Table 31. Production was in the range of 8 – 11 million tons, with average production of 9.5 million tons.

[79] *Source: "Sector Study on Biomass-Based Heating in the Western Balkans – Case Studies," International Bank for Reconstruction and Development / The World Bank, 2017.*

[80] *Source: "Sector Study on Biomass-Based Heating in the Western Balkans – Case Studies," International Bank for Reconstruction and Development / The World Bank, 2017.*

Table 31 Average production of cereals and oil crops in the cross-border region of Bosnia and Herzegovina, Croatia and Serbia, in tons[81]

	Wheat	Rye	Barley	Oat	Maize	Sunflower	Rapeseed	Soya
Bosnia and Herzegovina	90,416	395	20,318	4,225	257,304	171	1,185	6,124
Croatia	451,977	1,400	70,910	9,329	868,395	79,665	17,631	99,372
Serbia	1,643,872	3,602	204,198	17,336	4,669,169	452,528	42,657	448,413
Total	2,186,265	5,398	295,426	30,889	5,794,868	61,473	61,473	553,910

According to this study by applying sustainability criteria which consider residue-to-product ratios and harvesting index, and taking in to consideration competing uses for agriculture, and production of biofuels (30% of residues) and electricity (10% of residues), the sustainable technical potential of agricultural residues for heating use, in the cross-border region is estimated at 2.5 million tons of agricultural residues i.e. 847 ktoe – 660 ktoe in Serbia, 153 ktoe in Croatia, and 34 ktoe in Bosnia and Herzegovina. The most significant agricultural residues, in terms of quantity and energy content are maize, wheat, sunflower and soya residues. In the cross-border region, it is estimated that more than 170,000 hectares of agricultural land is currently unused. However, the share of unused agricultural land is lower compared to W-B average, due to good quality of soil in this region. The unused agricultural land could be used for growing perennial energy crops, such as Miscanthus. For the estimation of the potential, yield of 4.7 dry tons/ha was conservatively adopted, with moisture content of 20%, and lower heating value of 14.4 GJ/t. The potential of energy crops is estimated at 280 ktoe, of which Serbian part accounts for 48%, followed by Croatia (44%), and 8% of the potential is found in Bosnia and Herzegovina.

Unfortunately, agricultural residues remain largely unexploited in the region. The agro-biomass market is almost non-existent in Western Balkans countries, including Bosnia and Herzegovina. There are some exceptions, mainly in Serbia and Croatia, those are examples of agro-pellet production and energy production for industrial purposes[82].

Problem which became serious in Bosnia and Herzegovina with wood fuels is availability in some parts of Bosnia and Herzegovina, because several reasons, huge amounts fuel wood is exported, several big capacities (district heating systems) were built relatively close to each other, a quite far from the arias with largest potential of wooden biomass. In these circumstances biomass logistics also became serious problem. Due to that regional incentives as the one presented above will be very important and the fact that World Bank already financed such analysis. Because some serious bio refinery will be possible and more feasible as regional projects.

[81] *Source: "Sector Study on Biomass-Based Heating in the Western Balkans – Case Studies," International Bank for Reconstruction and Development / The World Bank, 2017.*

[82] *Source: "Biomass-Based Heating in the Western Balkans – A Roadmap for Sustainable Development, International Bank for Reconstruction and Development," The World Bank, 2017.*

5.2. SUMMARY AND CONCLUSIONS IN RELATION TO SWOT ELEMENTS

Bosnia and Herzegovina has a certain historical roots, related to development of some branches of domestic chemical industry as biobased. Certain production of charcoal and other biobased products already exists, some plans and incentives for some new products are actual, Bat the fact is that Bosnia and Herzegovina is a quite far from modern commercial bio-refineries. According to future biomass valorisation the bio-refining is much of an interest as is the other surrounding countries, but is important to find its own model of the future bio-refinery adequate to business and natural environment of the country.

The main SWOT analysis findings considering the bio-based industries, products and markets are summarised in table 32.

Table 32 SWOT analysis of bio-based industries, products and markets in Bosnia and Herzegovina

Strengths	Weaknesses
Abundant biomass resources Significant capacities in food processing industries exists Some experience and tradition in bio-based industries exists Potential industrial partners exist Existing of capacities to receive and process raw materials of agricultural origin Increased awareness about necessity of bio-based industries development Increased awareness about the importance of introducing standards in production Growing market for bio-based products exists	Lack of knowledge among the stakeholders in whole levels Lack of incentives and support from governmental side Low-level of promotion of bio-based industries Lack of investments in bio-refinery projects Certain segments of food industry are technologically outdated, inefficient and non-competitive Low level of utilization of capacities in food industry Large dependence on imports of inputs of raw materials
Opportunities	**Threats**
Companies with certain bio-based interests / state-of-the-art chemicals or plastic production Strengthening support for food industry to source inputs from domestic producers; Improved production quality, standards and reliability of supply to the food industry Strengthened value chain integration and linkages Job creation Increased competitiveness of the country	Loss of competitive market advantage / not developing own bio-based processes Lack of producer's trust and confidence in BiH governmental structures On-going reliance on imported agriculture products due to lower prices and reliability Lack of foreign direct investments and inability to secure sources of financing for new investments Non-compliance with market standards and inability to export Non-adequate management of food processing industries waste

6. Infrastructure, logistics and energy sector

6.1. EXISTING INDUSTRIAL HUBS AND HARBOURS

Sava River is the richest-in-water Danube tributary, and contributes with environ 25% to the Danube's total discharge. Its length is 945 km, with 594 km of the waterway (see Figure 11), from Sisak (Croatia) to Belgrade (Serbia). The Sava River runs 345 km in Bosnia and Herzegovina, through the Federation of Bosnia and Herzegovina (FBIH), Republika Srpska (RS), and Brčko District (BD). The largest share is in the RS (61 %), followed by the FBIH (32%).

Figure 11 Sava river waterway

Figure 12 present Sava River waterway transport system. On the Sava River, an international regime of navigation is established and jurisdiction over traffic is divided on three levels[83]:

- MoTC BiH, in charge of international traffic;
- MoTC FBIH, responsible for infrastructure;
- MoTC RS, responsible for infrastructure;
- Traffic Department in Brcko District, responsible for infrastructure.

The navigation infrastructure suffers of aging, lack of maintenance and incompleteness. Such status has a negative impact on the safety of navigation and increases possibility for accidents with potential adverse impacts on environment. For that reason, Bosnia and Herzegovina, Croatia, Slovenia and Serbia in 2002 established International Sava River Basin Commission (Sava Commission) with aim at rehabilitation and development of the waterway. The extension of the navigability upstream of Sisak is planned for a later phase in accordance with the development of the economic and transport activities. Most important activities for rehabilitation and development of Sava waterway include dredging and training works, bends improvement, reconstruction of 3 bridges, removal of 3 ship

[83] *Source: Framework Transport Strategy for Bosnia and Herzegovina," Ministry of Communications and Transport of Bosnia and Herzegocvina, 2016.*

wrecks, cleaning of areas from unexploded ordnances, and upgrading of winter ports. Currently most vessels serving the ports of BIH are registered in Serbia. At present, depending on the navigability and conditions of the Sava at different sections, vessels of up to 1,000 tons on Slavonski Brod-Brčko section, to up to 1500 tons on Brčko-Belgrade section operate on the Sava. Brčko port has significant storage space available. The port offers 11,000 m² of warehouse storage space and 16,000 m² for open storage. Recently the warehouses were renovated. The port has two railway tracks at the quay at its disposal, which are connected to the national railway system. The port of Bosanski Brod only handles liquid bulk from the nearby oil refinery, while new owners of Šamac port (originally designed to handle 1 million tons per year) have formulated an ambitious short-term investment plan to transform it into an efficient and multi-functional cargo transit point.

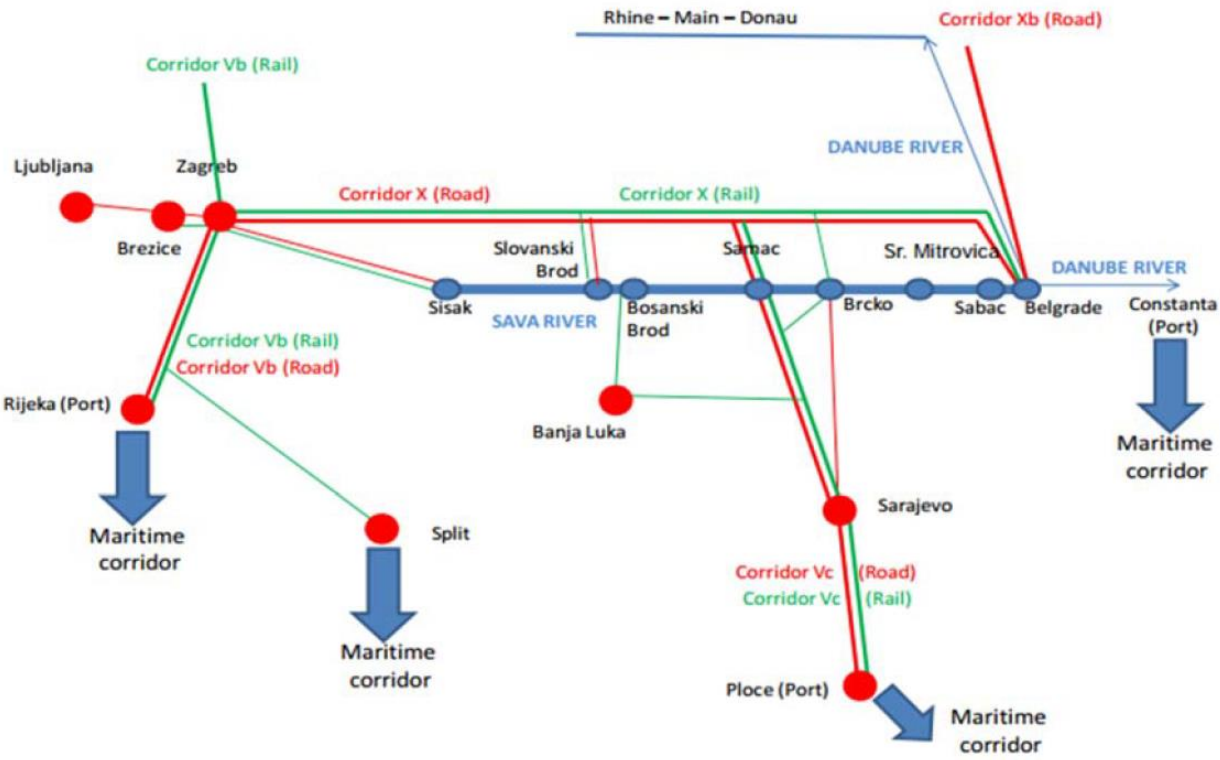

Figure 12 Sava River waterway transport system[84]

Table 33. Sava river ports in the cross-border region in Bosnia and Herzegovina[85]

Port		
Šamac	Dry bulk, break bulk	Open storage area, covered storage area
Brčko	Dry bulk, break bulk	Open storage area, covered storage area, customs warenhouse
Bosanski Brod	Refined oil products, crude oil	Oil storage tanks

[84] *Source: "Sector Study on Biomass-Based Heating in the Western Balkans – Case Studies," International Bank for Reconstruction and Development / The World Bank, 2017.*

[85] *Source: http://www.danube-logistics.info/," [Online]. [Accessed 06 2020].*

6.2. EXISTING RAILWAYS

According to the Framework Transport Strategy for Bosnia and Herzegovina in 2016, out of 1.030,389 km of railway lines in Bosnia and Herzegovina, 91.48% are single-track and 8.52% are double-track lines. The network is deployed 57% in FBiH, 40.4% in RS, and 2.6% in BD. The entire network is based on a standard gauge (1,435 mm) and the majority is single track (92%). More than 85% of the network is now classified as D4 in terms of UIC load categories, allowing maximum loads of 22.5 Tonnes per axle or 8.0 Tonnes per linear meter. Around 76% of the network is electrified with a mono-phase 25kV, 50HZ AC system[86].

Figure 13 shows overview of Boania and Herzegovina railway network.

Figure 13 Overview of BiH railway network[87]

[86] *Source: Framework Transport Strategy for Bosnia and Herzegovina," Ministry of Communications and Transport of Bosnia and Herzegocvina, 2016.*

[87] *Source: Framework Transport Strategy for Bosnia and Herzegovina," Ministry of Communications and Transport of Bosnia and Herzegocvina, 2016.*

The railway network consists of two main strategic lines, which are also the main railway lines for cargo:

- The North-South line Bosanski Samac-Doboj-Zenica-Sarajevo-Mostar-Capljina, located on Corridor Vc;
- The West-East line Dobrljin–Bosanski Novi-Banja Luka-Doboj-Tuzla-Zvornik which is the railway line parallel to Corridor X.

There are certain limitations in respect of the speed and safety of railway traffic oin the BiH railway network. These are mainly due to the unfavourable geographical configuration, incomplete safety system at stations, outdated signalling, lack of protection at level crossings etc.

The main operational and organizational limitations are the following:

- Maximum train length: 550 m,
- Maximum speed: 100 km/h,
- ·Change of locomotives to access non-electrified sections,
- ·Lack of communication devices.

The map on Figure 14 show the BiH railway lines included in the indicative extension of TEN-T Core and Comprehensive Network, as per Regulation (EU) No 2016/758, and as reported in SEETO MAP 2016.

Figure 14 Indicative extension of TEN-T rail network in Western Balkans EU neighbouring countries

6.3. EXISTING ROAD INFRASTRUCTURE

According to the Framework Transport Strategy for Bosnia and Herzegovina, total length of the road network in BiH is 24,796 km. The entire network may be divided following the categorisation[88]:

- 3,970 km main / state roads (16.0%); 128,7 km of which classified as Motorways2 (120 km of motorways and 28.7 km of roads reserved for motor traffic),
- 4,611 km secondary / regional roads (18.6%),
- 14,200 km other / local roads3 (57.3%).

[88] *Source: Framework Transport Strategy for Bosnia and Herzegovina," Ministry of Communications and Transport of Bosnia and Herzegocvina, 2016.*

An overview of the entire network can be seen in Figure 15.

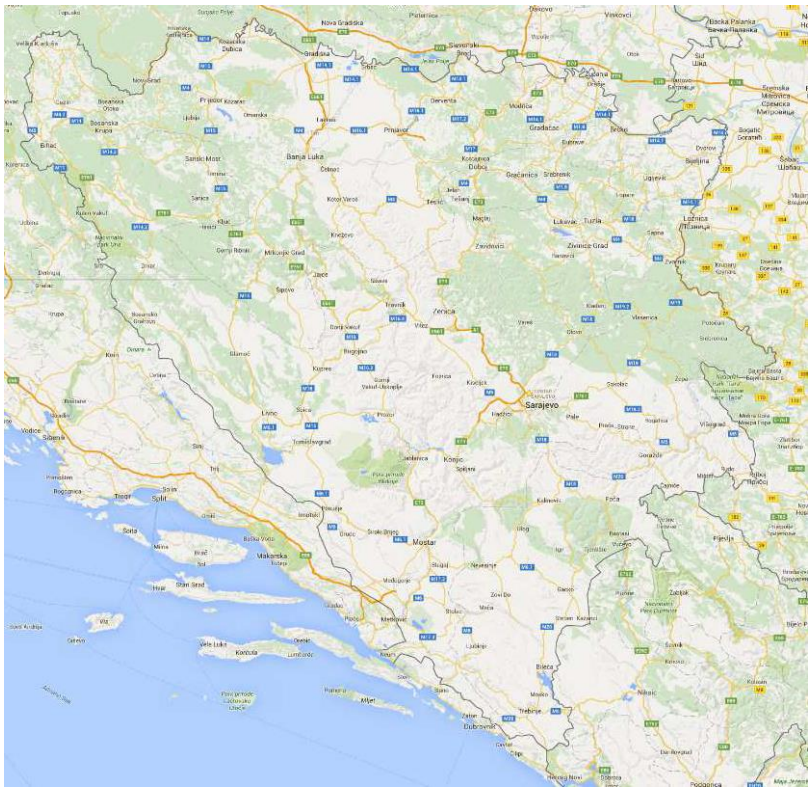

Figure 15 The map of the road network in Bosnia and Herzegovina

Part of the Bosnia and Herzegovina road network assumed strategic international relevance, within the Western Balkans Region, due to its inclusion in the SEETO4 (South East Europe Transport Observatory) Comprehensive network[89]. In this respect, the Comprehensive Network identified under SEETO Memorandum of Understanding, shall be considered as a multimodal regional transport network which is the base for the implementation of the transport investment programmes.

Furthermore, on 27 August 2015, during the Western Balkans 6 (WB6) Summit held in Vienna, WB6 representatives and the European Union reached an agreement on the indicative extension of the Trans-European Transport Network (TEN-T) to the Western Balkans[90]. As a result of this agreement, the entire SEETO comprehensive network is now integrated into the TEN-T network; consequently, the related TEN-T maps were updated accordingly. I In this respect, Figure 16 shows all road sections which are a part of the European TEN-T Core and Comprehensive Network.

[89] *Source: https://www.seetoint.org/*

[90] *Source: https://ec.europa.eu/neighbourhood-enlargement*

Figure 16 Indicative extension of TEN-T road network in Western Balkans EU neighbouring countries[91]

[91] *Source: Framework Transport Strategy for Bosnia and Herzegovina," Ministry of Communications and Transport of Bosnia and Herzegocvina, 2016.*

6.4. ENERGY SECTOR

Some important data related to Bosnia and Herzegovina energy sector are the following:

- Primary production in 2017 was 4,624.0 ktoe (share RES and biofuels was 1,012.2 ktoe).
- Gross available energy in 2017 6754.5 ktoe (share RES and biofuels was 792.1 ktoe).
- Total energy supply in 2017 6,744.0 ktoe (share RES and biofuels was 792.1 ktoe).
- Share of fossil fuels in gross available energy in 2017 was 90.6% (EU-28 is 74.1%).
- Share of electricity from renewable energy sources in total electricity generation in 2017 was 23.5% (EU-28 is 29.9%).
- Energy intensity of the economy (energy per GDP PPS) in 2017 was 207.8 (EU-28 is 111.8).
- Energy intensity of the economy (energy per chain-linked GDP) in 2017 was 458.0 (EU-28 is 121.0).
- Overall import dependency in 2017 was 34.0 (EU-28 is 55.1).
- Primary solid biofuels and charcoal available for final production in 2017 were 390 ktoe.
- Electricity generation from thermal power plants in 2017 was 1,070 ktoe.
- Electricity generation from CHP in 2017 was 19 ktoe.
- Heat generation from thermal power generation in 2017 was 138.4 ktoe.
- Heat generation from combined heat and power plants, incl. industrial waste heat in 2017 was 43.4 ktoe.
- Bioenergy production in 2017 was 725 ktoe.

Figures 17 and 18 presents Sankey diagrams of Bosnia and Herzegovina and EU28.

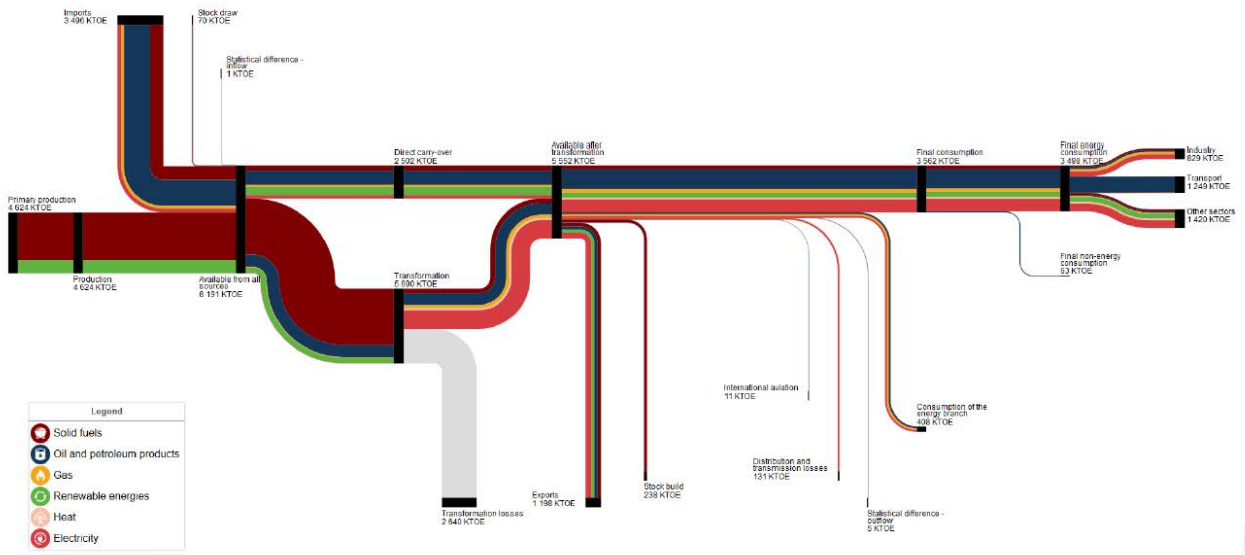

Figure 17 Sankey diagram of energy flows for Bosnia and Herzegovina in 2017[92]

[92] *Source: Energy Balance Sheets 2017 data," Eurostat, 2019.*

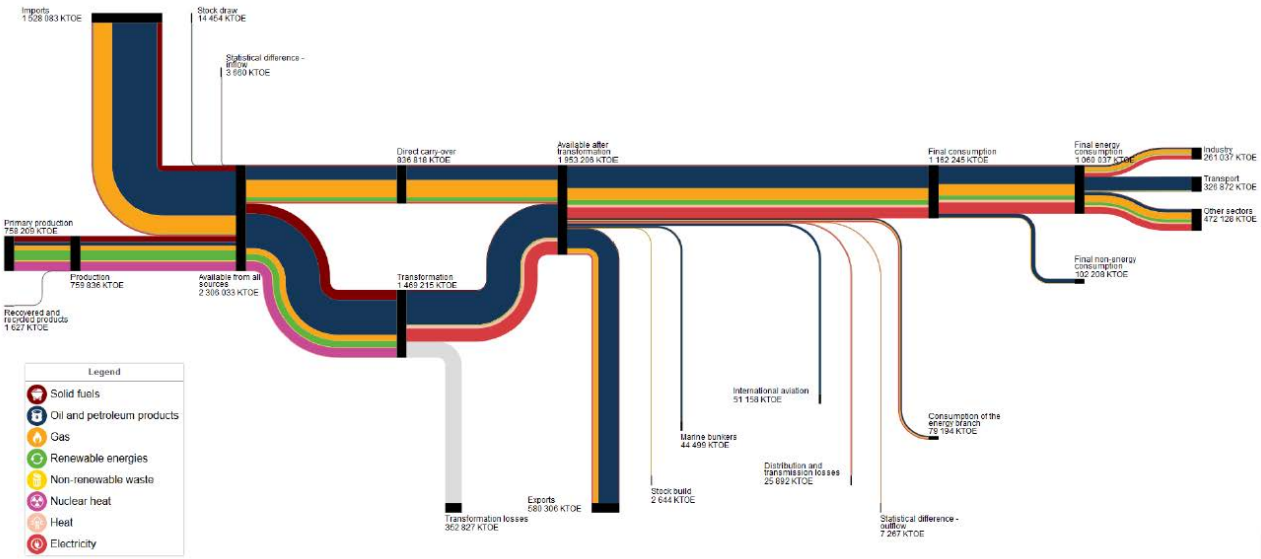

Figure 18 Sankey diagram of energy flows for EU-28 in 2017[93]

Category	Boania and Herzegovina	EU average	Unit
Primary energy consumption	1,8 [94]	3.22	toe/capita (2012)
Energy dependence	34.03	55.4	%
Renewable energy share	35.4[95]	17.9	%
GHG emissions	7.78	9.47	ton CO_2-eq/capita
Bioenergy in RE	6.47[96]*	69	%
Bioenergy in total energy	-	10.6	%
Biofuels prod. Capacity	-	0.051	ton/capita
CHP	-	17.3%	% gross electricity generation
District heating	450[97]	7,404	km
	-	0.3	m/capita

*Share in total electricity production capacities

[93] *Source: "Energy Balance Sheets 2017 data," Eurostat, 2019.*

[94] *Source: "Energy, transport and environment statistics", Eurostat,*

[95] *Source: Third Annual Report under the Energy Efficiency Directive," Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina , 2019.*

[96] *Source: "National Renewable Energy Action Plan of Bosnia and Herzegovina", 2016*

[97] *Source: https://www.euroheat.org/knowledge-hub/country-profiles/district-energy-bosnia-herzegovina/*

6.4.1. ELECTRICITY

The electricity market of Bosnia and Herzegovina is characterised by domination of 3 vertically integrated utilities: "JP Elektropriveda BIH d.d." (in further text JP EP BIH or EP BIH), "Mješoviti Holding Elektroprivreda Republike Srpske a.d." (in further text MH ERS or ERS) and "Elektroprivreda Hrvatske zajednice Herceg Bosne d.d." (in further text EP HZHB), wherein Elektroprivreda BIH (EP BIH) generated ~7,2 TWh, Elektroprivreda RS (ERS) ~5,8 TWh, and Elektroprivreda Hrvatske zajednice Herceg Bosne (EP HZHB) ~1,5 TWh.

Elektroprivreda RS is organised as a mixed holding and owns 2 thermal power plants with the related coal mines, 5 hydropower plants and 4 small hydropower plants. In Republika Srpska, energy is also generated in the plants using RES (16 small HPP and 38 solar power plants), with a total power capacity of 44,5 MW. Electricity is also generated by the company Alumina for its own needs. In 2016, thermal power plant Stanari also entered the system and generated ~ 1,5 TWh of electrical energy, while in the future it is expected to annually generate ~2TWh. In the Federation of Bosnia and Herzegovina, EP BIH produces energy from 2 thermal power plants, 3 hydropower plants and 7 small hydropower plants. On the other hand, EP HZHB produces electrical energy from 7 hydropower plants. Along with the listed energy generating facilities, in Federation of Bosnia and Herzegovina electrical energy is produced in privately owned generation units, 109 of them, and in 3 industrial power generating units for 2015. In 2016, there were registered 161 production units owned by 117 qualified producers.

Elactricity generation in Bosnia and Herzegovina in 2016 is presented on Figure 19.

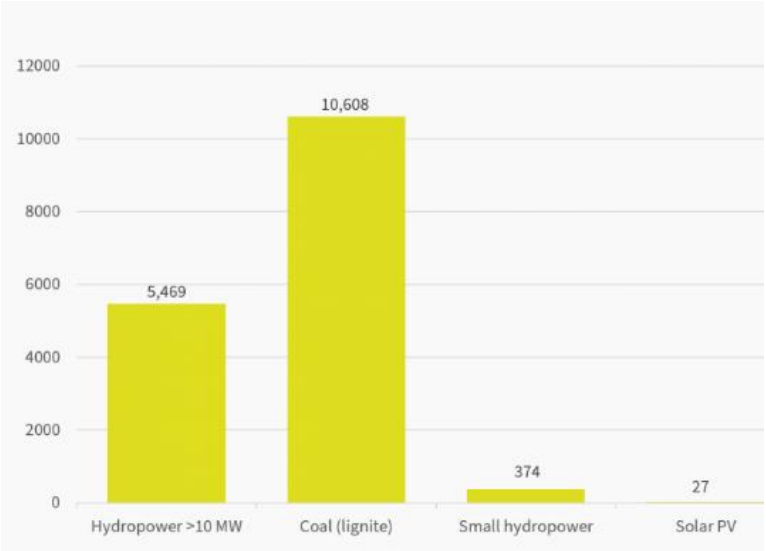

Figure 19 Electricity generation in Bosnia and Herzegovna in 2016 (in GWh)[98]

Table 34 shows an overview of the existing production facilities per subject without small and other industrial power plants in Bosnia and Herzegovina in 2016.

[98] *Source: A. Kazagic and e. al., "Future of the nee thermal power plants in BiH based on CHP, biofuels integration and processes optimization," Academy of Science of BiH, Sarajevo, 2019.*

Table 34 An overview of the existing production facilities per subject without small and other industrial power plants in Bosnia and Herzegovina, 2016[99]

	Company	Object	Type	Inst. power (MW)		Generation 2016. (GWh)		Expected decommission of TPP
FBIH	EP BIH	TPP Tuzla	Lignite/hard coal	715	1.173	3.687	5.781	2021(G3), 2022-23(G4), 2022-30(G5), >2035(G6)
		TPP Kakanj	Lignite/hard coal	450		2.094		2023-24(G5), 2024-27(G6), >2035(G7)
		HPP Jablanica	Storage	180	1.376	748	2.935	-
		HPP Salakovac	Storage	210		379		-
		HPP Grabovica	Storage	114		268		-
	EP HZHB	HPP Rama	Storage			687		-
		HPP Čapljina	Pump-storage	440		145		-
		HPP Mostar	Storage	72		232		-
		HPP Jajce 1	Run-of-river	60		195		-
		HPP Jajce 2	Run-of-river	30		153		-
		HPP Mostar Blato	Run-of-river	60		83		-
		HPP Peć Mlini	Run-of-river	30		45		-
RS	EFT Stanari	TPP Stanari	Lignite	300	900	1.566	4.838	-
	ERS	TPP Ugljevik	Hard coal	300		1.751		>2035
		TPP Gacko	Lignite	300		1.521		2024 or 2031
		HPP Višegrad	Storage	315	830	1.078	2.497	-
		HPP Dubrovnik G2	Run-of-river	126		717		-
		HPP Trebinje I & II	Storage	188		451		-
		HPP Bočac	Storage	110		251		-

The strategy for the development of the power generation mix in Bosnia and Herzegovina should be properly positioned within the key strategic goals of the energy trilemma, i.e. security of supply, price acceptability or sustainability (decarbonisation). Illustrative vision of strategic goals is presented in Table 35.

It is important to mention projects and initiatives, which are already undertaken in order to increase share of bioenergy resources in electricity production in Bosnia and Herzegovina.

- Project of co-combustion of biomass and coal in thermal power plants in Bosnia and Herzegovina, is in R&D phase, thay are running lab scale tests on Faculty of Mechanical Engineering Sarajevo.
- 0.1-rate biomass co-firing trial run at Kakanj CHP (5-118 MW units), in 2019.
- BIOFIT already started with a goal to achieve co-combustion (up to 30% w) on block 6, 223 MWe in TPP Tuzla[100].
- Full conversion on biomass on the block 5, 118 MWe TPP Kakanj.
- Wood chips gasification CHP plant 250 kWe and 500 kWt in Toplana prijedor.

According to Third Annual Report under the Energy Efficiency Directive from 2019, Primary Energy Consumption (PEC) will be reduced by 12% compared to forecasted consumption without energy efficiency measures. In absolute terms, in comparison to the forecasted TPEC of 8,031.98 ktoe without any energy efficiency measures, this amounts to 7,068.14 ktoe

[99] *Source: "Third Annual Report under the Energy Efficiency Directive," Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina , 2019.*

[100] *Source: https://www.biofit-h2020.eu/news-and-events/press-release-5-august-2019/*

with implementation of planned energy efficiency measures or a reduction of consumption by 963.84 ktoe[101].

Based on the Decision of implementation of the Directive 2009/28/EC, a binding goal has been defined pertaining to 40% of share of RES in total final consumption until 2020 for the entire Bosnia and Herzegovina, which equals 1.940 ktoe. Accordingly, a goal has also been defined for both entities with regard to the RES share in final consumption, in order to achieve the goal at the level of Bosnia and Herzegovina. According to Action plans, the goal for the Federation of Bosnia and Herzegovina is to reach 41% of RES share, and for Republic of Srpska 48%. The target is calculated as a sum of indicative targets for the Federation of Bosnia and Herzegovina, Republika Srpska and Brčko District of Bosnia and Herzegovina. Heating and cooling sector should contribute the most to achieving the target for Bosnia and Herzegovina with share of 56% in total RES energy consumption. It is expected that the share of electricity sector will be 38% and for transport 6%[102].

6.4.2. DISTRICT HEATING

According to available data , there are 23 heat plants in Bosnia and Herzegovina, from which 13 are in Republikc of Srpska (Banja Luka, Prijedor, Doboj, Zvornik, Gradiška, Brod, Istočno Sarajevo, Čelinac, Bijeljina, Pale and Sokolac) and 10 in the Federation of Bosnia and Herzegovina (Sanski Most, Tešanj, Lukavac, Tuzla, Banovići, Zenica, Kakanj, Breza, Sarajevo and Konjic). In addition to these heating plants, the Ugljevik TPP, which provides thermal energy for Ugljevik needs, is included in the supply system[103].

According to the data taken from the energy balance for 2016, district heating in Republika Srpska supplies about 2,3 million m^2 of residences, and 460 thousand m2 of business premises, while there are about 970 thousand apartments that are heated through larger heating companies. There is no system for hot water preparation in Bosnia and Herzegovina and heat supply is used only for heating purposes.

The primary fuel used in Republic of Srpska is fuel oil with the highest share of about 42%, then coal, natural gas and wood waste and wood. The primary fuel used in the Federation of Bosnia and Herzegovina is solid fuel and fuel oil, except in Sarajevo where primary source is natural gas.

According to Statistics Agency of Bosnia and Herzegovina district heating plants produced 3.371 TJ of heat in 2017, and Table 35 shows data about fuels consumption.

[101] *Source: "Third Annual Report under the Energy Efficiency Directive," Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina , 2019.*

[102] *Source: " Framework Energy Strategy of Bosnia and Herzegovina until 2035," Reform assistanece to Boania and Herzegovina , 2017.*

[103] *Source: " Framework Energy Strategy of Bosnia and Herzegovina until 2035," Reform assistanece to Boania and Herzegovina , 2017.*

Table 35 Fuel consumption in distric heating plants in Bosnia and Herzegovina in 2017[104]

Fuel use in district heating plant	Unit	Quantity
Brown coal	t	35.208
Lignite	t	49.101
Natural gas	Mn3	53.900
Wood wastes and pellets	t	15.437
Fuel wood	t	34.883
Fuel oil, light	t	104
Fuel oil, S<1%	t	999
Fuel oil, S≥1%	t	13.690

6.5. SUMMARY AND CONCLUSIONS IN RELATION TO SWOT ELEMENTS

Sava river flow with ports is good potential for biomass transport and regional cooperation, because biomass supply chains are mayor problem for the bioenergy projects, and became more serious in Bosnia and Herzegovina. Motorway network is under intensive development and construction, but local and state roads requires improvements. Railway network needs renovation and more intensive development. Bosnia and Herzegovina accounts for more than 20,000 km of forest roads.

Priority of Bosnia and Herzegovina is to increase the supply of energy from renewable sources and thus strives to replace outdated technologies with more efficient and environment-friendly technologies for using renewable sources. According to Action plans, the goal for the Federation of Bosnia and Herzegovina is to reach 41% of RES share, and for Republic of Srpska, 48%. According to that one of the important energy sources is biomass, wooden and other forms. According to available data Share of electricity from renewable energy sources in total electricity generation in 2017 was 23.5% (EU-28 is 29.9%).

The main SWOT analysis findings considering the infrastructure, logistics and energy sector are summarised in table 36.

[104] *Source: "Energy Statistics, First Release, no. 10," Statistical Institute Boania and Herzegovina, 2018.*

Table 36 SWOT analysis of the infrastructure, logistics and energy sector in Bosnia and Herzegovina

Strengths	Weaknesses
Motorway network under intensive development Relatively developed road infrastructure of forest roads Access to the Sava river Initiatives for integration of biofuels in power production sector Intensive development of DHS based on biomass	Lack of knowledge among the stakeholders in whole levels Lack of strategic planning regarding to bioenergy chains development Lack of biomass CHP plants Poor quality of state road transport Undeveloped and pure quality of rail network Lack of inland road/rail logistic terminals Lack of good and reliable statistical data necessary for planning Large portion of coal in electricity production
Opportunities	**Threats**
Good position of the BiH in WB countriesand on TEN corridors (Baltic-Adriatic and Mediterranean corridors) Opportunities for new RES based, energy technologies development and integration Available river harbors Opportunity for rail infrastructure development Job creation Increased competitiveness of the country	Worrying condition of the state road network Condition of the rail network High level of corruption in infrastructure, and energy sector Low level of reforms in power production and transmission sector Undefined legal status of DHS (they are under local authorities jursdiction)

7. Skills, education, research and innovation potential

7.1. RESEARCH INFRASTRUCTURE

In terms of European Research Area priorities, Bosnia and Herzegovina participates in the European Research Area Committee and related advisory bodies and initiatives. It also participates in the European Strategic Forum on Research Infrastructure, but has to develop the roadmap for researcher infrastructure. Bosnia and Herzegovina has concluded numerous bilateral cooperation agreements, with a focus on close cooperation with neighbouring countries and the EU[105].

According to available statistics, research infrastructure in Bosnia and Herzegovina is relatively weak, comparing to EU27 average. Research development personnel in 2018 were 2,200 full time equivalents and researchers were 1,600, full time equivalents, while Serbia had 20,900 and 14,500, respectively and EU27 had 2.79 Million and 1.77 million, respectively[106].

In Bosnia and Herzegovina higher education and science are under jurisdiction of entities. The research system in Bosnia and Herzegovina is decentralised, each entity enjoying decision-making and policy coordination autonomy. The Governments of BiH have put in place a range of measures aimed at training enough researchers to meet its R&D targets and at promoting attractive employment conditions in public research institutions.

In Republic of Srpska, sectors of higher education and science are under jurisdiction of RS Ministry of Education and Culture and the RS Ministry of Science and Technology. The RS Ministry of Science and Technology within the Government of RS is in charge of issues related to science and technology in the RS, and it actively participates in distribution of information related to research funds (such as FP7) in the field of science and technology[107].

According to the Register of the R&D institutions in the Republic of Srpska, there are in total 162 institutions in this sector belonging to 4 types of institutions[108]:

- Public Institutes: 33
- Private Institutes: 60
- Public Universities and Faculties: 38
- Private Universities and Faculties: 31

[105] *Source: "Commission Opinion on Bosnia and Herzegovina's application for membership of the European Union", 2019*

[106] *Source: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Research_%26_development_personnel_and_researchers,_2013-2018_(thousands_of_full-time_equivalents)_CPC20.png*

[107] *Source: "Third National Communication and Second Biennial Update Report on Greenhouse Gas Emissions of Bosnia and Herzegovina under the United Nations Framework Convention on Climate Change," UNDP , 2017.*

[108] *Source: "Roadmap of research infrastructures in Republic of Srpska (Bosnia and Herzegovina)", 2019*

There are 23 R&D institutions participating in EU projects, i.e. 14.2% out of all R&D organisations in Republic of Srpska. Republic of Srpska has adopted Strategy of Development of Scientific and Technological Development for the period 2017-2021.

In Federation of BiH, public universities are established by cantons, whereas the FBiH Ministry of Education and Science performs administrative, professional and other tasks at the level of entity, including copyright and protection of intellectual property rights, as well as coordination of scientific and research activities. Cantonal ministries in FBiH regulate the education and science policy for their cantons. Cantonal governments monitor the educational policy, finances and operations of public and private institutions of higher education. Federation BiH has adopted Strategy of Development of Scientific-Research and Research- Development Work in the Federation of BiH for the period 2012-2022. The strategy aims to improve the promotion of scientific work in universities, with a particular focus on education and the promotion of young researchers.

7.2. EDUCATION INFRASTRUCTURE

At the beginning of 2012/2013 school year, there were 471,543 students in Bosnia and Herzegovina15. Of these, 304,881 students attended 1,881 primary schools, which is for 3.7% less compared to the preceding school year; and 166,662 students attended 309 secondary schools, which is for 2.1% more than in the preceding school year. There are seven public universities (with 95 schools) and numerous private universities with a total of approximately 116,000 full-time students. Education in BiH is covered by legislation at various levels in the FBiH and RS. In RS, all education levels are covered by entity level legislation. There are separate laws for each

of the four levels of education mentioned above. In FBiH, education is regulated at the cantonal level. Each of the ten cantons has its own law on pre-school, primary and secondary education, and the cantons that have universities also have laws on higher education. The Brčko District, as a separate organizational unit in BiH, has its own laws covering each of the four levels of education. Therefore, there are more than thirty laws at different levels governing this area.

The responsibility for issues of higher education and science lies with the Entities of Republika Srpska and Federation of BiH, and in FBiH this role belongs to the cantons. The Ministry of Civil Affairs of BiH has a coordinating role at the state level; i.e., it coordinates the activities of the relevant entity bodies in this field and is in charge of international cooperation. Through two of its sectors – the Sector for Science and Culture and the Sector for Education – this Ministry coordinates and monitors the implementation of international agreements and strategic documents in the field of education and science, participation in activities of international organisations in the field of education and science, participation in EU programmes (FP7, COST, EUREKA, ERASMUS MUNDUS, etc.) and monitoring the process of European integration.

Participation in this EU programme fosters young people's non-formal learning at international and national levels so as to enhance their competences, skills and employability. Records show 3,700 mobilities of staff and students from Bosnia and Herzegovina since 2015, and 30 capacity building projects are currently being implemented in the field of higher education involving local beneficiaries[109].

7.3. ENVIRONMENT FOR START-UPS

The startup and venture ecosystem in Bosnia and Herzegovina is growing, but it is still underdeveloped, unexplored and undocumented. The number of programs for young entrepreneurs is expanding, from university programs through non-governmental organizations and government initiatives to professional incubators and accelerators. The geographical scope is also increasing highly and the aforementioned can be found in all bigger towns in the country including Sarajevo, Mostar, Banja Luka, Tuzla, Zenica. Smaller towns are also exposed to this trend through larger initiatives and/or as a part of current projects.

According to analysis presented in document under the title "Southeast Europe Startup Report" some of the key recommendations to the governments for the successful implementation and development of startup ecosystem in Bosnia and Herzegovina[110]:

- Improving overall business environment with a focus on administrative and regulatory obstacles,
- Enabling legal use of online payment gates such as Paypal, which would enable startups to offer their products abroad and to operate more effectively.
- Establishing seed-co-investment fund that would replace existing grant programs which are hard to monitor and are shown to be ineffective, and which would create safer environment for angel investors to invest in BiH startups.
- Creating an R&D Tax for IT companies that invest in product development and create new employment opportunities.
- Tax relief programs for incubators and accelerators that offer free office space for startups, but which, under existing infrastructure still have to pay taxes – to put it simply, today they have to
  pay to the government to provide free office space to young entrepreneurs.

7.4. PUBLIC PRIVATE PARTNERSHIPS

The constitutional and legislative structure of Bosnia and Herzegovina (BiH) is complex since it is composed of two entities – the Republic of Srpska (RS) and the Federation of Bosnia and Herzegovina (FBiH) – and Brcko District (BD) as a separate unit, and the legislation is adopted on the state level, entity level, and – in FBiH – on the cantonal level. This means that in BiH

[109] *Source: "Commission Opinion on Bosnia and Herzegovina's application for membership of the European Union", 2019*

[110] *Source: "Southeast Europe Startup Report," ©ABC Accelerator, 2017.*

as such there is no unified Law on PPP, but rather 12 laws on PPP. While the RS and BD adopted their PPP laws in 2013 and 2010, the FBiH drafted a Law on PPP in 2009 which remains in the adoption process. In addition, the cantons in the FBiH have their own set of PPP laws[111].

The few large scale PPP's in BiH have occurred mostly in Republic od Srpska, where, most prominently, the International Dialysis Center and Fresenius Medical Care successfully implemented PPP projects in the health sector. Republic of Srpska also entered into two PPP projects for the construction of thermal power plants: Stanari and Ugljevik 3. Beside of that DHS Banja Luka used PPP models in order to build new 50 MWt thermal plant and supporting infrastructure. Federation BiH has several times announced PPP models for the realization and construction of certain sections of the Vc corridor, but concerns about the bankability of the projects obviously blocked them from realization. There are alo some initiatives mainly under UNDP projects, which are focusing on PPP in public lighting sector.

7.5. Summary and conclusions in relation to SWOT elements

Relevant research/development infrastructure related to bio-based industrial development may be found at the:

- University of Sarajevo,
- University of Banja Luka,
- University of Tuzla ,
- University od East Sarajevo.

As already mentioned entities and state investment in R&D is small, but research programs are oriented towards the development of new technologies and products.

Above mentioned universities are engaged in education relevant to foster bio-economy in Bosnia and Herzegovina (chemistry, biology, engineering, etc.).

Some initiatives for start-ups creation and incubators already exists. It is also important to say that some associations and clusters related to wood processing and bio-economy exists and they are active, and also dealing with some aspects of education and knowledge improving among the members. Legal framework for PPP already exists in both entities and some PPP projects in bioenergy sector are active (mainly DHS).

The main SWOT analysis findings considering the skills, education, research and innovation potential are summarised in table 37.

[111] *Source: https://ceelegalmatters.com/analysis/8676-public-private-partnership-projects-in-bosnia-and-herzegovina," [Online]. [Accessed 06 2020].*

Table 37 SWOT analysis of the skills, education, research and innovation potential in Bosnia and Herzegovina

Strengths	Weaknesses
Highly-skilled engineering professionals are educated, which are very flexible or adaptable Modern strategies for R&D were adopted High education system is adopted according to Bologna Growth of startups in last decade PPP projects in last couple years	Lack of knowledge among the stakeholders in whole levels Weak R&D infrastructure Lack of investment in R&D Small number of applications to H2020 and similar funds Lack of interest from the industrial partners Lack of knowledge among industrial partners about cooperation possibilities with R&D
Opportunities	**Threats**
Setting up pilots in order to speed up development, as the rest is mostly available Definition of high-school programs and university programs oriented to different aspect of biomass resources use Incentives for dual education and prequalification Job creation Increased competitiveness of the country	The loss of engineers due to brain drain migration or competitiveness due to PPP pilots lacking The loss of high-school educated labour due to draining from the country High level of bureaucracy

This project received funding from the BBI JU under the EU Horizon 2020 research and innovation programme under grant agreement No.838087

8. Policy framework: Regulations, legislation, rule of law & taxes and tariffs

8.1. Introduction

The policy mechanisms have been grouped as:

- Regulations that define rules to control actions (coloured green). These include quota obligations, product standards, tax exemption and reduction, targets and qualifying criteria for incentives, feed-in-tariffs, green procurement, etc.
- Financing mechanisms that support investments and operation of value chains (coloured blue). They include feedstock premiums, capital grants, technology and feedstock related premiums, tax incentives, user charges, research funds, etc.
- Information provision mechanisms (coloured yellow) that include soft actions for the promotion and dissemination of best practices and successful lessons learnt, capacity building, awareness raising, etc.

	Biomass Production	Conversion	Distribution	End-use
Agriculture, Forest, Waste	Programme of subsidies for Agriculture and Rural Development			
	The Green for Growth Fund, Southeast Europe (GGF)			
		Law on Concessions: RES-E exclusion concession	Feed-in tariffs	
		The Regional Energy Efficiency Programme (REEP)		
	Climate Change Adaptation and Low-Emission Development Strategy			
	Nationally Determined Contribution (NDC) to Paris Agreement- Bosnia and Herzegovina			
	National Renewable Energy Action Plan- Bosnia and Herzegovina			

Policy	Feed-in tariffs[112]
Time period	Started 2011- Amended 2014, 2015, 2016:
Type of Instrument	Economic: Feed-in Tariff
Main objective	Is to increase the share of RES-E
Description	The main support scheme for the production of electricity from renewable energy sources in Bosnia and Herzegovina is a feed-in tariff, separately regulated by the RES Law Federation of BiH (FBiH) and special Decrees and Rulebooks. Also in Republic of Srpska (RS), production of electricity from renewable energy sources is supported by feed-in tariff, regulated by RES Law in Republic of Srpska and and premium, regulated by the Energy Law RS, Electricity Law RS and above all the RES Law RS, special Decrees and Rulebooks. In both cases the plant operators need to obtain RES Certificate and a Decision on the Right to Support by applying to the Energy Regulator (Regulatory Commission of RS and Regulatory Commission of FBiH), the status of a privileged power producer and in order to acquire the right to a price support for the generated electricity under the legal requirements. Hence, the Support Scheme Operator (in RS and FBiH) concludes a power purchase agreement at a guaranteed price. After having concluded a power purchase agreement with the plant operator, the Operator for Renewable Energy Sources and efficient cogeneration is legally obliged to buy the total amount of electric energy from privileged producers at an incentive price. The amount of the feed-in tariff is determined in the Decision on the determination of the guaranteed prices for electricity from renewable energy sources and efficient cogeneration and depends on the type of technology and the capacity of the power plant. Republic of Srpska has also introduced a feed-in-premium system as an option, whereas the Brčko District of BIH does not operate an RE support system. The funds are financed by an incentive fee that the final consumer is obliged to pay on the amount of consumed electricity (Art. 30 RES Law RS and). Outside the support system, electricity generation from RE sources can be remunerated on the basis of a reference price set by the Regulatory Commissions of the entities. Eligible technologies from the aspect of bioenergy are biomass and biogas, and they are divided by sizes of the plants as: micro, small, medium and macro in FBiH. In RS it is divided by sizes, for biomass is: up to 1 MW, and 1 to 10 MW, for feed-in and premium schemes, and for agricultural biogas is up to 1 MW and above 1 MW, for feed-in schmes.

Policy	The Green for Growth Fund, Southeast Europe (GGF)[113]
Time period	Started 2009: Ongoing
Type of Instrument	Financial: Loans, Investment subsidies

Main objective	Is to enhance energy efficiency and foster the use of RE through reduction of energy consumption and CO2 emissions.
Description	The GGF provides refinancing to financial institutions for on-lending to enterprises and private households seeking to finance energy efficiency projects. The GGF also invests directly in small to medium-scale renewable energy projects. To maximize the impact of the Fund's investment activities, the GGF's Technical Assistance Facility offers capacity building support to local financial institutions and partners. The GGF was initiated as a public-private partnership in December 2009 by the KfW Development Bank (KfW) and the European Investment Bank (EIB) with the financial support of the European Commission, the German Federal Ministry for Economic Cooperation and Development (BMZ), and the European Bank for Reconstruction and Development (EBRD). Its growing investor base comprises donor agencies, international financial institutions and institutional private investors, and recently added the International Finance Corporation (IFC) and Netherlands Development Finance Company (FMO).

Policy	Programme of subsidies for Agriculture and Rural Development [114][115]
Time period	Started in 2014- Ongoing
Type of Instrument	Economic: Investment subsidies
Main objective	Is to support agricultural production and rural development
Description	The first time BiH, as the state, has the Strategic Plan for Rural Development (SPRD) of BiH, 2018-2021 (framework document) (adopted in February 2018), which represents compilation of goals and measures from two valid entities' strategies of agricultural development (in FBiH and RS). Some of the strategic goals of SPRD are: ensuring the stability of incomes, strengthening the competitiveness of agriculture, forestry and rural areas, improving marketability of agro-food products, sustainable management of natural resources and climate change adaptation, improving the quality of life in rural areas and improving the institutional systems and capacities and harmonization of the legal framework. Rulebook on distribution of subsidies for Agriculture and Rural Development in 2014 provides guidelines for direct payments of budgetary subsidies for agricultural production and rural development. Direct payments included payments based on input as various types of premiums for production, mainly for

[112] *Source: http://www.res-legal.eu/search-by-country/bosnia-and-herzegovina/single/s/res-e/t/promotion/aid/federation-of-bosnia-and-herzegovina-feed-in-tariff-guaranteed-price/lastp/474/*

[113] *Source: https://www.s2biom.eu/images/Publications/D6.1_S2Biom_Policy_Database_Final.pdf*

[114] *Source: https://www.s2biom.eu/images/Publications/D6.1_S2Biom_Policy_Database_Final.pdf*

[115] *Source: https://ec.europa.eu/neighbourhood-enlargement/sites/near/files/20190529-bosnia-and-herzegovina-analytical-report.pdf*

	milk, direct payments per head of cattle/hectare and other direct payments. Support measures are not harmonised nor implemented at an even pace across the country.
Policy	Law on Concessions: RES-E exclusion concession procedure[116] [117]
Time period	Started in 2005- Amended in 2013
Type of Instrument	Economic: Tax reductions
Main objective	Is to stimulate investments in biomass and biogas (RES-E plants)
Description	Based on the provisions of the Law on Concessions, biomass and biogas RES-E plants are excluded from obligatory concession procedure for the construction of RES-E plants. As far as concessions are concerned, these are regulated at state, entity, cantonal and Brčko District level, resulting in 14 separate laws on concessions at all levels, while public-private partnerships are regulated by separate laws in the Republika Srpska entity, in the Brčko District, and in nine cantons. For concessions and private public partnerships various bodies are competent at the state, entity, cantonal and Brčko District levels. These include commissions for concessions, commissions for public-private partnerships, the Council of Ministers at the state, and governments at entity, cantonal and Brčko District level, as well as the respective ministries competent in this area. The legislative framework on concessions and public private partnerships is highly fragmented and needs to be aligned with the EU acquis. All legal and financial instruments used in the area of public procurement and concessions, including inter-governmental agreement concluded with third countries, should comply with the principles of transparency, competition, equal treatment and non-discrimination.

Policy	The Regional Energy Efficiency Programme (REEP)
Time period	Started 2013-Onging
Type of Instrument	Economic: Investment subsidies, Loans
Main objective	Is to stimulate investments in energy efficiency and use of renewable energy.
Description	The REEP aims to support energy efficiency investments in both public and private sectors and encourages the public sector to take leadership role as agreed in the National Energy Efficiency Action Plans. Energy Efficiency in public procurement: Under the scope of the REEP Current obligations on energy efficiency in public procurement are set by

[116] *Source: https://s2biom.vito.be/node/1263*

[117] *Source: https://ec.europa.eu/neighbourhood-enlargement/sites/near/files/20190529-bosnia-and-herzegovina-analytical-report.pdf*

the following EU Directives that must be transposed and properly implemented by the Western Balkan countries as Contracting Parties of the Energy Community:

- Directive 2006/32/EC (Article 5 "Energy end-use efficiency in the public sector" and Annex VI "List of eligible energy efficient public procurement measures")
- Directive 2010/30/EU (Article 9 – "Public procurement and incentives").

The Western Balkans Sustainable Energy Direct Financing Facility (WeBSEDFF) provided investment subsidies and loans to support small and medium RE projects. The new REEP for the Western Balkans seeks to benefit from prior experience with sustainable energy financing facilities (SEFFs) by replicating the model while modifying it to best support the participating countries to achieve their sustainable energy objectives as set out in their NEEAPs. The REEP is thus made out of three complementary „windows": policy dialogue and project preparation support window, credit line facility window (WeBSEFF II), and direct financing facility window (WeBSEDFF). WeBSEFF II presents the credit lines framework which is extended to local financial institutions for on-lending to smaller scale energy efficiency and renewable energy projects. WeBSEDFF presents direct financing windows which tends to invest in both medium-scale renewable energy and energy efficiency improvements in industrial enterprises, and with the intention to provide financing for ESCO projects.

Policy	Climate Change Adaptation and Low-Emission Development Strategy[118][119][120]
Time period	Adopted in 2013 and 2017
Type of Instrument	Information: Strategy
Main objective	Bosnia and Herzegovina adopted the Climate Change Adaptation and Low Emission Development Strategy in 2013, and ratified the Paris Agreement in March 2017. Yet the country has yet to begin implementing the Paris Agreement in a systematic manner. The country is also committed under the Energy Community Treaty to achieving a target of 40 per cent renewable energy in its energy mix by 2020. However, the reform of the renewable energy framework regarding net metering and development of incentive mechanisms has yet to be conducted. Is to outline innovative economic development plan, actions that would enable both economic growth and prevention of environmental destruction in sectors such as agriculture, biodiversity and susceptible

[118] *Source:https://www.ba.undp.org/content/bosnia_and_herzegovina/en/home/library/environment_energy/climate-change-adaptation-and-low-emission-development-strategy-.html*

[119] *Source: http://www.wb-reep.org/eng/about*

[120] *Source:https://www.ba.undp.org/content/bosnia_and_herzegovina/en/home/Blog/How_is_BiH_addressing_the_climate_challenge.html*

	ecosystems, energy sector, forestry, health, tourism and water management.
Description	The Strategy aims that Bosnia and Herzegovina will become sustainable and prosperous country of green economy by 2025. The approach outlined in this Strategy encompasses two closely linked components: climate change adaptation and low-emission development. The adaptation to climate change component implies an increase of Bosnia and Herzegovina's resilience to climate variability and long term climate change, whereby profit can be ensured. The low-emission development component aims to develop low-emission economy based on: - Efficient use of resources; - Increase in energy efficiency; - Wider utilization of renewable energy resources; and - Improved energy and transport infrastructure and services.

Policy	Nationally Determined Contribution (NDC) to Paris Agreement-Bosnia and Herzegovina[121]
Time period	Started in 2015-Ongoing
Type of Instrument	Regulatory: Target
Main objective	Is to reduce GHG emissions.
Description	In line with the trend of consumption and energy production growth, as a result of development of the country, total emissions also have an upward trend. According to the developed scenarios - their peak occurs in 2030; according to the baseline scenario (BAU) in 2030 expected emissions are 20% higher than the level of emissions in 1990. Emission reduction that BiH unconditionally might achieved, compared to the BAU scenario, is 2% by 2030 which would mean 18% higher emissions compared to the base year 1990. Significant emission reduction is only possible to achieve with international support, which would result in emission reduction of 3% compared to 1990, while compared to the BAU scenario it represents a possible reduction of 23%.
Policy	National Renewable Energy Action Plan of Bosnia and Herzegovina[122]
Time period	Adopted in 2016

[121] *Source:http://climatepolicydatabase.org/index.php/Intended_Nationally_Determined_Contributions_(INDC)_Bosnia_and_Herzegovina*

[122] *Source: https://www.enercee.net/index.php?id=322*

Type of Instrument	Regulatory: Target
Main objective	Is to promote the use of renewable energy
Description	A National Renewable Energy Action Plan (NREAP) was adopted in April 2016, however, both entities have adopted their own renewable energy laws (as of 2013), feed-in tariff systems and NREAPs (in 2014). In the Federation BiH, a federal law on renewable energy sources and efficient CHP was adopted in 2013. It sets a regulatory framework to promote high-efficiency CHP and renewable generation; the entity's NREAP targets 41 % of renewables and CHP in power generation by 2020, from 36 % in 2009. In the RS, a new Renewable Energy Law was adopted in 2013, followed by a NREAP in 2014. The NREAP sets a 48 % target for renewables and high efficiency CHP in power generation by 2020, from 42 % in 2009. In 2018 November, the Federation BiH updated its Renewable Action Plan. The action plan sets tentative targets for the share of renewable energy in the total final consumption in the heating and cooling, electricity and transportation sectors for 2020. According to the action plan, by 2020, the share of renewable energy should reach 44% in the electricity sector, 49% in the heating and cooling sector, and 10% in the transportation sector.

Policy	Strategic Policy of Energy Sector Operations in BiH Framework Energy Strategy of Bosnia and Herzegovina until 2035
Time period	Adopted in 208 ((“Official Gazette BiH” No. 70/18)
Type of Instrument	Regulatory: Strategy
Main objective	Determinants of development of BIH energy sector including renewable energy, are defined based on entity strategies. [123]
Description	Security of supply is one of the aspirations and priorities through the period of time until 2035. According to this document strategic goals of maintaining the energy sector competitive and having security of supply must be balanced with the agenda of sustainable development and reduction of negative impacts on the environment, particularly bearing in mind the current position of Bosnia and Herzegovina relative to the EU initiatives, energy-related trends, as well as current and future obligations

[123] *Source: “ Framework Energy Strategy of Bosnia and Herzegovina until 2035,” Reform assistanece to Boania and Herzegovina , 2017.*

towards the Energy Community and other bodies, including the Paris Agreement guidelines.

This implies identification and mapping of natural resources and potentials in all segments of renewable energy, assessment of the exploitation possibilities, bearing in mind sustainability and impact on the environment, including long-term goals of decarbonisation and sustainable system. Considering that efficient transformation of renewable sources into electricity also implies exploitation of new, innovative technologies (which from the economic aspect become more affordable), it is important to create the most suitable environment to encourage their exploitation.

8.2. Summary and conclusions in relation to SWOT elements

As in most surrounding countries bioeconomy is not the central topic of any specific Bosnia and Herzegovina's framework or policy. There are, however, several entity and national frameworks that touch on the topic of bioeconomy. Bosnia and Herzegovina has supporting schemes for bioenergy producton, trough feed-in tariffs and premiums. It is also important to emphasize that new strategies and action plans for energy, agriculture and renewable energy sources has adopted. Thanking to this, country will be channelized toward sustainable development, which will include more renewables in energy balances, as well as bio-economy and circular economy in production sectors, as the only acceptable approach for long term future. Unfortunately, previous experiences shown that operationalization of above mentioned strategic documents and plans is always problematic, and this will require more serious engagement of all stakeholders as well as international community, particularly EU, because Bosna and Herzegovina is member candidate.

The main SWOT analysis findings considering the policy framework: regulations, legislation, rule of law & taxes and tariffs are summarised in table 38.

Table 38 SWOT analysis of the policy framework: regulations, legislation, rule of law & taxes and tariffs in Bosnia and Herzegovina

Strengths	Weaknesses
Significant potential foe bio economy development exists in many areas Support schemes for electricity production in from different kinds of biomass exists trough feed-in tariffs and feed –in premium (in RS) New modern strategy for agricultural development exists on the state level New modern strategy for energy sector development is adopted National plans for RES and EE exists Some policy framework which touch aspect of bioeconomy already exists	There are no specific measures in the field of bioeconomy Bioeconomy is not recognized on appropriate way as development potential on entities and the state level Problems in operationalization of strategic documents and plans There are no explicit legislative bioeconomy support Most measures rely on voluntary pledges from the private sector Limited resources for possible measure implementation A lack of financial incentive/ subsidies to foster bioeconomy development
Opportunities	**Threats**
There is a growing awareness that structural changes in policies are need for the development of bioeconomy Policies for improved biomass managing, increase in the use of forest wood and stimulation of the use of recognized certificates Forest certification bears huge potential for multi-functional forest management Specific policy development related to bioeconomy	There are no bioeconomy-specific policies and legislation Ignoring of the raising awareness of the need for structural change in policy Lack of knowledge among the stakeholders about buioeconomy Current forest and agricultural policies (entities, cantons) need more inclusive and participatory processes

9. Financing

9.1. Introduction

Pro-business climate in is a quite complex in Bosnia and Herzegovina which can be illustrated by WB Ease of Doing Business, where BiH is on 131 place. There are several reasons for that, but significant level of corruption as well as huge bureaucracy are some of the primary reasons. Due to high potential of whole bioenergy sector a growing recognition of the importance of FDI (Foreign direct investment) exists. There are several agencies and bodies encouraging foreign investments in this sector, as for example Foreign Investment Promotion Agency on the state level.

According to World Bank study for whole Western Balkans area, only for district heating sector, significant financing needs to be mobilized through 2030 to exploit the economic opportunities to increase biomass use and make the existing use more efficient. The estimated total investment amount required through 2030 to sustainably increase the use of biomass for heating in the region is EUR 950 million[124]. Therefore, it is recommended that a financing facility (or program) be created to support the increased use and efficiency of biomass heating, in a sustainable manner, in the consumption sectors of the W-B countries.

Some of the financing organization present in Bosnia and Herzegovina, and financing renewable energy projects, including Bosnia and Herzegovina are[125][126]:

- Western Balkans Sustainable Energy Financing Facility (WEBSEFF), they provide loans of between €2 million and €5 million through local banks (Raiffeisen Bank d.d. or Bosna I Hercegovina UniCredit Bank d.d.) for private investments in energy efficiency or renewable energy projects. Loans can cover 100 percent of the investment costs.
- Western Balkans Sustainable Energy Direct Financing Facility (WeBSEDFF), they provide Locally SMEs with a sound financial and economic structure and sufficient means of equity capital can apply for direct loans from the European Bank for Reconstruction and Development's WeBSEDFF of between €2 million and €6 million.
- Green Growth Fund, they provide direct and indirect (through financial intermediaries) financing for small scale renewable energy projects usually not larger than EUR 50 million.
- International Finance Corporation (IFC), they provide investments (equity, loans and other financial instruments) and advisory services, IFC supports investment with focus on Climate change, including investments in infrastructure and energy sectors.
- European Bank for Reconstruction and Development (EBRD), provides renewable energy developers with equity, loans and loan guarantees for projects with good commercial prospects of up to 15 years' duration.
- GEFF in the Western Balkans is a credit line facility of up to €85 million to the Western Balkan participating financial institutions to on-lend to residential sector for energy

[124] *Source: "Biomass-Based Heating in the Western Balkans – A Roadmap for Sustainable Development," WBG/WBIF, 2017.*

[125] *Source: "Renewable energy snapshot: Boania and Herzegovina," UNDP, 2015.*

[126] *Source: "Third Annual Report under the Energy Efficiency Directive," Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina , 2019.*

efficiency and renewable energy projects. GEFF provides loans through local Participating Financial Institutions: UNICREDIT BANK, UUNIKREDIT BANK BANJA LUKA, SPARKASSE, PARTNER.

- KfW credit line: Raiffeisen Bank is the project partner and operates a 1,000,000 EUR credit line for energy efficiency projects. Loans are approved for a maximum period of 7 years, including a grace period of up to 3 years. The additional advantage for clients (investors) is that the cost of preparation of project documentation is included in the cost of the loan.
- The Bosnia Energy Efficiency Project (BEEP) is the largest energy efficiency project in Bosnia and Herzegovina, with total planned investments over the next three years of 19 million USD in the Federation BiH and 13 million USD in the Republic of Srpska.

Both of the country's two political entities, the Republic Srpska (RS) and the Federation of Bosnia and Herzegovina (FBiH), promote electricity generated from renewable sources (including biomass) via a feed-in tariff. Beside of that both entities prioritize grid connection for renewable energy source operators. FBiH and RS both offer other incentives for foreign investors, such as customs-free imported materials in FBiH and corporate tax exemption in RS (FIPA, 2012).

Various agencies operate in Bosnia and Herzegovina and implement funding provided by developed countries for third country development. In the domain of energy efficiency, the most active are the UNDP (United Nations Development Program), agencies aiding based on bilateral agreements such as GIZ (German technical assistance), USAID (United States Agency for International Development), DEZA (Swiss cooperation), etc. This funding is mainly used for technical assistance in the domain of energy efficiency and for grants for energy efficiency pilot projects[127].

ESCO market and PPP, Bosnia and Herzegovina presently do not have the conditions in place for the creation of an ESCO market (Energy Service Company) and energy performance contracting[128].

Regarding to agriculture sector financing, farms and business entities fund their investment and current needs from various sources: own sources, loans from commercial banks and MCO/MCC, donations, subsidies and other sources (leasing, joint investments, etc.) [9].

According to available resources, Bosnia and Herzegovina Slovenia, has a great potential for fostering bioeconomy, But, for that reason, it I necessary to define policies and general support framework.

[127] *Source: "Third Annual Report under the Energy Efficiency Directive," Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina , 2019.*

[128] *Source: "Third Annual Report under the Energy Efficiency Directive," Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina , 2019.*

9.2. Summary and conclusions in relation to SWOT elements

Bosnia and Herzegovina has a great and unexploited potential for bioenergy projects and bioeconomy development in general. This development ultimately depends on the financing. There are not special investment incentives pushing activities on bioeconomy and bioenergy on more serious level. Banking sector has started different credit schemes with different kinds of support for potential users, but mainly in energy sector, There asre no some specific credit schemes for bio-economy in industrial sector.

The main SWOT analysis findings considering the financing are summarised in table 39.

Table 39 SWOT analysis of the financing in Bosnia and Herzegovina

Strengths	Weaknesses
Educated labor force, language skills and willingness to learn Investment promotion and incentives exists on certain level Increase in the number and market share of large commercial producers in agriculture; Price competitive labor force; Legal framework exists for PPP and ESCO	Lack of labor force in some regions Lack of the investments in bioenergy and bioeconomy Weak support institutions rom entity levels Small scope of international projects, platforms, networks that are based in specific measure Weak investment activity in processing activities in the direction of transitioning to bio-based alternatives Weak supporting activity of financial institutions towards bioeconomy projects (e.g. venture capital funds
Opportunities	**Threats**
Enhance Entities, State or Government funding and subsidies for fostering bioenergy and bioeconomy Promoting cluster formation Regional market development	Stagnant or reduced Governmental funding on the all levels Limited approach to EU funds High level of corruption and bureaucracy Possible risky nature of investment A lack of agencies providing equity and loans for bio-based initiatives Lack of foreign direct investments and inability to secure sources of financing for new investments in agriculture

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D.2.2 COUNTRY REPORT: GREECE

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Executive Summary in English

Greece's geographical location, varied terrain, culture and historical background offer unique prospects for the development of novel bioeconomy activities, but also multiple challenges.

Major sources of raw materials for the bioeconomy are primarily expected to originate from the agricultural sector (which will have to utilize its residues), food processing sectors (which can bring new value to its own) and waste management (which will have to be modernized according to circular economy principles). Even though forests cover a large part of the country, several structural weakness, lack of funding and policy direction will make it unlikely to evolve as a major supplier of biomass for the bioeconomy in the short-to-medium term, beyond current and potential new, small-scale applications.

The bio-based scene in Greece is enhanced by the activities of very competent research centres and academic institutions (with presence in multiple BBI and H2020 projects) as well as by various good-examples of enterprises, which however mostly operate on the small-scale for the production of bio-based products, cosmetics and food supplements. Lack of medium / large biorefineries is a hurdle that may be overcome if some traditional, fossil based industries like fossil refineries make the transition to a bio-based economy.

Infrastructure in Greece is undergoing its own transformation: the road network and port hubs are already modernized and expanding their activities, but railway connectivity stills needs improvements. The energy sector is also transiting; more emphasis is place on the role of biomass in the long, 2050 terms rather than in the 2030 goals.

Policies and legislation are a major impacting factor on the way the Greek economy evolves. Some of them are foreseen to create opportunities for various categories of bio-based products. However, the lack of a national bioeconomy strategy is clear. Also absent at the moment is the political intention to transform the state, regional and municipal authorities into major promotes and end-users of bio-based products; hopefully this may change in the future.

Finally, new financing tools are emerging and many of them are well suited to support small-scale, start-up companies working on the bio-based economy. For larger biorefineries, the level of financing that can be mobilized is still unclear and would very much depend on the perceived uncertainties of such projects.

This report on Greece's bioeconomy sector is organized in 9 chapters. In chapter 1 a first description is given of the key characteristics of the country of Greece. In the chapters 2, 3, and 4 the biomass production including their current uses and opportunities for what biomass can be additionally mobilised, is summarized for respectively the agricultural, forest, and waste sectors. In Chapter 5 a description is given of the current biobased industries and markets, in Chapter 6 the infrastructure, logistics, and energy sector are described. Chapter 7 focusses on the innovation potential. Chapter 8 focusses on the policy framework, in chapter 9 potential financing options related to the development of biobased production chains are discussed. The chapters are closed by swot analysis.

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Executive Summary in Greek

Η γεωγραφική θέση, η σύνθετη γεωμορφολογία, η κουλτούρα αλλά και το ιστορικό υπόβαθρο της Ελλάδας προσφέρουν ιδιαίτερες ευκαιρίες για την ανάπτυξη νέων δραστηριοτήτων της βιο-οικονομίας, αλλά θέτουν επίσης και σημαντικές προκλήσεις.

Οι κύριες πηγές πρώτων υλών για τη βιο-οικονομία αναμένεται πρωτίστως να προέρχονται από τν αγροτικό τομέα (ο οποίος θα πρέπει να διαχειριστεί τα υπολείμματά του), από τις βιομηχανίες επεξεργασίας τροφίμων (οι οποίες θα μπορούν να παράξουν νέα αξία από τα δικά τους) και από τη διαχείριση των απορριμμάτων (η οποια θα πρέπει να εκσυγχρονιστεί σύμφωνα με τις αρχές της κυκλικής οικονομίας). Τα δάση καλύπτουν ένα μεγάλο μέρος της χώρας, ωστόσο αρκετές δομικές αδυναμίες, η έλλειψη χρηματοδότησης και η κατεύθυνση πολιτικής, φαίνεται ότι συνηγορούν στο ότι δε θα αποτελέσουν σημαντικό προμηθευτή βιομάζας για τη βιο-οικονομία βραχυπρόθεσμα ή μεσοπρόθεσμα, πέραν των ήδη υπαρχόντων και πιθανώς νέων εφαρμογών μικρής όμως κλίμακας.

Ο τομέας των βιο-υλικών και βιο-προϊόντων στην Ελλάδα ενισχύεται από τις δραστηριότητες ανταγωνιστικότατων ερευνητικών κέντρων και ακαδημαϊκών ιδρυμάτων (με παρουσία σε πολλά έργα του Ορίζοντα 2020 καθώς και στα προγράμματα BBI), καθώς και από αρκετά καλά παραδείγματα εταιρειών, οι οποίες όμως λειτουργούν κυρίως σε μικρή κλίμακα για την παραγωγή βιο-βασισμένων προϊόντων, καλλυντικών ή συμπληρωμάτων διατροφής. Η έλλειψη μεσαίου ή μεγάλου μεγέθους βιο-διυλιστηρίων ίσως να ξεπεραστεί ένα κάποιες από τις υπάρχουσες βιομηχανίες ορυκτών καυσίμων, όπως τα διυλιστήρια πετρελαίου, αποφασίσουν να κάνουν τη μετάβαση στη βιο-οικονομία.

Οι υποδομές στην Ελλάδα διέρχονται κι από αυτές από τη δική τους μετάβαση. Το οδικό δίκτυο έχει σε μεγάλο βαθμό ήδη εκσυγχρονιστεί, ενώ τα λιμάνια επεκτείνουν το δυναμικό και στις δραστηριότητές τους, ωστόσο υπάρχει ακόμα ανάγκη για βελτίωση των σιδηροδρομικών συνδέσεων. Ο ενεργειακός τομέας επίσης μεταμορφώνεται, ωστόσο δίνεται περισσότερη έμφαση στο ρόλο της βιομάζας στους μακροπρόθεσμους στρατηγικούς στόχους για το 2050 παρά στους πιο άμεσους στόχους του 2030.

Οι πολιτικές κατευθύνσεις και η νομοθεσία επηρεάσουν σε πολύ μεγάλο βαθμό την εξέλιξη της ελληνικής οικονομίας. Ορισμένες πολιτικές αναμένεται να δημιουργήσουν ευκαιρίες για ορισμένες κατηγορίες βιο-βασισμένων προϊόντων. Ωστόσο, είναι φανερή η έλλειψη μιας συνολικής εθνικής στρατηγικής για τη βιο-οικονομία. Απουσιάζει επίσης προς το παρόν η πολιτική βούληση για τη μεταμόρφωση της κεντρικής κυβέρνησης, των περιφερειών και των δήμων σε βασικούς καταναλωτές βιο-βασισμένων προϊόντων. Ίσως αυτό αλλάξει το μέλλον.

Τέλος, νέα χρηματοδοτικά εργαλεία διαμορφώνονται και πολλά από αυτά είναι κατάλληλα για την υποστήριξη νέων, μικρής κλίμακας start-up εταιρειών που δραστηριοποιούνται στη βιο-οικονομία. Για τα μεγαλύτερα βιοδιυλιστήρια, είναι ακόμα ασαφές το επίπεδο χρηματοδότησης που μπορούν να κινητοποιήσουν νέες επενδύσεις, καθώς αυτό εξαρτάται σε μεγάλο βαθμό από τις θεωρήσεις για την αβεβαιότητα τέτοιων έργων.

Η παρούσα μελέτη σχετικά με τον τομέα της βιο-οικονομίας στην Ελλάδα χωρίζεται σε 9 κεφάλαια. Στο κεφάλαιο 1 συνοψίζονται ορισμένα βασικά χαρακτηριστικά της χώρας. Στα κεφάλαια 2, 3 και 4 παρουσιάζεται η παραγωγή βιομάζας και οι τρέχουσες χρήσης της στην Ελλάδα, καθώς και οι ευκαιρίες για την κινητοποίηση πρόσθετων ποσοτήτων από τους τομείς της γεωργίας, των δασών και της διαχείρισης απορριμμάτων αντίστοιχα. Στο κεφάλαιο 5 παρουσιάζονται οι τρέχουσες βιομηχανίες και αγορές βιο-προϊόντων, ενώ το κεφάλαιο 6 περιγράφει τις υποδομές στον τομέα των μεταφορών και της ενέργειας. Το κεφάλαιο 7 επικεντρώνεται στο δυναμικό καινοτομίας. Το κεφάλαιο 8 εξετάζει το θεσμικό πλαίσιο, ενώ το κεφάλαιο 9 εστιάζει στις πιθανές πηγές χρηματοδότησης για την ανάπτυξη αλυσίδων παραγωγής βιο-βασισμένων προϊόντων και υλικών. Κάθε κεφάλαιο ολοκληρώνεται από μια σύντομη ανάλυση SWOT.

This project received funding from the BBI JU under the EU Horizon 2020 research and innovation programme under grant agreement No.838087

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1 Introduction

1.1 Objectives and approach

The main objective of CELEBio is to contribute to the strengthening bioeconomy-related activities in Bulgaria, Czech Republic, Croatia, Hungary, Slovak Republic, Slovenia and neighbouring countries. To this end, one of the key activities is to develop seven comprehensive reports for the target countries and the wider neighbouring region on the availability of sustainable biomass, logistics, costs and biomass business opportunities assessed through an analysis of the Strengths, Weaknesses Opportunities and Threats (SWOT).

This report aims to provide the necessary background information needed to evaluate the possibilities for setting up bio-based production chains in Greece. Greece is one of the six countries adjacent to the core project area for which the CELEBio project also extends its activities.

The information structure and analysis presented in this report was developed by building on the method designed and applied by Van Dam et al. (2014) and was further refined through the execution of interviews with bio-based business developers and other experts. In these interviews further information was obtained on key factors that guide the choice of setting up bio-based activities in countries. Most of the experts stressed that all the identified factors are important and that a system approach is key in developing bio-based initiatives. If one link in the chain is missing, the bio-based initiative will not succeed. The identified factors are mapped in this report and will be the basis for performing a SWOT analysis for development of bio-based production chains.

In Annex 1 a further explanation is given of the approach used to set-up this country report.

1.2 Reading guide

This report is organised in 9 main chapters. Chapter 1 gives an overview of Greece's key characteristics. In the chapters 2, 3, and 4 the biomass production including its current uses and opportunities for what biomass can be additionally mobilised, is summarized for respectively the agricultural, forest, and waste sector. First the main traditional production and availability of biomass for food, feed, forest biomass and wood products are discussed and how this is handled in further processing industries and/or used for domestic markets and exports. Subsequently an overview is given of additional biomass potentials that are likely to be still unused or only partly used and that are a good basis for development of new bio-based activities. In Chapter 5 a description is given of the current bio-based industries and markets, advanced bio-based initiatives, and future biomass valorisation options. Chapter 6 describes the infrastructure, logistics, and energy sector. Chapter 7 focusses on the innovation potential, particularly in the context of bio-based research and development options. The research and educational infrastructure are discussed and the potential for developing bio-based start-ups and Public-Private-partnerships will be taken into a consideration. Chapter 8 gives an overview of the policy framework and describes extensively what regulations, legislation, taxes and tariffs exist of relevance for the development of bio-based production chains. Additionally, attention will be paid to situations where regulation and support measures are actually missing and to which extend the rule of law situation influences the establishment of new bio-based activities. In Chapter 9 potential financing options related to the development of bio-based production chains are discussed.

1.3 Short characteristics of country

Greece has a surface of 131,957 km². With 10.7 million inhabitants its corresponding population density is lower than the EU average one (See table 1.3.1). However, it should be noted that the national average distorts the large local / regional differences: the urban centres of Athens and Thessaloniki rank among the highest in population density in Europe; on the contrary, rural areas are much more sparsely populated. The average income level is below the European mean, but generally higher compared to CEE or SEE countries.

Table 1.3.1 Main population, land surface, GDP and trade characteristics of Greece benchmarked against EU average

Category	Greece	EU	Unit	Source / Year
Population	10.7	512.4	million	2018 / [1]
Area (total)	131.6	447	million ha	2018 / [1]
% population in urban areas	39.6%	41.8%	% of total population	2018 / [2]
% territory predominantly rural	62.52%	43.8%	% of total territory	2018 / [2]
% territory predominantly urban	5.68%	10.7%	% of total territory	2018 / [3]
Agricultural Area	5.1	173.3	million ha	2018 / [3]
Forest area	7.4	164.8	million ha	2018 / [3]
Population density	81	115	n°/km²	2018 / [1]
Agricultural Area per capita	0.48	0.34	ha/capita	2016 / [1]
Forest area per capita	0.69	0.32	ha/capita	2016 / [1]
GDP/capita	17,264	30,956	at current prices	2018 / [1]
	21,116	30,956	GDP at purchasing power	2018 / [1]
GVA by Agriculture, forestry and fishing	4.3%	1.6%	% of total GVA	2018 / [1]

GDP = Gross Domestic Product; PPS = Purchasing Power Standard; GVA = Gross Value Added; UAA = Utilised Agricultural Area
Sources:
[1] Eurostat most recent statistical data sources (Accessed July 2020) (https://ec.europa.eu/eurostat/data/database) and statistical factsheets (https://ec.europa.eu/agriculture/statistics/factsheets_en)
[2] Eurostat. Distribution of population by degree of urbanisation, dwelling type and income group - EU-SILC survey
[3] CORINE land cover data series. Forest areas includes forest and semi-natural areas.

56.31% of Greece's surface represents forests and semi-natural areas according to the CORINE land cover data series, while agricultural areas represent another 38.81%. A distinguishing feature of Greece is the fact that more than 80% of the terrain is mountainous/hilly. Another feature is the long coastline and the numerous (numbering in the thousands) islands, of which 227 are inhabited.

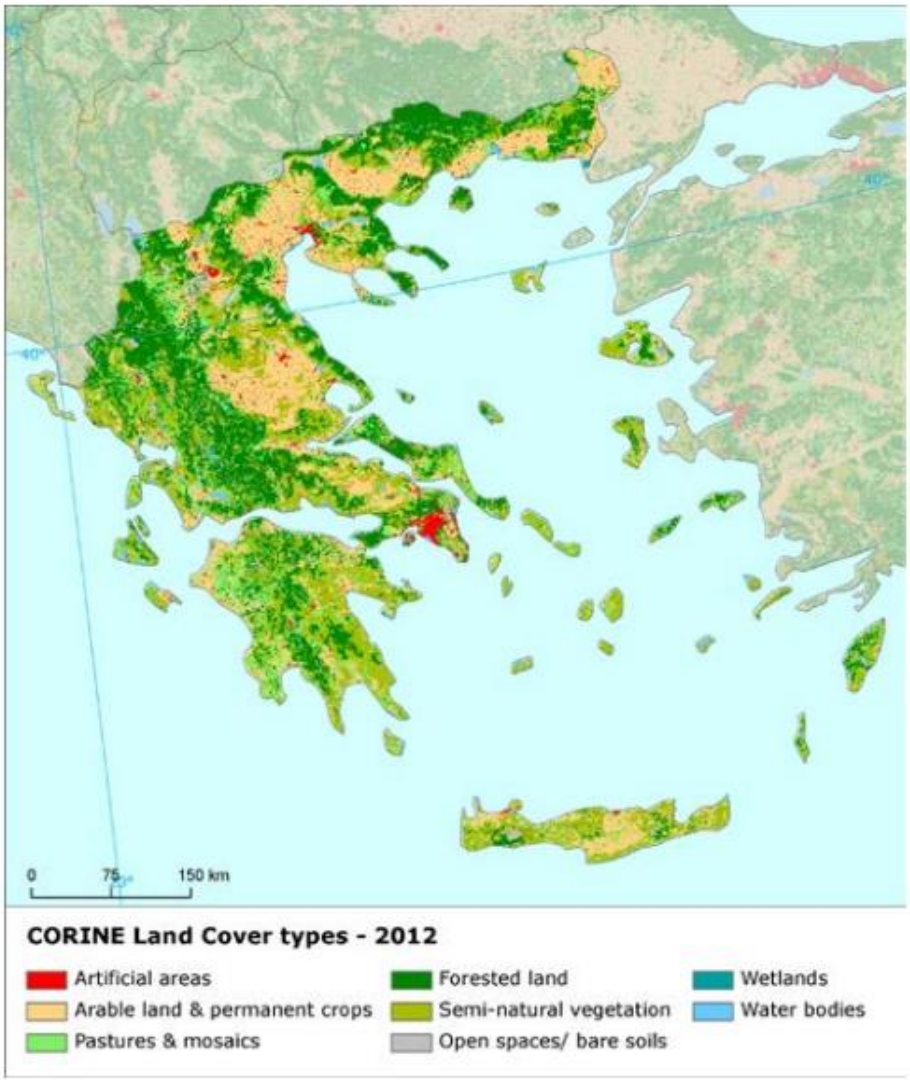

Figure 1.3.1 Main land cover distribution over Greece.

Greece shares land borders with Albania, North Macedonia, Bulgaria and Turkey, as shown on figure 1.3.2.

Figure 1.3.2: Greece and its bordering countries

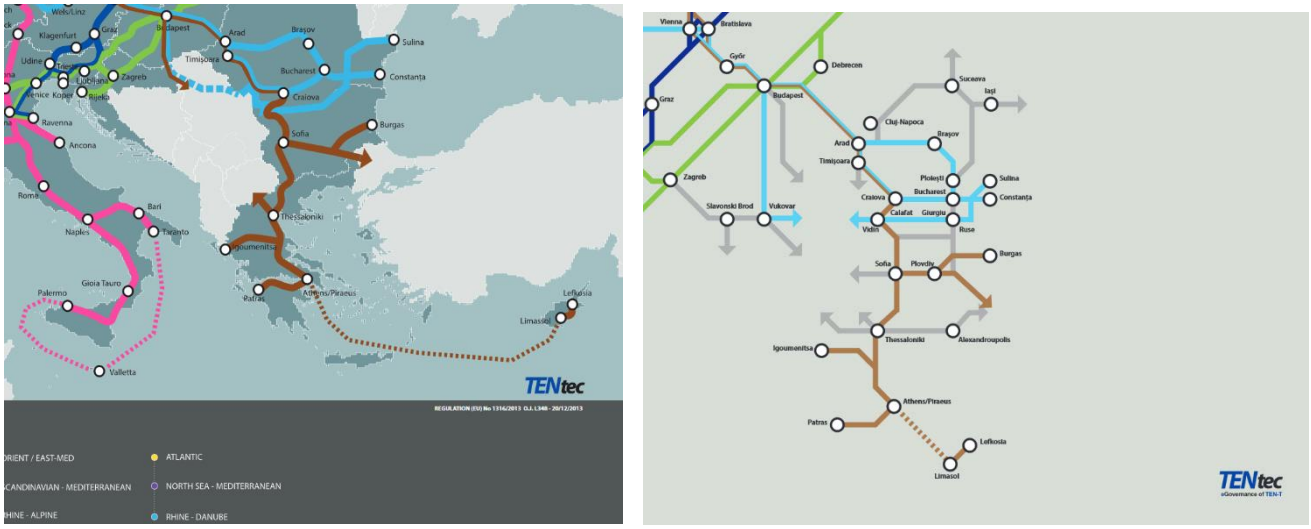

Figure 1.3.3 Position of Greece in the Trans-European Transportation Network

Located in the South-Eastern most extreme of mainland Europe, Greece is a major entry point of cargo traffic from Asia into European space. Greece is part of the Orient / East-Med TEN-T Core Network Corridors, linking by sea and through the port of Piraeus, Cyprus. To the north, the land corridor links through Bulgaria to the Rhine-Danube Core Network. Through other networks and with focal points in the port cities of Thessaloniki and Alexandroupolis, Greece is also linked with Turkey to the east, Albania and North Macedonia to the northwest and north respectively. The ports of Patra and Igoumenitsa also serve as connections with the Italian mainland to the west. Figure 1.3.3 shows the position of Greece in the Trans-Europe Transportation network. Figure 1.3.4 gives an insight into biomass flows in Greece (top) in comparison to average biomass flows of EU-28.

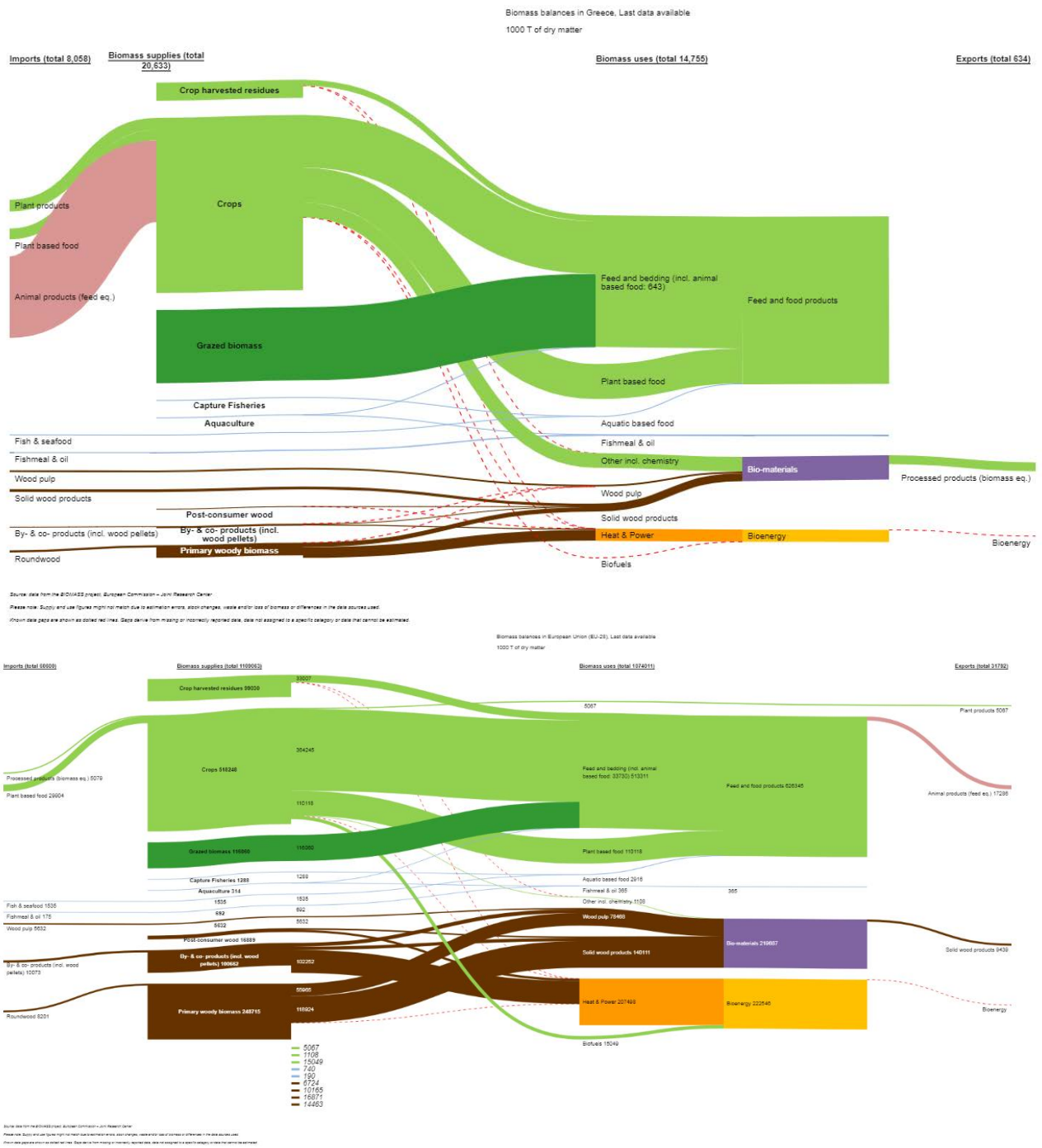

Figure 1.3.4: Biomass flows in Greece (top) and EU-28 (bottom)

Explanation of Sankey diagram (Figure 1.3.4):

The Sankey biomass diagram is split into biomass supply (shown on the left of the diagram) and biomass uses (right portion of the diagram). Each of these areas shows different categories: agriculture, forestry and fishery (supply), as well as feed and food, biomaterials, bioenergy, and direct exports for each sector (uses). All supply and uses of biomass have been converted to ktons of dry mass before integrating in the diagram. It is important to know that some of the components of the diagram will be missing for a certain country and/or year if the corresponding data has been reported as zero. This implies that the flow data should be interpreted with care as not all diagrams cover all biomass supply and/or use categories present.

Further information on the method and source data in: https://publications.europa.eu/en/publication-detail/-/publication/a19750d4-5498-11e7-a5ca-01aa75ed71a1/language-en

General conclusions from the Sankey diagram for Greece (Figure 1.3.4): in terms of domestic supply, biomass supply is directly linked with agriculture (over 90 %) and relates to the production of food and feed. Smaller quantities are diverted into the bio-based materials market, along with smaller quantities of primary woody biomass from forests and wood pulp. Imports are sizeable, but mostly refer to animal products. Bioenergy is a distant third in terms of biomass use, fuelled primarily from primary woody biomass (logwood) and to a lesser extent by imported co-/by-products (including wood pellets), crop (processing) residues and crop harvesting residues. Exports refer mostly to processed products from bio-based materials. As such, there are significant differences with the overall EU-28 Sankey diagram (Figure 1.3.4) in which primary woody biomass is playing a bigger role in supply, while also bioenergy / biofuels are more important.

2 Biomass supply: Agriculture

2.1 Introduction

In this chapter the agricultural biomass production and main uses is described. A distinction will be made between the main economic products produced and their main process chains and residual biomass potentials from primary production and available as by-products of food processing industries. In addition to presenting the main biomass production attention will also be paid to the importance and the structure of the agricultural sector and to the main environmental challenges associated with agriculture in Greece.

2.2 Characterisation of current agriculture sector

Agriculture is an important economic activity in Greece, amounting to 4.2% of the Greek GDP and 11% of the total employment. One of the key features of Greek agriculture is its diverse output, as local / regional differences in terrain and climate allow a large number of crops to be cultivated.

Another key feature of agriculture in Greece is its fragmentation; of the 684,950 agricultural holdings in the country, 77.3% correspond to a Utilized Agricultural Area of less than 5 ha, while the average holding size in only 6.6 ha. There is also an important age gap, only 3.7 % of the holders being younger than 35 years, while 33.5% of them are more than 64 years. A gender cap is also apparent, with only 34.8% of farm holders being female; however this share is marginally better than the EU-28 one (30.7%). Table 2.2.1 summarizes the main features of the agricultural sector in Greece.

In order to overcome these issues, farmers in Greece typically opt for collective forms of organization. Agricultural cooperatives is the main collaborative scheme that has been used in Greece; lately other organization types such as producer groups are also gaining in popularity.

Table 2.2.1: Key characteristics for the agricultural sector in Greece.

Category	Greece	EU	Unit	Source / Year
Agriculture in % of total employment	11%	4.1%	% of total employment	2019 / [1]
Agricultural area per capita	0.48	0.34	ha/capita	
Cereal yield	4.38	5.2	t/ha	2018 / [2]
Crop output in total output	74.1%	56%	% of total agricultural output value	2019 / [1]
Livestock output in total output	23.9%	44%	% of total agricultural output value	2019 / [1]
Agricultural income (2010=100)	93.9	121	Index 2010=100	2018 / [1]
Livestock density	0.46	1.02	LSU/ha UAA	2016 / [3]
High input farms	30%	29%	%/ total farms	2016 [5]
Low input farms	34%	39%	%/ total farms	2016 [5]
Gross nutrient balance nitrogen	55	47	kg of nutrient per ha	Average 2011-2015 / [4)
Gross nutrient balance phosphorus	0	1	kg of nutrient per ha	Average 2011-2015 / [4)
Irrigated utilised agricultural area	38.1%	n.a.	% of UAA	2018 / [2]
Average farm size	6.6	16.6	ha UAA/holding	2016 / [1]
% of agr. holdings < 5 ha	77.3%	62.6%	%/total no. of holdings	2016 / [1]

Sources:
[1] Stastistical Factsheet Greece (https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/farming/documents/agri-statistical-factsheet-el_en.pdf)
[2] Hellenic Statistical Authority – Annual Agricultural Statistics Survey: 2018 (www.statistics.gr/en/statistics/-/publication/SPG06/-)
[3] Eurostat, Main livestock indicators by NUTS 2 regions (ef_lsk_main) & Main farm land use by NUTS 2 regions [ef_lus_main]
[4] Eurostat, Gross nutrient balance [aei_pr_gn])
[5] Eurostat, Utilised agricultural area (UAA) managed by low-, medium- and high-input farms (source: FADN) [aei_ps_inp]

2.2.1 Crop production

The cultivated areas in Greece / 2018 are broken down as follows: arable land 53.4 %; permanent crops 33.7 %; fallow land 11.0 %; horticulture vegetables 1.9 %. The table below summarizes the main surfaces under each regime; to those, around 1,860 ha of permanent grasslands (Eurostat, 2016) should be taken into consideration.

Table 2.2.2: Areas under cultivation for different crop types in Greece (2018 ELSTAT).

Category	Surfaces (1,000 ha)
Total cultivated agricultural area	3,221.68
Irrigated	1,227.87
1. Arable land (net area)	1,719.56
Irrigated	714.41
2. Horticulture land (net area)	61.89
Irrigated	62.35
3. Permanent crops	1,085.10
Irrigated	451.11
4. Fallow land	355.13
Of which lands preserved in good agricultural and environmental conditions	195.58

Cereals

Although not amongst the top-EU producers, cereal cultivation is very relevant for the Greek agricultural sector. In terms of surfaces cultivated, durum wheat is the most popular crop, while maize is the main producer. The major centres for production are in the plains of Macedonia, Thessaly and Thrace, however there are some variations. For example, there is significant cultivation of maize in Aetoloakarnania / Western Greece, while rice production is mostly concentrated near Thessaloniki.

Table 2.2.3: Surfaces and production of cereals in Greece (Source: 2018 ELSTAT)[1]

Cereal crops	Surfaces (1,000 ha)	Production (1,000 tons)	Yield (tons/ha)
Durum wheat	312.3	928.5	2.97
Barley	126.3	364.5	2.89
Soft wheat	116.2	332.1	2.86
Maize	110.9	1,287.9	11.61
Oat	50.6	112.9	2.23
Rice	28.4	233.4	8.22
Other cereals	18.7	44.4	2.37
Rye	9.5	21.3	2.24
Total	772.9	3325.0	4.30

Industrial crops

Greece is the only EU-member state with a large area devoted to cotton cultivation. Moreover, it is the 4th largest producer of tobacco in the EU. In the last years, surfaces allocated to sunflower and rapeseed (used for biodiesel production) are increasing. Macedonia, Thrace and Thessaly are the major production centres for industrial crops; large areas of cotton can also be found in Central Greece. The production of aromatic plants, the extracts of which are used in various cosmetic products, is also an expanding sector.

[1] *Hellenic Statistical Authority – Annual Agricultural Statistics Survey: 2018 (www.statistics.gr/en/statistics/-/publication/SPG06/-)*

Table 2.2.4: Surfaces and production of major industrial crops in Greece (Source: 2018 ELSTAT, own processing)

Industrial crops	Surfaces (1,000 ha)	Production (1,000 tons)	Yield (tons/ha)
Cotton	280.5	859.6	3.06
Sunflower	72.0	190.5	2.65
Tobacco	17.0	31.5	1.85
Rapeseed	15.3	30.6	2.00
Aromatic plants	6.4	n/a	n/a
Soya (seeds)	3.3	9.6	2.91
Sugar beets	1.5	85.1	56.73

Permanent crops

EUROSTAT reports that Greece is the EU member state with the highest share of permanent crops in the UAA and the one out of three (along with Cyprus and Portugal) with a share higher than 20%. This is a quite distinct characteristic of the agricultural sector in Greece.

Olive trees: Greece is the 3rd largest olive oil producer in the world, behind Spain and Italy. Greece is also the 2nd largest producer of edible olives in the EU. The major centres of olive oil production are in Creta and Peloponnese. Table olives are mainly produced in Chalkidiki (Central Macedonia), Fthiotida (Central Greece) and Aetoloakarnania (Western Greece). The islands of Lesvos in the Aegean and Corfu in the Ionian Sea are also important areas for olive production.

Vineyards: Greece is the only member state were a significant share of grapes is used to produce raisins. The Greek wine sector is also expanding, with increased visibility and exports. Vineyards can be found all over the country, with important centres of production in the Peloponnese, Macedonia, Crete, Central Greece and Attica.

Citrus trees: 3rd largest producer of oranges in the EU, significant producer of lemons and tangerines. Peloponnese is the main area for citrus trees, but there are examples of cultivation throughout the national territory.

Fruit trees: Greece is the 3rd largest peach and nectarine producer in the EU, as well as leader in peach processing. 4th largest apricot producer, the 2nd largest producer of kiwis, as well as significant producer of pears, cherries, apples and figs.

Nut trees: Greece is the 3rd largest producer of almonds and walnuts in the EU, and the largest producer of pistachios. Geographical distribution varies depending on the exact species; almonds mostly in Macedonia and Thessaly, pistachios in Attica and Central Greece and walnuts mostly in mountainous areas.

Table 2.2.5: Surfaces and production of permanent crops in Greece (Source: 2018 ELSTAT, own processing)

Permanent crops		Surfaces (1,000 ha)	# of trees	Production (1,000 tons)
Vineyards		89.2	-	815.6
Olive trees	For olive oil	792.1	151,912,245	2,340.9
	For edible olives			423.8
Citrus trees	Lemons	4.1	2,051,526	78.0
	Oranges	29.3	13,786,734	744.8
	Tangerines	8.1	4,060,504	176.0
	Others	0.3	-	-
Pomefruit trres	Pears	4.2	3,450,000	273.1
	Apples	9.3	10,731,941	100.8
	Kiwis	16.3	5,346,196	233.2
	Pomegranates		1,582,872	41.9
	Figs / fresh		422,585	10.5
	Figs / dry		646,170	13.2
	Others		-	-
Stonefruit trees	Peaches & nectarines	39.6	18,749,665	670.4
	Cherries	15.8	6,842,373	82.7
	Apricots	8.0	3,670,366	107.5
	Others	2.5		-
Nuts trees	Almonds	14.0	4,699,016	48.5
	Walnuts	12.9	2,609,774	41.2
	Hazelnuts	13.7	120,482	0.6
	Chestnuts	25.6	1,502,000	34.2
	Pistachios		-	-
Other trees		792.1	-	-

2.2.2 Livestock production

Livestock raising is one of the historic activities of rural Greece, which is however facing several challenges in the last years. Greece has become a net importer of animal products such as meat and milk, which has a serious impact on its trade deficit.

The following tables present the number of livestock in Greece and the associated holdings.

Table 2.2.6: Animal heads and main products in Greece (Source: 2018 ELSTAT)[2]

Animal species	# of heads	Products (1,000 tons)
Bovine animals	625,673	Meat: 42.4 Milk: 638.4
Pigs	719,727	Meat: 79.9
Sheep	8,908,739	Meat: 52.4 Milk: 873.7
Goats	3,941,960	Meat: 20.2 Milk: 407.7
Hens	37,299,748	Meat: 244.3 Eggs: 1,376 (million pieces)
Geese	20,864	
Ducks	25,012	
Turkeys	258,266	
Rabbits	816,275	n/a
Beehives	1,674,494	Honey: 22.3

Cattle farming in Greece is mostly oriented to the production of milk and milk products. However, Greece has a deficit in cow milk, importing about 1 million tons per year to cover the dietary needs of the population3. Low prices and lower productivities compared to the EU-average are major challenges to the sector, which is looking for alternatives and support. The major center for cattle raising is Central Macedonia, which is where most of the milk production is taking place.

Pig farming is one of the dynamic livestock sectors in Greece. Despite recent troubles, the production of pig meat is quite stable over the last years and enough to cover about 30% of the country needs4. Geographical, pig farms are located mostly in the regions of Thessaly and Epirus, followed by Western Greece, Central Macedonia, Central Greece, Peloponnese and Crete. Several larger farms have already invested in biogas units and others are considered expansion or creation of new such plants[5].

Sheet and goat farming dominate the Greek livestock sector in terms of number of animal heads (with the exception of poultry), placing Greece on the top positions of related products (meat, milk and cheese) both in the EU and globally. Practised in mountainous and semi-mountainous areas all over Greece, sheep and goat husbandry now has to face the challenge of product modernization while taking into account the peculiarities of local conditions. Sheep (and to some extent goat) milk is used for the production of one of the major Greek food exports, feta.

Poultry farming is the most organized livestock sector in Greece at the moment, with a high level of vertical integration. Poultry meat is the main domestic meat product by quantity and covers about 75% of national demand6. Poultry meat production is concentrated in Epirus, followed by Central Greece, Macedonia and Thrace. Egg production on the other hand takes place mostly in Attica, Central Greece, Central Macedonia and the Peloponnese[7].

[2] Hellenic Statistical Authority – Annual Agricultural Statistics Survey: 2018 (www.statistics.gr/en/statistics/-/publication/SPG06/-)
[3] www.ellinikogala.gr
[4] www.pigfarmer.gr/Arthra/mia-apopsi-gia-tin-elliniki-xoirotrofia
[5] www.agronews.gr/ekmetaleuseis/hoirotrofia/184503/vioaerio-kai-nea-shimata-metexelissoun-ton-klado-tis-eghorias-hoirotrofias
[6] www.ypaithros.gr/ekdoseis/ptinotrofia-paron-kai-mellon
[7] www.neapaseges.gr/el/products/details/ANAKOINOSEIS/Ektrofi-Poylerikon-gia-Paragogi-Aygon-Katanalosis

Apiculture has a long history in Greece and a presence throughout the country. There are more than 1,600,000 beehives and 15,000 beekeepers, of which 3,000 are considered to be professionals[8]. Beekeeping in Greece is mostly nomadic, meaning that the beehives are more seasonally depending on the blooming season of local plants. Honey production is around 14,000 – 16,000 tons per year, and the domestic consumption is circa 1.5 – 2.0 kg per person, one of the highest in the world and almost double the EU-average. Exports at the moment are limited to around 200 tons per year. Apart from honey, other products have a high value for nutrition or other purposes and are used for the production of cosmetics (see Section 5.1.2). The main honey varieties are pine (60-65%), fir (5-10%) and thyme (15%).

2.3 Biomass potentials from agricultural residues and unused lands

Primary agricultural residues – arable crops

The table below compares the biomass potential of the main arable crops in Greece, as calculated by the S2Biom project tool (see below) and the AgroBioHeat project[9]. The AgroBioHeat calculations are based on the 2017 crop production data from ELSTAT and the use of Residue-to-Product (RPR) ratios that are following the S2Biom methodology; an RPR ratio for cotton residues is also used. AgroBioHeat calculates only the technical potential, while S2Biom calculates under certain assumptions, technical, base and user defined potentials.

The results indicate a large volume of arable agricultural residues that are produced on an annual basis in Greece, exceeding 3 million tons dry matter. However, considerations related to maintain soil organic carbon, as considered by the base potential in S2Biom has a significant impact on the potential, reducing it by half or more for most residues; for cereal straw, competing used may limit availability even further. However, the potential is still significant; the use of cotton and maize residues appears to be of relevant but may be a significant challenge as well, due also to the lack of major experience not only in Greece, but in the EU in general.

Table 2.3.1: Comparison of arable crop residue potential (kton dm) between S2Biom and AgroBioHeat

Arable crop residues	S2Biom (Reference year: 2020)			AgroBioHeat (Reference year: 2017)
	Technical	Base	User Defined	Technical
Cereal straw	2,021	796	454	1,039
Maize stover	1,227	627	627	915
Sugar beet leaves	165	96	96	n/a
Sunflower straw	208	164	164	257
Oil seed rape straw	n/a	n/a	n/a	20.1
Rice straw	255	142	142	241
Cotton residues	n/a	n/a	n/a	890
Total	3,876	1,825	1,483	3,362

[8] www.greekgastronomyguide.gr/meli-ethniko-proion

[9] M. Karampinis, M.A. Kougioumtzis, I.P. Kanaveli, P. Grammelis, C. Stavropoulou, C. Papasideri (2020) AgroBioHeat Deliverable 5.1: National and European framework conditions. Part 6: National framework conditions – Greece.

Primary agricultural residues – prunings

The table below compares the biomass potential of prunings from permanent crops in Greece, as calculated by the S2Biom project tool (see below) and the AgroBioHeat project. In addition, the results of a recent study by Dyjakon & García-Galindo[10] based on the EuroPruning project is included.

There are significant differences between the methodologies employed. S2Biom is primarily using Residue-to-Surface (RSR) ratios to calculate the technical pruning potential, while AgroBioHeat is using RPR ratios. Dyjakon & García-Galindo employ RSR values but a different methodology to assess the implementation potential, e.g. the fraction of the economic potential that can be implemented within a certain time frame and by considering existing socio-economic constraints. The use of pruning biomass per tree ratios is also suggested as an alternative approach.

Estimating the pruning production from permanent crops is much more complicated than arable crops. In reality, there are major differences in pruning productivity depending on multiple factors: varieties, local climate and soil conditions, agronomic preferences. Considering the methodological differences, as well as the fact that the biomass potential from various permanent crops has not been so thoroughly studied, it should not be a surprise that there are large variations in the technical potential.

In any case, it is quite clear that the technical pruning potential in Greece is very high, comparable to that of arable crop residues. Indeed, in many areas of Greece, prunings are the major local agricultural biomass resource.

A major issue for agricultural prunings is that their main management method in Greece (as in almost all European countries) continues to be open-field burning, contributing to local air pollution and a potential fire hazard. Alternatives such as on-field mulching or chipping and leaving them as soil cover are gaining in popularity, but phytopathologists warn of potential dangers and they are not always adopted by the farmers[11]. The agricultural pruning management is still an open issue not only in Greece, but also in Europe; at the moment, the CAP GAEC (Good Agricultural and Environmental Conditions) do not provide any strict guidelines about agricultural prunings (unlike arable crop stubble). The possibilities for their management – including their valorization for the bioeconomy – have to be assessed carefully on a case by case basis, taking into account local peculiarities.

It should be noted that the potentials presented below, exclude the utilization of larger pieces of prunings (e.g. branches) which are already collected by farmers and used as firewood. This volume is not insignificant, exceeding 450,000 tons per year and may be in the level of 19% of total firewood consumption in Greece[12].

[10] A. Dyjakon, D. García-Galindo (2019) Implementing Agricultural Pruning to Energy in Europe: Technical, Economic and Implementation Potentials. Energies Vol 12(8), pp. 1513. https://doi.org/10.3390/en12081513
[11] AgroBioHeat Deliverable 5.1, ibid.
[12] http://biomasudplus.eu/wp-content/uploads/2017/09/D2.1-Market_report_Consolitated-6.pdf

Table 2.3.2: Comparison of permanent crop prunings potential (kton dm) between S2Biom and AgroBioHeat

Agricultural prunings	S2Biom (Reference year: 2020)		AgroBioHeat (Reference year: 2017)	Dyjakon & García-Galindo, 2019 (Reference year: 2010)	
	Technical	Base	Technical	Technical	Implementation
Vineyards	93	5	49.7	94.1	Not provided
Olive trees	1,165	77	1,881.4	895.5	Not provided
Fruit trees	211	37	391.3	161.7	Not provided
Citrus trees	73	14	237.9	68.6	Not provided
Nut trees	-	-	92.7	20.3	Not provided
Total	1,542	133	2,653	1,240.0	457.7-891.6

Box 2.2: Methodology of S2BIOM to calculate the crop residues potentials.
It identifies the part of the residues that can be removed from the field without adversely affecting the Soil Organic Carbon Content in the soil. For cereal straw a subtraction is also applied according to demand for straw for animal bedding & feed. For corn stover, rice straw, and sunflower and rape stubbles NO competing uses are assumed. The soil organic carbon balance is the difference between the inputs of carbon to the soil and the carbon outputs. A negative balance, i.e. outputs are larger than the inputs, will reduce the SOC stock and might lead to crop production losses on the long term. To calculate the soil carbon balance at regional level S2BIOM used the MITERRA-Europe model (Lesschen et al., 2011) to provide the input data and the "RothC-26.3" model (Coleman & Jenkins, 1999) to calculate the soil carbon dynamics in a spatially detailed assessment. For further details on the whole assessment of biomass potentials in S2BOM consult Dees et al[16] and a summary is given in Annex 2.

Manure from livestock production

Scarlat et al.[13] have performed in 2018 a spatial analysis of biogas potential from manure in Europe. The key findings for Greece are as follows:

- Total manure production is estimated at 16.9 million tons per year, while the collectable volume is 9.3 million tons.
- The theoretical biogas potential is 558 million m^3 of CH_4, while a realistic estimate brings it to 278 million m^3 of CH_4. This is compared to a natural gas consumption of 3, 648 million m^3 of CH_4.
- The biogas plant capacity in Greece has a potential of 241 MW, however a more realistic estimate is for 120 MW, which can produce 898 GWh of electricity annually.
- Considering a constant collection radius, 355 manure-based biogas plants can be built, none of which would have a capacity higher than 5 MW; 3 would be up to 3 – 5 MW and 51 plants would have a capacity between 1 – 3 MW. The average plant capacity would be 506 kW and the total combined would add up to 179.8 MW.
- In the scenario of variable radius / fixed capacities, biogas units in Greece would amount to 495. 67 units would have a capacity of 1 MW and 75 units would be at 500 kW. The average plant capacity would be 317 kW and the total combined would add up to 157.1 MW.

An estimation of the biogas potential from manure in Greece performed by CRES in the framework of the BiogasIN project is presented in the table below and is fairly consistent with the theoretical potential of Scarlat et. al.

[13] N. Scarlat, F. Fahl. J.F. Dallemand, F. Monforti, V. Motola (2018) A spatial analysis of biogas potential from manure in Europe. Renewable and Sustainable Energy Reviews Vol 94, pp 915-930. https://doi.org/10.1016/j.rser.2018.06.035

Table 2.3.3: CRES evaluation on biogas potential from manure[14]

Source	# of units	# of animals	Manure (tons/year)	Biogas potential (MW)
Cattle farms	32,875	727,040	14,540,800	278
Pig farms	36,593	140,645	2,268,220	37
Total	-	-	16,809,020	315

As of August 2018, the Hellenic Association of Biogas Producers (HABio) lists 26 biogas plants in Greece operating with "agricultural" feedstock[15], meaning manure, silage and other agricultural residues. Their combined capacity amounted to 22.3 MWe; a few more units have started operation since that time. Among those is the biogas plant of Epilektos Biogas Farsala S.A., with an installed capacity of 5.252 MWe. The largest plant of its kind in South Eastern Europe, it will process up to 300,000 tonnes of livestock and agricultural waste per year from 100 nearby farms and processing units[16].

Unused / abandoned lands

According to ELSTAT, 355.13 thousand hectares of agricultural land were labelled as "fallow" in 2018, of which 195.58 thousand hectares were preserved in good agricultural and environmental conditions and were thus eligible for CAP payments. These correspond to 11% and 6% of the UAA in Greece respectively.

The H2020 MAGIC project (https://magic-h2020.eu/) has published the MAGIC-MAPS tool, which provides data on the marginal land in Europe. As can be seen in the picture below, several Greek regions are estimated to have shares of marginal land exceeding 45% Larisa, Achaia, most of Epirus, Evritania, Fokida and major parts of Crete and the Aegean islands.

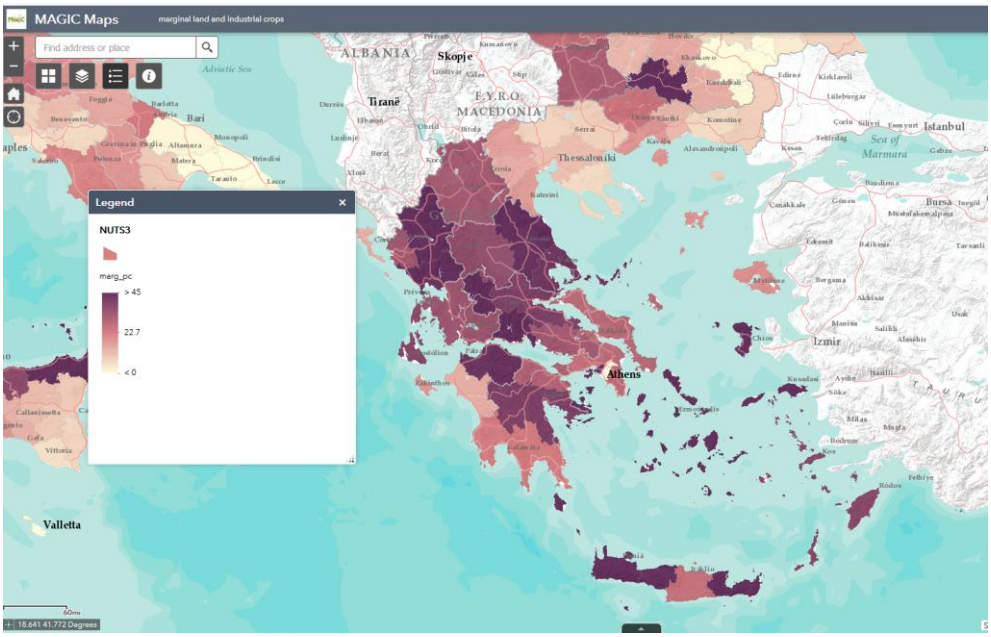

Figure 2.3.1: Map of marginal lands in Greece from MAGIC project[17].

[14] www.cres.gr/kape/publications/pdf/biogasin/06_C.Zafiris_PresentationBiogasIN.pdf
[15] https://habio.gr/wp-content/uploads/2019/08/%CE%A7%CE%91%CE%A1%CE%A4%CE%97%CE%A3.pdf
[16] www.avkvalves.com/en/cases/sustainability-cases-placeholder/avk-products-in-largest-biogas-plant-in-southern-europe
[17] https://iiasa-spatial.maps.arcgis.com/apps/webappviewer/index.html?id=010a68ba425649569a049d111b3dcbe7

Another recent study[18] estimated that 14.6% of the marginal land in Greece, corresponding to 1.9 million ha, is suitable for biomass cultivation for bioenergy, considering various cut-off criteria (protected areas, specific land uses, and slope steepness). The energy crops suggested by the study are mainly poplar, with the possibility of using switchgrass in some areas. A limitation that may apply for poplar cultivation is the need for irrigation on an annual basis, especially under the conditions prevailing in Greece[19]. In addition, removals costs for poplar plantations at the end of their lifetime should be considered. Finally, it should be noted that farmers may be reluctant to cultivate forest species in agricultural land, even marginal, since they might consider that there is a long-term risk of its being considered as "forest" land, in which other limitations for exploitation may apply.

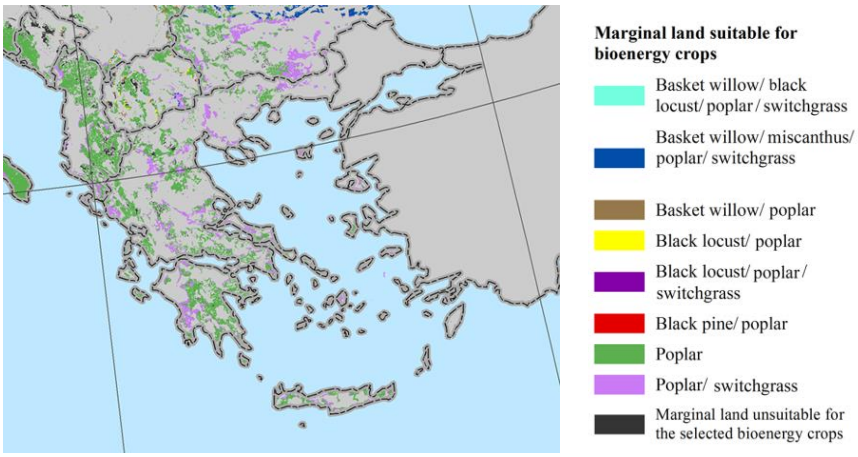

Figure 2.3.2: Suggested locations of marginal lands for energy crops in Greece (Source: Gerwin et al., 2018).

2.4 Secondary agricultural residues from processing industries

The food industry in Greece is one of the most important sectors of economic activity. More than 14,000 food industries operate, 24.9% of the total processing industries in the country. The food industry employs more than 80,000 and contributes more than 2.6 billion EUR in the gross added value[20].

For the purposes of biomass production from secondary agricultural residues, the olive oil sector industries are the most important. It should be noted that most of these residues (with the exception of grape drags) are mostly already valorized in energetic or other applications.

Olive oil by-products: Two types of industries and two major types of residues have to be considered in the olive oil sector. Olive mills perform the first pressing of olives; there are about 2,500 such facilities spread all over the olive producing areas of Greece. In recent years, olive mills are increasing switching from the three-phase production scheme to the two phase one[21]. The transition is not complete in all areas. Pomace mills, of which there are about 35 in the country, mostly located in Peloponnese and Crete, get the olive pomace from the

[18] W. Gerwin, F. Repmann, S. Galatsidas, D. Vlachaki, N. Gounaris, W. Baumgarten, C.Volkmann, D. Keramitzis, F. Kiourtsis, D. Freese (2018) Assessment and quantification of marginal lands for biomass production in Europe using soil-quality indicators. SOIL 4, pp. 267–290, https://doi.org/10.5194/soil-4-267-2018

[19] S. Mantziaris, C. Iliopoulos, I. T. Theodorakopoulou, E. Petropoulou (2017) Perennial energy crops vs. durum wheat in low input lands: Economica nalysis of a Greek case study. Renewable and Sustainable Energy Reviews 80, pp. 789-800, https://doi.org/10.1016/j.rser.2017.05.263

[20] http://iobe.gr/docs/research/RES_05_B_06042017_REP_GR.pdf

[21] The three phase system produces olive oil, a fairly dry olive pomace (around 55% moisture) and wastewater. The two phase system produces olive oil and a wet olive pomace (around 75% moisture). The transition to the two phase system solves the problem of olive mill wastewater treatment at the level of olive mills, but has created challenges in the operation of pomace mills which were not originally designed to handle such a wet pomace.

olive mills, dry it and extract the residual oil with hexane. The resulting by-product is called "pirinoksilo" in Greek and it is a mixture of the crushed olive stones and the exhausted olive fruit flesh and skin.

Some olive mills or pomace mills perform the separation of the olive stones from the pomace; olive stones have a lower ash content and are sold for higher prices on the market.

The AgroBioHeat project estimates that the technical potential for 2017 was 170.0 kton of dry matter for olive stones and 403.5 kton dry matter for exhausted olive cake[22]. The S2Biom technical potential estimation for 2020 is fairly consistent with this, at 182 ktom dm.

A large volume of pirinoksilo is self-consumed by the pomace mills in order to dry the pomace they receive and to produce steam for the secondary oil extraction. The transition to the two-phase system has increased self-consumption due to the higher energy requirements for drying a wetter pomace. The Association of Olive Kernel Oil Producers of Greece (SPEL) estimates that for a typical year in which olive oil production reaches 250,000 t, the total quantities of pirinoksilo available for the market are in the range of 135,000 ktons and they are used in various applications, including greenhouses, agro-industries and domestic heating.

Pressed grape drags: S2Biom estimated a potential of10 kton dm in 2020. AgroBioHeat estimates around 42.5 kton dm in 2017 of grape marc. Differences in the exact definition may explain these variations. Such residues are produced from wineries, of which there are about 1,000 in Greece.

Rice husks: produced as a by-product of the rice mills, AgroBioHeat estimates that 46 kton dm of rice husks were produced in Greece in 2017. Rice husk is used as a fuel for rice cooking by the industry itself, or sold to external end-users. It should be noted that rice husk ash is almost pure silica and has a market value.

Peach stones: produced by peach canning plants, of which they are about 17 in Greece, mostly in Central Macedonia. AgroBioHeat estimated that production of peach stones in 2017 was 19.7 kton dry matter. Some of the larger peach canning factories have installed biomass boilers and use them as a fuel in-house, often supplemented by other biomass fuels.

Nut shells: produced by nut crushing plants, of which they are several, often in small size, in the nut producing regions. Not all nuts are processed in such facilities (most walnuts and pistachios are not); AgroBioHeat estimates that the nut shell production in 2017 amounted to 25.1 kton dry matter, mostly almonds.

Sunflower husks: a by-produce of sunflower pressing for oil extraction, availability of sunflower husks is mostly connected to biodiesel production in Greece. AgroBioHeat estimates that the technical potential may be around 36.5 kton dry; however, not all extraction plants separate the husks from the sunflower meal which is used as animal feed. Based on market data, it may be that up to 20,000 tons of sunflower husks (in the form of pellets) are produced in Greece for a few larger processing plants.

Cotton ginning residues: AgroBioHeat estimates that the cotton ginning residues for 2017 are 70.4 kton dry matter. This by-product is produced from cotton ginning plants, which are mostly located in the main cotton cultivation areas (Thessaly, Central Greece, Macedonia). Cotton ginning residues are mostly used in-house for steam production. A 1 MWe power plant in Imathia uses cotton ginning residues as part of its fuel mixture.

Cereal bran: S2Biom estimates that the technical potential for cereal bran in Greece / 2020 is 394 kton dry matter. A by-product of cereal mills, it is assumed that all of this material is processed again for the production of bran flour.

Box 2.3: Methodology of S2BIOM to calculate the secondary residue potentials from food processing

All the secondary agricultural residues presented refer to residues of crops that are mostly grown and processed in the same country. Their assessment can therefore be based on production information (area and/or yield information) derived from national agricultural statistics.

For further details on the whole assessment of biomass potentials in S2BOM consult Dees et al (2017) and a summary is given in Annex 2.

[22] AgroBioHeat Deliverable 5.1, ibid.

2.5 Cost of main biomass source

Since for primary agricultural residues and energy crops no commodity market has developed yet in Greece it is very difficult to provide figures on prices. Instead cost estimates can be presented building on the S2BOM methodology and assessment. The cost refers to *Roadside cost* and these cover all biomass production collection and pre-treatment cost up to the road where the biomass is located. The roadside cost are only a fraction of the total 'at-gate-cost.' The range of road side costs (min, average, max) for Greece are presented in Table 2.5.1 below; for further details on the cost calculation in S2BOM see Annex 2.

Table 2.5.1: Road side cost levels (€/ton d.m.) for agricultural biomass sources in Greece based on S2BIOM cost calculations

Road side cost for agricultural biomass	(€ ton dm, 2020 cost level)		
	Min	Average	Max
Miscanthus	46	79	169
Switchgrass	46	79	169
Giant reed	46	79	169
Cardoon	46	79	169
Reed Canary Grass	46	79	169
SRC Willow	46	79	169
SRC Poplar	46	79	169
Other SRC	46	79	169
Rice straw	34	68	236
Cereals straw	45	79	252
Oil seed rape straw	34	58	181
Maize stover	23	36	104
Sugarbeet leaves	64	87	203
Sunflower straw	30	50	153
Residues from fruit tree plantations (apples, pears and soft fruit)	149	301	565

It should be noted that the maximum road side costs indicated in the table above are related to limited quantities of biomass available in urban areas (e.g. Athens) or some islands. Therefore, it should be expected that the range of costs between the minimum and average values would provide better indications of expected prices. In addition, the cost ranges for residues from fruit tree plantations seems extraordinary high and is probably way off.

Some indicators of expected costs for a number of primary agricultural residues in Greece can be found from published results of various projects:

- An analysis of a 14-day demonstration[23] of olive tree pruning harvesting in Agios Konstantinos, Central Greece performed within the framework of the AGROinLOG project resulted in a cost of 58 €/ton d.m. (average moisture content of 25 %). Through the analysis of a second, improved demonstration, the cost was found to go down to 45.7 €/ton d.m. with further possibilities for reduction. The demonstration

[23] M.A. Kougioumtzis, E. Karampinis, P. Grammelis, E. Kakaras (2019) Exploitation of Olive Tree Prunings. Evaluation of an Integrated Harvesting Demonstration in Central Greece. Proceedings of the 27th European Biomass Conference and Exhibition, pp. 312 – 317. DOI: 10.5071/27thEUBCE2019-1DV.3.17.

included all harvesting steps and haulage to a biomass depot in a distance of 5 – 10 km from the harvesting location.

- Results from demonstrations – including five in Greece – organized in the framework of the uP_running project[24] indicate that prices of biomass from agricultural prunings and plantation removal ranging from 30 – 70 €/t are possible. Higher prices generally refer to harvesting chains requiring more manual work for the collection / processing.
- An assessment[25] of wheat straw supply chains for biomass co-firing applications quoted a straw field (e.g. roadside) price of 70 €/t (as received) for applications likes animal feeding, bedding etc.; considering the low moisture content of straw during harvesting in Greek conditions, this translated to around 78 €/ton d.m. For long-term contracts, it was believed that roadside prices of 35 €/ton were also possible and enough to cover the expenses of the collection.

Secondary agricultural residues already have established markets, although most operate on a local / regional level or as B2B arrangements. There are no official market prices indexes for these biomass feedstocks and prices may vary for a number of reasons, most notably availability of supply (e.g. secondary residues quantities are lower when the production of the primary agricultural product is reduced), level of self-consumption by the producing industries and weather conditions. Generally though, the heating values of these fractions is good and the prices are at relatively low level, resulting in fuel energy costs in the gross range of 15 – 32 €/MWh (of fuel input), which is very completive compared to wood pellets, heating oil and other heating fuels. A recent survey of the AgroBioHeat project[26] presents some indicative price ranges for these fuels:

- Exhausted olive cake: 50 – 80 €/ton
- Sunflower husk pellets (imported): 80 – 120 €/ton
- Olive stone: 50 €/ton
- Rice husks: 60 – 80 €/ton
- Nut shells: 65 – 120 €/ton
- Peach stones: 60 – 80 €/ton

[24] CIRCE (2018) uP_running Deliverable 3.3 "uP_running demonstration case studies analysis". Available online at: www.up-running.eu/wp-content/uploads/2016/10/uP_running_D3.3_Demonstrations_cases_study_analysis_submitted.pdf

[25] E. Karampinis, F. Sissot, P. Grammelis, F. Rossi, E. Kakaras (2012) Investigation of Wheat Straw Supply Chains for Co-Firing Power Plants in Northern Greece. Proceedings of the 20th European Biomass Conference and Exhibition, pp. 136 – 142. DOI: 10.5071/20thEUBCE2012-1BO.8.4.

[26] M. Karampinis, M.A. Kougioumtzis, I.P. Kanaveli, P. Grammelis, C. Stavropoulou, C. Papasideri (2020) AgroBioHeat Deliverable 5.1 "National and European framework conditions. Part 6: National framework conditions – Greece".

2.6 Summary and conclusions in relation to SWOT elements

Variety and high quality of products are among the main strengths of the Greek agricultural sector. Lack of modernization and continuation of outdated practices can be considered as some of the main weakness. Shielded to some extend by geographical remoteness and the CAP support schemes, the Greek agricultural sector undergoes changes but slowly and incrementally. However, pressure is increasing and the upcoming CAP revision might result in a completely changed scene.

In terms of new bioeconomy sectors, agriculture offers various opportunities, having the capacity to provide large volumes of biomass resources. A closer policy focus and a continuation of pilot / demonstration activities already ongoing will be required to support innovation.

Table 2.6.1: SWOT elements in relation to biomass supply from agriculture

Strengths Varied agricultural sector with multiple different products Multiple well established networks and enterprises	Weaknesses Fragmentation of agricultural holdings Lack of modernization Lack of a coordinated bioeconomy policy focusing on residues Geographical constraints (e.g. slopped terrain)
Opportunities CAP revision and increased emphasis on bioeconomy / environmental protection Emergence of vertically integrated enterprises, with capacity to focus on by-product utilization Major focus on the bioeconomy potential of the agricultural sector by various projects / activities	Threats Continuation of polluting practices (e.g. open-field burning) Competition from other countries shrinking of various sectors Climate change threatening traditional crops Danger of desertification

3 Biomass supply: Forestry

A comprehensive description of the state Greek forests is challenging; the National Forest Inventory report has not been updated since 1992, in total contract with most members that produce updated versions every five years[27]. As a result, despite the significant coverage of forests in the Greek territory, their direct economic impact is limited to only 0.2% of the national GDP; in addition, forest production has been steadily declining over the last 25 – 28 years. A new National Forest Strategy was adopted in 2018 for the next 20 years period, aiming among others to increase the forests' contribution to the GDP to 1%; however, this goal has been challenged by experts[28]. The updating, publication and approval of forest maps is a major work that is coordinated by the Hellenic Cadastre (land registry); up to now, 54.58% of the country has been covered[29], however the process is facing numerous legal issues and challenges.

Table 3.1.1. summarizes the main characteristics of Greek forests. Indicative of the declining production volume of Greek forests is the fact that 2,979 thousand cubic meters of felling were recorded in 1990, decreasing to 50% after 20 years. Roundwood removal is mostly geared towards the production of firewood (and charcoal), with industrial roundwood being a minority in total removals.

Most of the Greek forests are located in mountainous areas, at altitudes of 600-1200 m (41%) and with slopes ranging from 26-45% (42.5%). For this reason, forest operations are performed with relatively simple methods, e.g. lumberjacks and mules for transportation[30].

The Greek state owns 74.1% of the forests, one of the highest shares in Europe; 9% is owned by municipalities, 6.5% is private forests and 10.4% is owned by monasteries and joint ownership schemes. Forest fires have become a major issue for the preservation of Greek forests, affecting 0.57% of their total area[31].

[27] K. Almpanis. G. Ksanthopoulos, G. Skouteri. N. Theodoridis, A. Christodoulou, D. Palaskas (2015) Methodology for valuing forest land in Greece – A comprehensive handbook. In Greek. Available online at: www.fria.gr/files/ForestValueManual.pdf
[28] https://dasarxeio.com/2019/05/14/67504 /
[29] www.ktimatologio.gr/categories/dasikoi-hartes
[30] https://link.springer.com/chapter/10.1007/978-3-319-44015-6_22
[31] Almpanis et. al (2015), ibid.

Table 2.6.1: Greek forests in numbers.

	Value	Unit	Source / Year
Forest area	3,903.0	1,000 ha	2015 / [1]
Forest available for wood supply	3,594.7	1,000 ha	2015 / [1]
Growing stock	47	m^3/ha	2010 / [2]
	185	1,000,000 m^3	2010 / [2]
Coniferous trees	79	1,000,000 m^3	2010 / [2]
Deciduous trees	106	1,000,000 m^3	2010 / [2]
Annual increment	4,511	1,000 m^3	2010 / [3]
Fellings in forests available for wood suppply	1,842	1,000 m^3	2005 / [3]
	1,463	1,000 m^3	2010 / [3]
Roundwood removals for firewood - coniferous	93.21	1,000 m^3	2010 / [4]
Roundwood removals for industrial use - coniferous	349.47	1,000 m^3	2010 / [4]
Roundwood removals for firewood - coniferous	792.19	1,000 m^3	2010 / [4]
Roundwood removals for industrial use - coniferous	141.64	1,000 m^3	2010 / [4]

Sources:
[1] Eurostat, Area of wooded land (source: FAO - FE)
[2] FAO, Global Forest Resources Assessment 2010. www.fao.org/3/i1757e/i1757e.pdf
[3] Eurostat, Volume of timber (source: FAO - FE)
[4]Eurostat, Roundwood removals by type of wood and assortment
Values reported over bark

3.1 Primary biomass resources from forestry

Table 3.2.1. describes the primary biomass potential from forests in 2020. Data was obtained during the S2Biom project. It should be noted that biomass potential is expressed in thousands of tons (Kton) of dry matter (d.m.). Compared with the results of removals presented in the previous section (expressed in m^3), it is clear that the current biomass production from Greek forests is behind its potential; the difficult conditions, lack of modern means and absence of updated forest management plans are major influencing factors.

Table 3.1.1: Primary biomass potential from forests in kton d.m. (S2BIOM Base potential 2020).

Type	Greece
Final fellings from non-conifer trees	610
Final fellings from conifer trees	453
Thinnings from non-conifer trees	601
Thinnings from conifer trees	447
Logging residues from final fellings of non-conifer trees	68
Logging residues from final fellings of conifer trees	81
Logging residues from thinnings of non-conifer trees	36
Logging residues from thinnings of conifer trees	43
Total	2,339

Table 3.1.2 summarizes how the harvest levels and the total additionally harvestable stemwood and residue resource relate to the total yearly forest biomass increment. It becomes clear from this table that in almost all countries the common harvest levels are considerably below the yearly increment level, this also applies to Greece. Part of this low level can be explained by a skewed age structure in the forest population but may also refer to a large unused potential.

Table 3.1.2: 2010, 2020 and 2030 EFI-GTM harvest levels expressed as % of yearly average biomass increment level in forests. (Source: Biomass Policies, Elbersen et al., 2016)

		% Harvest & residues potential/Increment			% Harvest & residues potential + Maximum additional harvestable potentials/increment		
Country code	Country	2010	2020	2030	2010	2020	2030
AT	Austria	60%	53%	59%	110%	91%	86%
BE	Belgium	55%	55%	53%	87%	87%	85%
BG	Bulgaria	22%	18%	18%	55%	44%	43%
HR	Croatia	72%	67%	64%	181%	169%	162%
CZ	Czech republic	69%	75%	72%	110%	99%	100%
DK	Denmark	24%	17%	17%	68%	46%	41%
EE	Estonia	56%	68%	68%	103%	98%	93%
FI	Finland	59%	57%	53%	64%	58%	53%
FR	France	29%	26%	35%	83%	68%	71%
DE	Germany	43%	47%	50%	76%	76%	74%
EL	Greece	35%	46%	48%	80%	80%	80%
HU	Hungary	23%	33%	30%	79%	75%	66%
IE	Ireland	36%	40%	47%	67%	60%	68%
IT	Italy	8%	10%	13%	88%	84%	80%
LV	Latvia	44%	42%	55%	94%	95%	115%
LT	Lithuania	49%	49%	53%	84%	74%	76%
LU	Luxembourg	44%	48%	63%	109%	98%	108%
NL	Netherlands	36%	31%	33%	60%	53%	53%
PL	Poland	47%	56%	53%	79%	78%	73%
PT	Portugal	58%	56%	63%	88%	85%	97%
RO	Romania	26%	36%	35%	65%	56%	53%
SK	Slovakia	95%	81%	82%	120%	105%	104%
SI	Slovenia	21%	31%	45%	161%	167%	156%
ES	Spain	41%	39%	35%	73%	65%	60%
SE	Sweden	69%	62%	62%	93%	81%	77%
UK	United Kingdom	45%	47%	49%	80%	78%	84%

3.2 Secondary biomass resources from wood processing industries

The table below presents the secondary biomass potential from wood processing, as calculated by S2Biom.

Table 3.2.1: Secondary biomass potential from wood processing in kton d.m. (S2BIOM Base potential 2020).

Type	Greece
Sawdust (conifers)	15
Saw dust (non-conifers)	19
Other residues (conifers)	28
Other residues (non-conifers)	41
Residues from industries producing semi finished wood based panels	14
Residues from further wood processing	167
Total	284

The Greek wood processing industry is relying heavily on imports, since domestic industrial roundwood production is not enough (or of the required quality) to cover its needs. News sources estimate that the value of imported wood products in Greece reaches 65 million EUR[32].

Wood processing by-products are mostly already utilized for energy production, either in-house, through their upgrade into pellets, or by external biomass end-users.

Some relevant industries of the wood processing sector in Greece are:

- Alfa Wood (www.alfawood.gr) is the largest wood processing industry in Greece and one of the largest in the Balkans. Alfa Wood owns three facilities in Larisa, Grevena and Nevrokopi; the last one includes the largest pellet mill in Greece, with an annual production capacity of 65,000 tons of wood pellets. All of its facilities feature biomass combustion plants, while those at Larisa and Nevrokopi have installed 1 MWe biomass CHP plants featuring the Organic Rankine Cycle (ORC) technology.
- AKRITAS (www.akritas.gr) is the largest producer of synthetic wood products in Greece. Its production facilities are located in Tychero, Thrace, close to the border with Turkey. The company uses biomass residues in-house.
- MOURIKIS S.A. (www.mourikis.gr) is one of the largest wood processing industries in Greece, specializing in the production of wooden floors and veneer products. Its production facilities are near Corinth and feature a private jetty. Also uses wood residues in-house.
- Taglis S.A. (www.taglis.gr) is a timber processing company managing wood logos from Greece and Central Europe. The company upgrades residues from wood processing (sawdust and chips) into briquettes.

[32] www.enet.gr/?i=news.el.article&id=356337

3.3 Summary and conclusions in relation to SWOT elements

Despite significant forest areas in Greece, several structural weakness and lack of coordinated efforts limit mobilization of forest biomass resources. Despite a large decrease in the production of woodlogs over the last years, it is considered unlikely that the Greek forests will evolve into a major supplier of biomass for biorefineries in the short-to-medium term. However, considering risks from forest fires through biomass accumulation, as well as the already ongoing illegal loggings (mostly for using firewood), some increase of biomass extraction might be anticipated.

Table 3.4.1 summarises SWOT elements in relation to biomass supply from forestry in Greece.

Table 3.3.1: SWOT elements in relation to biomass supply from forestry

Strengths Large forest area	Weaknesses Difficult terrain for operations Outdated harvesting methods Limited funding allocated to forestry sector Lack of forest management
Opportunities Drafting of new management plans for forests New forest strategy Extraction of biomass as a way of reducing risk of forest fires	Threats Illegal logging operations Competition from neighbouring countries in the wood supply sector Public opposition against major forest-based economic activities Lack of management leads to higher fire risks

4 Biomass supply: Waste

4.1 Introduction

The development of a modern waste management scheme integrating the principles of circular economy is one of the major challenges in Greece. In a press conference in September 2019, the Ministry for Environment and Energy highlighted the following major issues[33]:

- Greece is 2nd in the EU-28 in landfilling, with over 80%.
- Greece is 25th in the EU-28 in recycling, less than 18% (compared to the national target for 2020 of 37%)
- 53 illegal landfills operating in the country.
- Lack of an integrated plan for the management of other major categories of waste (e.g. agricultural, demolition / construction, etc.).
- Slow rates in using Structural Funds for implementation of waste treatment facilities.

The Ministry has announced a series of policy interventions / measures, which are expected to be documented in an updated National Waste Management Plan. Some key points which are of special interest for bio-waste include:

- Implementation of source collection of biowaste with application of the brown bin throughout the country by 2023.
- Expansion of the Biowaste Treatment Plants, with tendering procedures for 31 new facilities by 2023[34] (currently only 4 operate).
- Increase of recovery of biowaste from the current 6% to 12% and up to 20% -22% within 4 and 10 years respectively.

The following table summarizes the main categories of waste produced in Greece according to the 2015 National Waste Management Plan; it is clear that biowaste is a significant part of the municipal solid waste. Further details on the composition is provided on the following section.

It should also be highlighted that the per capita municipal solid waste (MSW) production in Greece has increased, contrary to the general EU trend: from 412 kg/capita (2000) to 504 kg/capita (2017).

[33] https://ecopress.gr/wp-content/uploads/ypen-1.pdf
[34] www.kathimerini.gr/1087537/article/epikairothta/politikh/pente-metra-gia-th-diaxeirish-twn-aporrimmatwn---oi-stoxoi-toy-ypen

Table 4.1.1: Waste production in Greece per category, 2011 (Source: NWMP, 2015[35]).

Waste type	Waste quantities (1,000 tons)		
	Non-hazardous	Hazardous	Total
I - Municipal waste	5,743	6.5	5,749
(1) Municipal solid waste	5,569	6,5	5,575
Biowaste	2,470	-	2,470
Packaging waste	866	-	866
Other recyclable materials	1,860	-	1,860
Electronic waste	66	1.1	67
Batteries	-	1.1	1.1
Others	307	4.3	311
(2) Sewage sludge	174	-	174
II – Industrial waste and related streams	17,186	272	17,459
(1) Industrial waste	17,034	136	17,171
(2) Waste from municipal facilities	2.9	16	19
(3) Waste oils	-	56	56
(4) Batteries	-	47	47
(5) End-of-life vehicles	104	1.0	105
(6) Used vehicle tires	38	-	38
(7) Electronic waste	7.4	-	7.4
(8) Hospital waste	-	16	16
III – Waste from demolition, construction, excavation	1,306	0,6	1,307
IV – Waste from agriculture / livestock	10,781	-	10,781

4.2 Waste from biological resources

Biowaste represents a major part of MSW, around 44% on a national level, and ranging from 30 to 53.9% depending on the region. Biowaste quantities produced in Greece are foreseen to increase, in line with the quantities of MSW, and will remain a stable part of its share up to 2030 at least. Most of the biowaste quantities in MSW is associated with household foodwaste, but there is also a sizeable contribution of waste from the commercial / service sector as well as "green" waste from gardens and parks. Production is mostly concentrated in regions with large urban centres: Attica / Athens and Central Macedonia / Thessaloniki. The tables below summarizes the estimations of the Ministry of Environment and Energy as to the biowaste production from different sources up to 2030.

[35] National Waste Management Plan (2015) Available online at: www.opengov.gr/minenv/wp-content/uploads/downloads/2015/06/paragogikhsanasygkrothsh.pdf

Table 4.2.1: Estimation of production and origin of bio-waste in Greece, 2012-2030 (Source: YPEN, 2012[36]).

Waste type	Quantities (1,000 tons)						
	2012	2013	2014	2015	2020	2025	2030
Municipal Waste	5,832	5,915	6,086	6,543	7,038	7,563	5,832
Bio-degradable	3,923	3,978	4,093	4,398	4,725	5,071	3,923
Bio-waste	2,568	2,599	2,660	2,822	2,985	3,149	2,568
1. Household	2,197	2,223	2,273	2,409	2,538	2,669	2,197
1a. Food waste	1,679	1,699	1,736	1,839	1,936	2,034	1,679
1b. Garden / Park waste	518	524	536	570	602	635	518
2. Industry	30	30	31	33	35	37	30
2a. Fruit industries	3	3	3	3	3	3	3
2b. Meat and fish industries	3	3	3	3	3	3	3
2c. Other food industries	12	12	12	13	14	14	12
2d. Household-type	13	13	13	14	15	16	13
3. Commercial activities and services	341	346	356	380	412	443	341
3a. Retail / wholesale	80	81	83	87	96	104	80
3b. Various commercial enterprises	69	70	72	77	83	90	69
3c. Food and entertainment services	89	90	93	100	108	116	89
3d. Education	27	27	28	30	32	35	27
3e. Offices and services	26	26	27	29	31	33	26
3f. Health and social care	51	52	53	57	61	66	51

36 www.epperaa.gr/Lists/Custom_Announcements/Attachments/194/%CE%9F%CE%94%CE%97%CE%93%CE%9F%CE%A3%20%CE%92%CE%99%CE%9F%CE%91%CE%A0%CE%9F%CE%92%CE%9B%CE%97%CE%A4%CE%91.pdf

Table 4.2.2: Production distribution and MSW composition per Greek region, 2011 (Source: YPEN, 2012).

Region	Share in national MSW production (%)	Composition (%)					
		Biowaste (Organic fraction)	Paper	Metals	Plastics	Glass	Others
East Macedonia and Thrace	5.84	45.8	15.3	16.5	3.4	4.3	14.7
Central Macedonia	15.06	38.6	21.6	14.9	3.9	3.4	17.6
West Macedonia	2.32	46.2	19.4	14.4	2.3	1.9	15.8
Epirus	2.82	44.9	18.9	1.3	5.2	3.8	15.8
Thessaly	8.14	53.9	17.1	16.3	3.8	6.7	2.2
Ionian Islands	1.73	47.0	20.0	8.5	4.5	4.5	15.5
Western Greece	6.49	47.0	20.0	8.5	4.5	4.5	15.5
Central Greece	5.52	47.0	20.0	8.5	4.5	4.5	15.5
Attica	35.55	43.6	28.1	13.0	3.4	3.4	8.6
Peloponnese	4.86	41.0	29.0	14.0	3.5	3.5	9.0
North Aegean	2.10	48.3	21.6	9.4	3.2	5.8	11.7
South Aegean	3.16	30.0	28.0	21.0	3.0	7.0	11.0
Crete	6.41	39.2	20.0	6.9	5.0	5.3	13.7

The table below also provides the S2Biom estimations on biowaste and post consumer wood potential in Greece. The S2Biom estimations seems to be in line with available national data:

- In 2016, 50,800 tons of hazardous waste wood were recorded and led to recovery process[37].
- Estimated production of post-consumer wood from MSW in 2020 is 265,800 tons38. The target of the National Plan is to collect at the source 132,900 tons, recover 79,740 tons through mechanical treatment, leaving 53,160 tons for alternatives.

Table 4.2.3: S2Biom estimation on biowaste and post-consumer wood base potential (kton dm) in Greece.

Type	2012	2020	2030
Biowaste unseparately collected	2,045	1,781	1,679
Biowaste separately collected	0	198	187
Hazardous post-consumer wood	63	70	74
Non hazardous post-consumer wood	258	294	316

4.3 Current waste treatment and unused potentials estimates

The Ministry for Environment and Energy is responsible for overall policy making and national planning of waste management. Municipal authorities are responsible by default for the collection, transportation and storage of MSW. Various Waste Management Authorities (F.o.S.D.A.) have been established on regional / local level from

[37] https://ekpaa.ypeka.gr/wp-content/uploads/2019/09/Soer_2018_GR_Waste-Management.pdf
[38] National Waste Management Plan, 2015 (ibid.)

various municipal authorities and are responsible for the operation of transfer stations, processing and disposal of waste; a national association of F.oS.D.A.s has been formed (www.diktiofodsa.gr).

The Greek Recycling Association – EOAN (www.eoan.gr) is responsible for managing the National Registry of Producers, applicable to certain product categories, e.g. packaging material, batteries, etc. EOAN also approves and supervises the operation of Alternative Management Schemes that fall within the Extended Producer Responsibility Principle. At the moment, 22 such systems operate in Greece[39].

The waste treatment facilities in Greece include the following:

- 21 Material Recycling Facilities (MRF), some operated by private companies. MRF units mostly treat materials collected from the blue bin of recyclables as well as other source-collected materials.
- 5 Mechanical and Biological Treatment (MBT) Plants.
- 4 biowaste management plants.
- Numerous landfills, of which several illegal ones still in operation. 4 power plants using landfill gas with a total installed capacity of 14.8 MWe are operating in landfills in Athens, Volos, Chalkida and Thessaloniki.

The new National Waste Management Plant foresees the creation of 28 new MBT facilities and 30 new plants for biowaste management. The total estimated cost for new waste management infrastructure is estimated at 1.92 billion EUR. In addition, the Plan also considers for the first time the creation of 3 – 4 waste incineration plants that will use Solid Recovered Fuel (SRF) from MRF plants, which is currently mostly going to landfills. Another 632 - 805 million EUR will be required for these incineration plants[40]. For collected / separate biowaste, it seems that the main intention is to use it as a raw material for biogas production and compost.

Several municipalities have started small-scale projects for home composting of biowaste. Some of these initiatives have started back in 2007, while others are more recent. It was estimated that 14,757 tons of compost were produced by these initiatives in 2011[41].

Sewage sludge production in Greece was 119,768 tons in 2016. In 2011, 260 sewage treatment plants were operating in Greece, covering 89% of the population[42]. The major center for sewage sludge production is Athens, followed by Thessaloniki. In Athens, EYDAP operates the Psyttalia Waste Water Treatment Plant[43] which treats wastewater for biogas production; heat is used for the drying of the sewage sludge, then sold to industries for energetic utilization. The installed capacity of Psyttalia is 11.39 MWe / 17.15 MWth from biogas and 12.9 MWe / 17.3 MWth from natural gas. In 2018, dried sewage sludge from Psyttalia amounted to 44,239 tons[44]. A smaller biogas / natural gas CHP plant (2.6 MWe) is operated by EYATH in Thessaloniki; solar drying solutions are also applied in other cases[45]. Some quantities of dried / treated sewage sludge are used as fertilizer in agricultural applications, but there are still major amounts going to landfilling.

[39] www.eoan.gr/wp-content/uploads/EOAN_ENHMEROTIKO/Ενημερωτικό_για_ΕΜΠΑ.pdf
[40] www.newmoney.gr/roh/palmos-oikonomias/ependyseis/ipen-schedio-mamouth-gia-58-ergostasia-ke-4-monades-kafsis-aporrimmaton-ipsous-e3-dis
[41] www.epperaa.gr/Lists/Custom_Announcements/Attachments/194/%CE%9F%CE%94%CE%97%CE%93%CE%9F%CE%A3%20%CE%92%CE%99%CE%9F%CE%91%CE%A0%CE%9F%CE%92%CE%9B%CE%97%CE%A4%CE%91.pdf
[42] https://edeya.gr/imerides/diaxeirisi-ergwn-edeya-se-nees-synthikes-1/299-diaxeirisi-ilios-1/file
[43] www.eydap.gr/userfiles/c3c4382d-a658-4d79-b9e2-ecff7ddd9b76/Fact-sheet-PWWTP.pdf
[44] www.eydap.gr/userfiles/Presentations/viosimi_anaptyxi_2018.pdf
[45] https://mesogeos.gr/en/solar-drying

Table 4.3.1: Sewage sludge production and treatment in Greece, 2016 (Source: Eurostat, Sewage sludge production and disposal).

Sewage sludge treatment	Quantity (tons)
Agricultural use	21,528
Compost and other applications	-
Landfill	34,030
Incineration	38,360
Other	25,860
Total	119,768

Used Cooking Oil (UCO) potential in Greece has been estimated at 46,000 tons[46]. Of those, 20,000 tons correspond to domestic UCO of which only a minor fraction is currently collected. Professional sector UCO corresponds to 21,600 tons already collected, with a growth potential of 20 %, reaching finally 26,000 tons. Several local initiatives for the recycling of domestic UCO have been established. Prasino Ladi (www.prasinoladi.gr) is a subsidiary and sole supplier of biodiesel producer ElinVerd (see Sections 5.1.6 and 6.5.3) that facilitates the collection of UCO from both professionals and the domestic sector by setting up a large network of collection points.

Various independent initiatives for the separate collection of specific organic waste fractions are also ongoing. Kafsimo[47] from FoodTreasure/InCommOn (www.incommon.gr) aims to collect spent coffee grounds (SCG) from cafeterias / coffee shops and upgrade them into a combustible biomass fuel. The initiative estimates that around 40,000 tons of SCG are produced in Greece per year(circa 26,000 tons d.m.); it has already performed pilot actions in Kilkis and is planning expansion in Thessaloniki. Kafsimo is working together with the social cooperative Staramaki (see Section 5.1.1) in a circular economy, reciprocal concept (collaborating cafeterias supplying SCG will receive products from Staramaki). Cigaret Cycle (www.cigaretcycle.org) aims to collect cigarette butts, which are estimated to amount to 3,500 tons on an annual basis. The plastic part will be recycled into various plastic products, while the organic part and ash will be composted and used as a fertilizer.

46 www.theicct.org/sites/default/files/publications/Greenea%20Report%20Household%20UCO%20Collection%20in%20the%20EU_ICCT_20160629.pdf

47 www.facebook.com/kafsimo.greece

4.4 Summary and conclusions in relation to SWOT elements

It is quite clear that the current situation in waste management in Greece is far behind the EU targets and that new interventions are required, both on the policy level as well as in the creation of new infrastructure. Indeed, a new scheme for waste management has become one of the main priorities of the current administration and a revamping of the national plan is ongoing.
Biowaste represents a major part of the total municipal solid waste and up to now its handling has been sub-optimal. The new management plant is placing major emphasis on this biogenic resource, aiming to create new infrastructure for its processing and – ultimately – its energetic valorization.

Beyond the top-down approach in waste management, it is encouraging to see various independent, bottom-up approaches emerging. Usually focusing on specific biogenic resources, these initiatives can encourage their separation at the source as well as the development of tailored-made solutions / applications, fitting to the specific properties of each targeted fraction.

Table 4.4.1 summarises SWOT elements of waste sector in Greece.

Table 4.4.1: SWOT analysis in relation to waste sector in Greece

Strengths Major centres of concentrated MSW production High potential for valorization of biogenic waste currently going to landfilling New, modern infrastructure already available in a few regions (e.g. West Macedonia, Epirus)	Weaknesses Beyond the urban areas, challenges in collecting / transporting waste to treatment centres (e.g. islands)
Opportunities New waste management plan in preparation Resources to be allocated Increase of landfilling costs New, independent schemes for management of various biogenic waste fractions on local / regional / national level Interest in renewable gases might prompt new utilization opportunities for biomethane from anaerobic digestion of biowaste Waste incineration plants might allow valorization of various solid waste fractions, including biogenic	Threats Funding gap for new projects Delays in implementation Social acceptance issues for the positioning of new waste management infrastructure Limited to no attention on novel technologies for biowaste management beyond the anaerobic digestion / incineration Uncertainties as to compost properties for agricultural use

5 Bio-based industries, products and markets

5.1 Current bio-based industries

5.1.1 Biobased plastics, polymers, materials, packaging

Several manufacturers of paper packing materials are active in Greece and many are members of the Association of the Greek Manufacturers of Packaging & Materials.

Regarding bioplastics, the only Greek company participating in the European Bioplastics association (www.european-bioplastics.org) is Procos S.A. (www.procosparty.com). The company is listed as a plastics converter, producing disposable tableware from paper with biopolymer. The company offers products that are certified with the "OK Compost Home" and "OK Compost Industrial" labels as well as a new range of disposable wooden tableware.

Matrix Pack (www.matrixpack.gr) produced and markets since 2018 eco-friendly straws (biodegradable and compostable) from natural resources. Since early 2019 the company has also developed paper straws produced exclusively in Greece.

PHEE (https://phee.gr) is a company founded in 2015. It uses seagrass (Posidonia Oceanica) to produce boards used for furniture, packing, interior decoration, accessories. One of the most successful Greek start-ups, having received various awards, its founder, Stavros Tsompanidis, has made it into the "30 under 30" list of Forbes for 2018.

Staramaki (www.staramaki.gr) is a social cooperative based in Kilkis. It produces drinking straws made from local cereal straw residues. The enterprise aims to utilize straw from 5 hectares in 2020 and to expand in the future by establishing similar social cooperative in 7 more areas in Greece. Moreover, it is working together with the FoodTreasure team on the Kafsimo project (www.facebook.com/kafsimo.greece) aiming to collect spend coffee grounds from cafeterias and transform them into a solid biomass fuel.

KIZI STUDIO (www.kizistudio.com) has launched a series of furniture with panels made from cardoon (cynara cardunculus) fibers and natural resins.

5.1.2 Biobased specialty chemicals

Binders

CHIMAR Hellas (www.chimarhellas.com) is a specialized company providing state-of-the-art binder technology to wood-based panel industries in any part of the world. In 1998, CHIMAR patented its first bio-based binder technology and currently provides both chemical binders, as well as engineering solutions and R&D services for the production of binders and particle boards from various materials of biogenic origin.

Cosmetics

The Greek cosmetics industries has for many years now utilized extracts and compounds from herbs, plants and animal products to create high-added value natural products. Numerous companies operate in the sector, including small, family-owned enterprises. The two largest companies are KORRES and APIVITA.

KORRES S.A. (www.korres.com) was established in 1996 as a continuation of the first homeopathic drugstore in Greece. KORRES has launched several innovative products such as the wild rose moisturizing crème (its first product and continued bestseller), after sun lotions based on edible yogurt, the antiwrinkling crème based from the Arcadian chestnut trees, white and black pine based cremes and silica-free hair shampoos.

Established in 1979, APIVITA (www.apivita.com) has pioneered the use of apiculture (beekeeping) products in cosmetics. Its products contain natural ingredients at rates from 85 to 100 %.

The example of Mastic Spa (https://masticspa.com) can illustrate how the rich Greek biodiversity is applied on the cosmetics sector. Using the resin from the mastic trees of the island of Chios, the company has launched its first mastic product in 1985 and now offers more than 130 codes based on this unique resource.

5.1.3 Textiles

Greece is the major cotton producer in the EU, with more than 80 % of the production[48].

Cotton ginning plants perform the first step in the processing of the harvested cotton. Their production capacity is high and generally underutilized, since most were built in the '90s at a time of higher cotton production. Nearly 80 % of them are privately owned, while the others belong to agricultural cooperatives. Some of the cotton ginning plants currently active in Greece are presented in the following list:

- VIOLAR S.A. (www.markoubros.com)
- EPILEKTOS S.A. (www.epilektos.com)
- Ekkokkistiria Serron (www.mouzakis-serres.gr)
- Siarkos S.A. (www.siarkos.gr)
- Ekkokkistiria Giannitson (www.ekkokkistiria.eu)
- Thrakika Ekkokistiria (https://thrakika.gr)
- Ekkokkistiria Agelousis (www.agelousis.gr)
- Varvaressos S.A. (https://varvaressos.eu)
- Ekkokkistiria EAS Trikalon (https://eastrikalon.gr/ekkokkistiria)
- Karagiorgos S.A. (www.karagiorgos.gr)
- Kafantaris – Papakostas S.A. (www.kafpap.gr/English/KafPapUkEkkok_New.htm)
- Ekkokkistiria Imathias (www.imathiacotton.gr)
- PETSAS S.A. (www.petsas-sa.gr)

Cotton seed is typically crushed for oil and oilseed cake. The former is used for biodiesel production, while the latter is used as animal feed.

Due to geographical proximity, Greek cotton has a comparatively low ecological footprint when processed in Europe, while exports in Eastern Countries have increased thanks to improvements in the cotton technical characteristics[49].

Spinning mills process about 10 % of the domestic lint production. As of 2019, only five spinning companies were said to be operating in Greece[50], with several historic firms having closed down due to competition from third countries and high taxation. Generally, the spinning mills still in operation are connected with cotton ginning plants.

48 https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Cotton%20and%20Products%20Annual_Rome_Greece_3-28-2019.pdf
49 https://textile-future.com/archives/7604
50 https://textile-future.com/archives/20761

5.1.4 Food and feed ingredient

Established in 2011 in Larisa, PolyHealth S.A. (www.polyhealth.gr) employes state of the art, patented technologies, organic and plant originated raw materials without any involvement of organic solvents to produce natural phytochemical products. The main raw material used by the company is vegetation water from olive mills, a compound rich in olive polyphenols and especially hydrotyrosol.

Coffeco (www.facebook.com/coffeco.gr) is a start-up company that is working on the isolation of phenolic compounds from coffee waste. The extracted phenols can be used as food supplements and for the production of pharmaceuticals and cosmetics. Winner in several competitions, the company has attracted funding from angel investors and others and is collaborating with companies like Nestle and Rezos Brands.

ProsPer (www.facebook.com/ProsPer.foodproducts) is a spin-off company of researchers from the Agricultural University of Athens. The company aims to produce 1,200 tons per year of "fish powder" from the by-products of fish processing (e.g. cutting). The material has a high nutrional value and flavour. ProsPer won the first prize in the FoodTech category of the first "Trophy – Τροφή Challenge" completion[51].

5.1.5 Advanced biofuels

At the moment, there is no production of advanced biofuels from cellulosic or lignocellulosic feedstocks in Greece.

5.1.6 Commercial biorefineries

The JRC "Map for Bio-based industry and biorefineries"[52] currently lists 37 biorefineries facilities in Greece, distributed as follows:

- 19 facilities for liquid biofuels production
- 13 facilities for pulp and paper
- 7 facilities for chemicals
- 5 starch and sugar refineries

Further details on facilities producing liquid biofuels can be found in Section 6.5.3 of this report. At the moment, biodiesel is the only liquid biofuel produced in Greece and the main feedstocks used for its production are oilseed crops (sunflower and rapeseed), cotton seed and used vegetable cooking oils. Glycerol is the main by-product of biodiesel product and is mostly sold to companies for the production of pharmaceuticals or cosmetics. It is interesting to note the case of Elin Verd (https://elinverd.gr) which has successfully retrofitted its facility in Volos from the production of 1st generation biodiesel from vegetable oils to the exclusive use of used cooking oils[53]. The company will also move into the production of oleochemicals.

The 5 starch and sugar refineries refer to the production facilities of the Hellenic Sugar Industry (www.evz.gr). With severe operational problems for many years that have affectively stopped production in most facilities, work is expected to start again in the factoris at Plati Imathias and Serres, which have been leased to Royal Sugar.

[51] www.typosthes.gr/oikonomia/190010_aytoi-einai-oi-4-megaloi-nikites-toy-1oy-diagonismoy-agrodiatrofis
[52] https://datam.jrc.ec.europa.eu/datam/mashup/BIOBASED_INDUSTRY
[53] www.biofit-h2020.eu/files/pdfs/190318-Biofit-Factsheet-Greece_low.pdf

5.1.7 Regional bio-based initiatives

Regional bio-based initiatives in Greece are often established in the framework of EU-funded projects. An earlier example was the FP7 project BIOCLUS[54], which on the Greek side focused on the Region of Western Macedonia. Together with other follow-up projects, such as BERST[55], it facilitated the creation of the Cluster of Bioeconomy and Environment of Western Macedonia (CLuBE), which was formally established in 2014. CLuBE is active in EU and national projects, further details are provided in Section 7.5 of this report.

A more recent example is the BIOREGIO project[56], which aims to foster bio-based circular economy through transfer of expertise about best available technologies and cooperation models. The Greek partners in the project are the Aristotle University of Thessaloniki and the Regional Development Fund of Central Macedonia, on behalf of the regional authorities.

5.2 Advanced bio-based initiatives: demo and pilot plants and major innovation activities

There is some Greek participation in ongoing flagship and demonstration BBI projects (e.g. EXILVA, BIOFOREVER); however, it seems that its scope is related to specialized services, e.g. process & product development / testing. As of now, no demo and pilot plants for biorefineries have been detected in Greece.

Various H2020 projects with Greek participation are working on innovative solutions for biomass utilization. An indicative list is presented below:

- BioCatPolymers (www.biocatpolymers.eu) aims to demonstrate the conversion of low quality residual biomass to high added-value biopolymers, based on an integrated hybrid bio-thermochemical process. The project specifically targets the production of isoprene and 3-methyl 1,5-pentanediol (3MPD), two momoners with very large markets that can be further processed in the existing infrastructure for fossil-based polymers for the production of elastomers and polyurethanes, respectively. BioCatPolymers aims to demonstrate and optimize the entire value chain at a scale of 0.5 ton of biomass/day scale, and to produce bio-isoprene at 50% cost reduction and 3MPD at 70% cost reduction compared to average market price. The project is running from January 2018 to December 2020 and is coordinated by CERTH.
- BioSFerA (https://cordis.europa.eu/project/id/884208) aims to develop a cost-effective technology for the gasification of biogenic residues and wastes, with follow-up fermentation of the syngas to roduce bio-based triacylglycerides (microbial oil) which, in turn, will be hydrotreated, resulting in drop-in biofuels for aviation and maritime transport. The BioSFerA will conduct both lab and pilot tests to optimise and validate the process and increase its overall performance with regard to the feedstock flexibility, the final product yield and production cost. It will also carry out an assessment of the related environmental, social, health and safety risks. The project runs from April 2020 to March 2024 and is coordinated by CERTH, with the participation of NTUA from the Greek side.
- CLARA (https://clara-h2020.eu/) has at its core the Chemical Looping Gasification (CLG) process. Preceded by biomass pre-treatment and followed up by syngas cleaning and conversion through Fischer-Tropsch (FT) process, CLARA aims to demonstrate production of advanced transport biofuels from lignocellulosic biomass. CERTH is involved in the consortium, performing among other experiments for production of drop-in biofuels at its Hydro-cracking Test Rig in Thessaloniki.
- BioMates (http://www.biomates.eu/) aims to produce bio-based products from residual straw and miscanthus that can be used for co-feeding in fossil refineries. The project runs from October 2016 to November 2021 with the participation of CERTH.

[54] https://cordis.europa.eu/project/id/245438
[55] www.berst.eu
[56] www.interregeurope.eu/bioregio

Demonstration projects related to biofuels production from residual biomass have also been implemented; some examples:

- Waste4Think (https://waste4think.eu) is a H2020 that works on development of advanced waste management systems with citizen involvement. The project is implemented in Greece by NTUA and the Municipality of Halandri and focuses on valorization of food waste. The demonstration action includes the production of biogas from locally collected and processed food waste in new, special garbage trucks acquired by the municipality.
- BIOFUELS-2G[57] was an award-winning LIFE project coordinated by CERTH with the participation of the Municipality of Thessaloniki and the Association of Restaurant Owners of Thessaloniki. The project demonstrated the production of 2nd generation biodiesel from used cooking oil, which was used in a municipal garbage truck.
- The Municipality of Rethimno along with the Renewably and Sustainable Energy Systems Laboratory of the Technical University of Crete have established a network for the collection and recycling of used cooking oil into biodiesel in the frameworks of projects RECOIL (www.recoilproject.eu) and COMPOSE (https://compose.interreg-med.eu/) .

Finallly, the BioWaste 2 BioPlastic project (www.biowaste2bioplastic.gr) aims to develop an integrated source separation of food waste, with emphasis on restaurants, and transform them into compostable bioplastics. The project is developing a pilot unit in Crete. The project is funded through the "Research – Create- Innovate" programme by the ERDF and national funds. Project partners are Environplan S.A. (www.enviroplan.gr), FORTH (www.forth.gr), University of Crete (www.uoc.gr) and the Hellenic Mediterranean University (www.hmu.gr).

5.3 Future Biomass valorisation options

Future biomass valorization options in Greece will be affected both by the overall policy goals as well as by market developments and trends. At the moment, there are more clear indicators regarding the former; some targets for 2030 can be discerned from the final NECP for Greece, while long-term directions can be found in the 2050 strategy. A few indicators are summarized below:

- The NECP foresees that an expansion of the installed biomass (solid biomass + biogas) power capacity, foreseen to reach 300 MWe by 2030 from around 88 MWe in 2030. No mentions about biochemical / biomaterial industries and biorefineries are included.
- Domestic biodiesel production will continue to be promoted, but with more focus on advanced biofuels compared to 1st generation ones.
- Creation of a domestic bioethanol market is foreseen, using conventional biomass feedstock (e.g. corn, wheat, sugar beets) as well as residual and waste biomass and non-food crops.
- The biomethane market will be promoted, both for injection in the natural gas grid as well as for use as a transport biofuel.
- For 2050, major emphasis on the utilization of lignocellulosic biomass for advanced biofuel production and renewable gases is placed.

Other utilization pathways are also proposed. For example, the H2020 AgroBioHeat project[58] aims to promote the use of local agricultural residues, agro-industrial residues and lignocellulosic energy crops as a source of renewable, cost-effective heating in rural areas. The project is coordinated by CERTH.

57 https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=3465

58 www.agrobioheat.eu

5.4 Greek participation in BBI projects

Finally, it is worth summarizing briefly Greek participation in BBI projects. Considering the latest call for proposals that has been evaluated (2019), Greece counts 21 individual participations in 18 funded projects, with a total budget of 6.8 mil. EUR. In total 12 different organizations have participated in BBI projects: Q-PLAN, Chimar, Tsatsos Georgios Cosmetic and Agricultural University of Athens in 3 projects each, National Technical University of Athens in 2 projects and other participants (Aristotle University, University of Crete, Biognosis, API Europe, CluBE, DIADYMA, Novagrica) in 1 project each. Greek participation covers all different action types (CSA, RIA, IA) and a variety of value chains. It is also worth noting that two projects (BIOWAYS, VALUEMAG) are coordinated by Greek partners.

Table 5.4.1: Greek participation in BBI projects.

Project	Action type	Website	Duration	Total budget (EUR)	Greek partners	Greek share of budget (%)
AQUABIOPRO-FIT: AQUAculture and Agriculture BIOmass side stream PROteins and bioactives for Feed, FITness and health promoting nutritional supplements	RIA	www.aquabioprofit.eu	01 Apr 2018 31 Mar 2022	4,163,240.00	Aristotelio Panepistimio Thessalonikis / Panepistimio Kritis / Biognosis	13.6%
BIOBRIDGES: Bridging Consumers, Brands and Bio Based Industry to improve the market of sustainable bio-based products	CSA	www.biobridges-project.eu	01 Sep 2018 31 Dec 2020	995,485.00	Q-Plan	12.4%
BIOFOREVER: BIO-based products from FORestry via Economically Viable European Routes	IA - Demo	www.bioforever.org	01 Sep 2016 31 Dec 2019	15,237,405.75	API Europe	12.1%
BiOPEN: Accelerating and supporting business development of bio-based industries and downstream sectors	CSA	www.biopen-project.eu	01 May 2017 31 Dec 2019	1,205,451.25	National Technical University of Athens	5.8%
BIOWAYS: Increase public awareness of bio-based products and applications supporting the growth of the European bioeconomy	CSA	www.bioways.eu	01 Oct 2016 30 Sep 2018	965,750.00	Q-Plan	17.8%
EXILVA Flagship demonstration of an integrated plant towards large scale supply and market assessment of MFC (microfibrillated cellulose)	IA - Flagship	www.h2020-exilva.com	01 May 2016 30 April 2020	44,634,926.50	Chimar	0.7%
HYPERBIOCOAT: High performance biomass extracted functional hybrid polymer coatings for food, cosmetic and medical device packaging	RIA	www.hyperbiocoat.eu	01 Sep 2016 31 Aug 2019	4,623,753.50	Tsatsos Georgios Cosmetic	6.9%

This project received funding from the BBI JU under the EU Horizon 2020 research and innovation programme under grant agreement No.838087

Project	Action type	Website	Duration	Total budget (EUR)	Greek partners	Greek share of budget (%)
LIBBIO: Lupinus mutabilis for Increased Biomass from marginal lands and value for BIOrefineries	RIA	www.libbio.net	01 Oct 2016 31 Mar 2021	4,923,750.00	Agricultural University of Athens	4.4%
MANDALA: The transition of MultilAyer/multipolymer packagiNg into more sustainable multilayer/single polymer products for the fooD and phArma sectors through the deveLopment of innovative functional Adhesives	RIA	N/A	01 Jun 2019 31 Dec 2022	4,573,892.50	Tsatsos Georgios Cosmetic	2.8%
MODEL2BIO: Modelling tool for giving value to agri-food residual streams in bio-based industries	RIA	www.model2bio.eu	01 May 2020 30 Apr 2023	5,970,585.00	CluBE, DIADYMA	11.4%
MPowerBIO: eM-POWERing SME Clusters to help SMEs overcome the valley of death	CSA	N/A	01 May 2020 30 Nov 2022	1,578,908.13	Q-Plan	11.7%
PERCAL: Chemical building blocks from versatile MSW biorefinery	RIA	www.percal-project.eu	01 Jul 2017 30 Sep 2020	3,394,181.26	Agricultural University of Athens	10.6%
PHERA: PHEromones for row crop applications	IA - Demo	www.phera.info	01 Mar 2020 28 Feb 2023	8,510,358.01	Novagrica	3.0%
Pro-Enrich: Development of novel functional proteins and bioactive ingredients from rapeseed, olive, tomato and citrus fruit side streams for applications in food, cosmetics, pet food and adhesives	RIA	www.pro-enrich.eu	01 May 2018 30 Apr 2021	3,956,640.86	Chimar	3.1%
Prolific: Integrated cascades of PROcesses for the extraction and valorisation of proteins and bioactive molecules from Legumes, Fungi and Coffee agro-industrial side streams	RIA	www.prolific-project.eu	01 Sep 2018 31 Aug 2022	5,342,470.45	Tsatsos Georgios Cosmetic	5.1%
SElectiveLi: Conceptual Study of Electrochemical based novel process using Lignosulfonates to produce bio-based monomers & polymers	RIA	http://selectiveli-project.uni-mainz.de	01 May 2019 30 Apr 2023	2,853,118.85	Chimar	6.6%

Project	Action type	Website	Duration	Total budget (EUR)	Greek partners	Greek share of budget (%)
USABLE PACKAGING: Unlocking the potential of Sustainable BiodegradabLe Packaging	RIA	www.usable-packaging.eu	01 Jun 2019: 31 May 2022	6,506,043.79	Agricultural University of Athens	3.6%
VALUEMAG: Valuable Products from Algae Using New Magnetic Cultivation and Extraction Techniques	RIA	www.valuemag.eu	01 Apr 2017 31 Jul 2020	4,789,000.00	National Technical University of Athens*	15.2%

5.5 Summary and conclusions in relation to SWOT elements

The bio-bases sector in Greece is mostly doing well on two fronts: well established sectors of the economy expanding or finding new opportunities for products and on RTD actions, which however do not necessarily lead to implementation within the country. Exceptions do exist, but the major future challenge will be to establish commercial biorefineries projects, especially if large biomass volumes should be processed. It may be the case that the larger, fossil refineries operating in Greece could evolve along this way in the future.

The small, internal market size may well play a role in this; smaller initiatives may be embraced but at the moment there is no wider push for the adoption of new bio-based products.

Table 5.5.1: SWOT analysis of bio-based industries, products and markets in Greece.

Strengths	Weaknesses
Active participation in research, pilot and demonstration projects Strong enterprises in the food, cosmetics, pharmaceutical sectors	Lack of commercial medium/large scale biorefineries Limited capacity of internal market No major large-scale consumer movement to embrace bio-based products beyond certain sectors
Opportunities	**Threats**
New companies (often start-ups) offering bio-based products Re-start of the national sugar production, possibly integrating bioethanol production	Continued focus on 1st generation biofuels RTD projects results not taken up by the industry Limited focus on agricultural residues

6 Infrastructure, logistics and energy sector

6.1 Existing industrial hubs

According to a study[59] from the Hellenic Federation of Enterprises (SEV), there are 53 designated industrial areas (industrial parks / zones) covering a total area of around 6,779.4 ha. It is estimated that less than 13% of Greek manufacting enterprises are located in those areas, contributing to around 5 – 6 % of industrial activities[60].

Non-designated industrial hubs are said to reach almost 200, with at least 70 being major (surface over 30 ha, coverage of buildings over 10 % of total area), amount to a total area of over 6,000 ha and over 3,000 entperises. It is characteristic that the largest industrial hub in Greece – in the area of Oinofyta, north of Athens – is not part of a designated industrial area.

ETVA VI.PE. (www.etvavipe.gr) is managing 25 of the designated industrial areas of Greece. A 2019 study[61] concluded that around 36,000 persons are employed in those areas, mostly in Central Macedonia (37 %), East Macedonia and Thrace (16.2 %) and Creta (14.4 %), while the total annual turnover was in the range of € 7.5 billion.

The SEV study indicates that there are significant advantages in the establishment of a business in a designated industrial zone, such as a 25.5% reduction of the installation costs. However, it also notes that the current framework (Law 3982/2011) for industrial zones has certain weaknesses which – coupled with the Greek financial crisis – have hindered the development of industrial zone. The outdated infrastructure of several existing designated industrial zones (e.g. lack of broadband internet connection) is also noted. Several proposals for the improvement of the policy framework are proposed.

[59] http://www.sev.org.gr/Uploads/Documents/50520/special_report_27_9_2017.pdf
[60] www.insider.gr/eidiseis/oikonomia/126493/lysi-meso-espa-gia-ti-dimioyrgia-biomihanikon-parkon
[61] http://iobe.gr/docs/research/RES_05_F_03122019_REP_GR.pdf

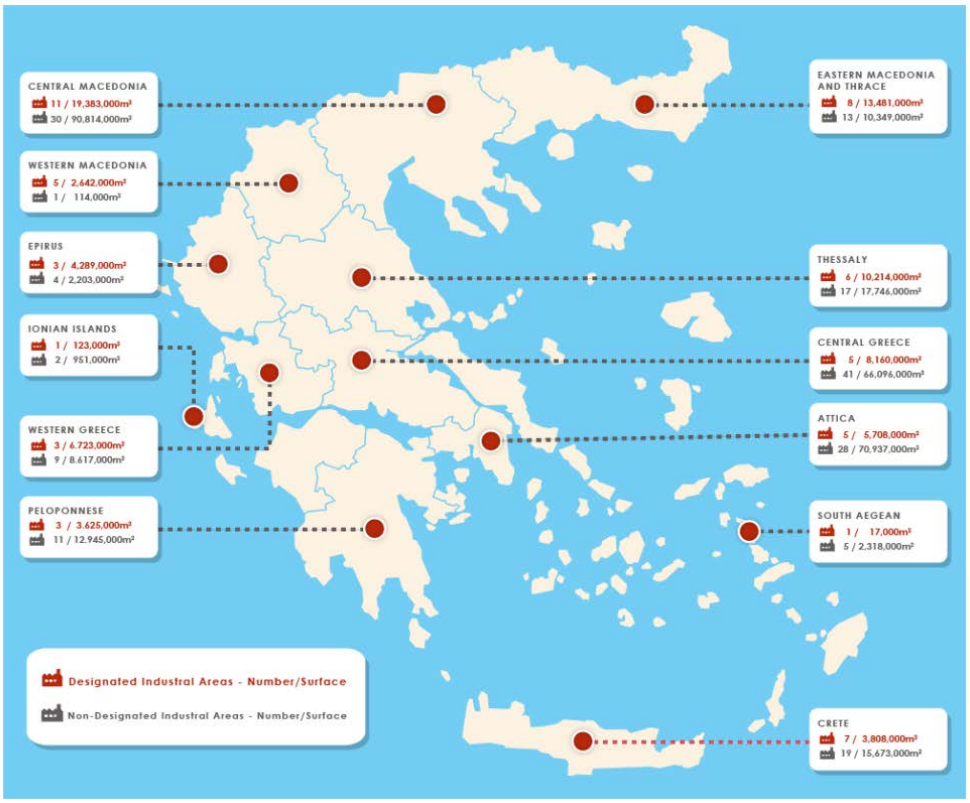

Figure 6.1.1: Overview of designated and non-designated industrial areas in Greece (Source: Arbitrage RE).

6.2 Harbours

Considering Greece's geography and long-time involvement in the maritime sector, it is not surprising that the country features a long list of ports, including several international ones. All Greek ports (with the exception of private jetties connected to industries) offer coastal shipping services (passenger, mail, cargo), while cruise shipping is also becoming more and more important for several ports. Key throughput data for Greek ports in 2014[62] are presented below. It should be noted however that increasing trends in tourism and transportation in the last years, means that several of these number are already surpassed:

- 6.36 million tonnes of dry bulk cargo
- 3.98 million TEUs
- 28.23 million coastal passengers
- 2.07 million cruise passengers

The biggest port in Greece is that of Piraeus. Piraeus has exhibited tremendous growth in the last decade, reaching more than 5.7 million TEUs in 2019, ranking 4th position in the "Top 15 of container ports in Europe in 2019"[63]. Piraeus is also the major car terminal in Eastern Europe, the largest passenger port in Europe (more than 16 million passengers), offering services from Athens to numerous Greek islands, and a major stop for cruise ships, exceeding 1 million passengers in 2019[64].

The 2nd largest port is that of Thessaloniki. Container traffic in 2018 reached 424.500 TEUs, being the 2nd largest container port in Greece after Piraeus. Passenger traffic compared to Piraeus is very low (44,474); however,

[62] www.porteconomics.eu/2016/09/12/greport-2016-download-for-free-study-on-greek-ports
[63] www.railfreight.com/intermodal/2020/02/24/gdansk-and-piraeus-most-dynamic-container-ports-in-europe
[64] www.olp.gr/images/pdffiles/presentations/Presentation_Financial_Results_2019b.pdf

Thessaloniki's major role is a dry bulk port. With a total volume of 3.4 million tons in 2018[65], mostly related to ores/cements/limes and plaster, the port of Thessaloniki serves various industries in Greece as well as in neighboring countries both as a supplier of raw materials as well as for the transportation and exporting of their products. Thessaloniki is also the major Greek port handling liquid bulk material; in the Athens area, the major liquid bulk volume are handled by the private ports of the refineries.

Table 6.2.1: Cargo traffic in the port of Thessaloniki for 2018 (Source: Thessaloniki Port Authority).

	Seaborne traffic		
YEAR	**2018**		
	IN	**OUT**	**TOTAL**
TOTAL THROUGHPUT	**9.508.731**	**3.380.046**	**12.888.777**
LIQUID BULK	**4.895.236**	**1.732.752**	**6.627.988**
Crude oil	2.833.047	0	**2.833.047**
Refined (petroleum) products	1.752.183	1.732.752	**3.484.935**
Gaseus, liqufied or compressed petroleum products and natural gas	290.029	0	**290.029**
Chemical products	19.977	0	**19.977**
Other liquid bulk	0	0	**0**
DRY BULK	**2.218.818**	**1.190.260**	**3.409.078**
Cereals	27.551	137.499	**165.050**
Foodstuff/Fodder/Oil seeds	199.714	1.501	**201.215**
Coal and lignite	372.504	0	**372.504**
Ores/cement/lime/plasters	1.232.793	975.981	**2.208.774**
Metallurgical Products	207.297	29.080	**236.377**
Chemical products	170.107	0	**170.107**
Other dry bulk	8.852	46.199	**55.051**
GENERAL CARGO	**2.394.677**	**457.034**	**2.851.711**
Containerized (including Ro-Ro containers)	1.946.971	240.162	**2.187.133**
Ro-Ro (excluding Ro-Ro containers)	26.220	63.200	**89.420**
Other general cargo	421.486	153.672	**575.158**

The biggest port in Greece is that of Piraeus. Piraeus has exhibited tremendous growth in the last decade, reaching more than 5.7 million TEUs in 2019, ranking 4th position in the "Top 15 of container ports in Europe in 2019"[66]. Piraeus is also the major car terminal in Eastern Europe, the largest passenger port in Europe (more than 16 million passengers), offering services from Athens to numerous Greek islands, and a major stop for cruise ships, exceeding 1 million passengers in 2019[67].

Several other Greek ports have important roles in the local / regional industrial eco-systems. Significant volumes of dry balk cargo are handled by the ports of Volos, Kavala, Alexandroupolis and Elefsina, while some container traffic takes place in Heraklion, Volos and Lavrio.

[65] www.thpa.gr/index.php/en/olth/statistics/itemlist/category/169-2018
[66] www.railfreight.com/intermodal/2020/02/24/gdansk-and-piraeus-most-dynamic-container-ports-in-europe
[67] www.olp.gr/images/pdffiles/presentations/Presentation_Financial_Results_2019b.pdf

Figure 6.2.1: Overview of international ports in Greece (Source: Cockett Greece).

6.3 Existing railways

Greek railway infrastructure amounts to 2,265 km lines in operation, 80% of which is standard gauge (1,435 mm). The speed limit distribution is as follows[68]:

- 19% - speed limit of 160 km/h
- 23% - speed limit of 120 - 159 km/h
- 39% - speed limit of 80 – 119 km/h
- 19% speed limit of 79 km/h

The following figure provides an overview of the Greek railway system. The main axis is the P.A.Th.E./P (Patras-Athens-Thessaloniki-Eidomeni/Promachonas), parts of which are already completed and parts are still under construction. The line connects the city of Patras to the west with Athens to Thessaloniki and connects through Eidomeni with North Macedonia and Promachonas with Bulgaria. The line has a total length of about 700 km and will be standard double gauge and fully electrified.

[68] www.ose.gr/en/o-s-e/the-network

Figure 6.3.1: Overview of the current Greek railway system (Source: OSE).

The key actors in the Greek railway system are the following:

- Hellenic Railways Organisation S.A. (OSE) which owns, maintains and operates all the railway infrastructure in Greece, with the exception of the metro lines in Athens.
- ERGOSE S.A., a subsidiary of OSE managing most of the ongoing or to be assigned projects for the modernization of the railway infrastructure, funded through European or national funds.
- TRAINOSE S.A., a former subsidiary of OSE, privatized and part of the Ferrovie dello Stato Italiane (FSI)Group since 2017. Up to now, TRAINOSE is the only provider of rail transport for passengers and freight in Greece.

According to the company website (http://www.trainose.gr), TRAINOSE employs 637 staff members, uses 1,160 locomotives, wagons and flatcars and performs 342 routes (passenger and commercial trains) a day. In 2016, TRAINOSE transported a total of 15.6 million passengers, of which 10.1 million used the suburban lines and 5.5 million the national network. In addition, a total of 1.1 million tonnes of goods were also transferred.

TRAINOSE offers domestic and international freight transportation services – with regular wagons or containers (multimodal transportation), carried either on individual wagons or in block trains (average cargo of 750 tons). All types of freight can be transferred: bulk, scrap, fuel, wood, containers. Since December 2013 TRAINOSE offers a service of container transportation (Intermodal Cargo Shuttle- ICS), with a regular daily trip from Athens (Thriasio) to Thessaloniki/ Sindos and back. ICS also serves multimodal transportation needs to and from the Port of Thessaloniki and the Port of New Ikonio. Moreover, TRAINOSE manages two multimodal transportation terminals, one at the Freight Station of Thriasio and another in Thessaloniki- Trigono (Old Station), where it also offers the capability of container loading and unloading.

6.3.1 Investments in railway infrastructure

For many decades, investments in the Greek railway system have been low and emphasis was placed on developing urban railway connections. Recently through, several projects have been concluded or are close to completion and new investment plans promise to transform the way railways operate in Greece. Some of the most important ones are as follows:

- The Piraeus – Athens – Thessaloniki railway connection was upgraded through completion of work on the new double-track railway from Leianokladi to Domokos and electrification system in 2019. These works have shortened the travel time from Athens to Thessaloniki in about 4 hours (with a fast service), while remaining work in the signaling / control components, expected to be finalized in 2021, will bring it down even further to about 3 hours.
- The Athens–Patras railway will connect the Athens International Airport with the city of Patras. The total length will be 235 km. Up to now, work has been concluded in the following sections: Athens Airport - Acharnes Railway Center (30 km); Acharnes Railway Center - Kiato (105 km); Kiato – Aigio (71 km). As of 2020, work has been completed till Rodofafni (near Aigio) and the following sections are under tendering procedures: Aigio – Psathopyrgos (21.5 km); Psathopyrgos - Rio (10.5 km); Rio – Patras New Port (8.5 km – covered or 5.16 km covered).
- The Egnatia Railway[69] is a proposed project with a total estimated budget of 10 billion €. It aims to establish a rail corridor running from Alexandroupolis in Thrace to Igoumenitsa in Epirus through Thessaloniki. It will also connect with through the Kozani-Krystallopigi line with Albania. The project has four main components: a) upgrade the Alexandroupolis–Thessaloniki rail line and new routing, b) upgrade the Thessaloniki–Kozani rail line, c) upgrade & construction of subsection Kozani-Krystallopigi rail line, d) construction of the Kozani-Igoumenitsa rail line. The project is intended as a major link along the whole of Northern Greece, enabling the increased utilization of 6 airports (Alexandroupolis, Kavala, Thessaloniki, Ioannina, Kastoria, Kozani) and 4 ports and corresponding logistics hubs (Alexandroupolis, Kavala, Thessaloniki, and Igoumenitsa). As of now, the project is still in early maturity stage.

Figure 6.3.2: Overview of the scope of the Egnatia railway, connecting Northern Greece from East to West system (Source: Ministry of Infrastructure, Transport & Networks).

[69] www.ergose.gr/wp-content/uploads/2018/04/Sidirodromiki_Egnatia.pdf

6.4 Existing road infrastructure

The Greek road infrastructure has two main components: the motorways and the national roads. The key difference is that the former are built with higher construction standards compared to the former. Motorways in Greece have a total length of more than 2,500 km; their construction has started since the 1980s, with several large and important sections finished only very recently (e.g. A2 / Egnatia Odos in 2009, A8/ Olympia Odos in 2017, A1 / A.Th.E. in 2017). As a result, the motorways network is very modern.

Figure 6.4.1: The Greek motorway system as of 2019[70].

[70] Source: Theodooritus - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=59588761

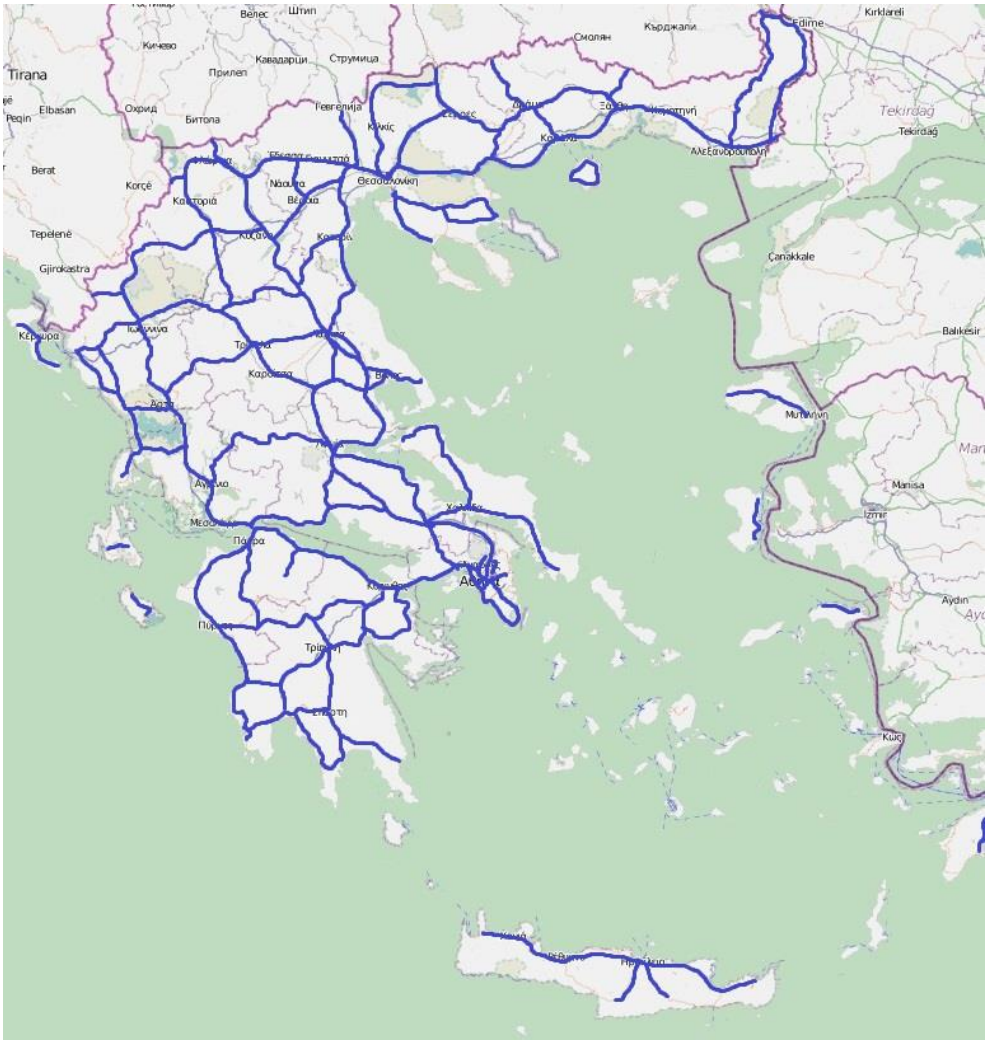

Figure 6.4.2: The national road network in Greece.

At the moment, the national road network servers as the major method for freight transportation in Greece, as can be seen in the table below.

Table 6.4.1: Freight transportation statistics in Greece (Source: Hellenic Statistical Authority[71]).

Freight transportation (in million tons)	2012	2013	2014	2015	2016
Road transportation	400.1	480.8	403.3	420.0	410.3
Sea transportation	123.6	130.2	137.3	135.7	143.2
Air transportation	89.6	87.9	89.7	92.6	101.0

[71] www.statistics.gr/en/infographic-freight-transport

6.5 Energy sector

The following table provides a short overview of the energy sector in Greece, comparing it with the EU average, while in the following paragraphs more specific information on different subjects is provided.

An important characteristic of the Greek energy sector is its dependency on imports. For decades, the exploitation of domestic low-quality coal reserves for power production was a mitigating factor; in addition, a relatively small oil field has been operating in Prinos since 1974[72]. The future evolution is still up in the air, with increased production of intermittent renewables (wind and solar) on the other hand, and on the other increased share of natural gas as well as the "promise" of exploitation of large hydrocarbon reserves in Western Greece, the Ionian Sea and the Libyan Sea.

The transformation of the Greek energy system is underway and changes are rapid. Major infrastructure investments are in various states of development. Among those are:

- The Independent Power Transmission Operator (IPTO / Greek ADMIE) is planning total investments of 4.3 billion € by 2030, mostly aiming to connect the Greek islands with the Greek mainland electricity transmission system. Among the connections are: final phase of the interconnection of Cyclades islands (389 mil. €, expected within 2020); Creta - Peloponnese (350 mil. €, expected within 2020); Creta – Attica (781 mil. € expected by 2023); Dodecanese (1.5 bil. €, expected by 2027); North Aegean islands (885 mil. € by 2029). These interconnections promise to stop the operation of oil-fired power plants in the islands, while also allowing their RES potential to be exploited on the mainland.
- Major investments are also ongoing or planned for the natural gas infrastructure. These include: the completion of the TAP (Trans-Adriatic Pipeline), already in very advanced stage of construction; the IGB interconnector[73] between Greece and Bulgaria; new LNG handling terminals; and the expansion of the natural gas distribution grid to 39 cities. The Eastern Mediterranean (EastMed)[74] pipeline is a major project, confirmed a PCI (Project of Common Interest) in 2015. EastMed aims to develop 1,300 km of offshore pipeline and 600 km of onshore pipeline, connecting the Eastern Mediterranean natural gas reserves to mainland Greece via Cyprus and Crete; it will have a capacity of 10 billion cubic meters per year and a project cost of around 7 billion €.

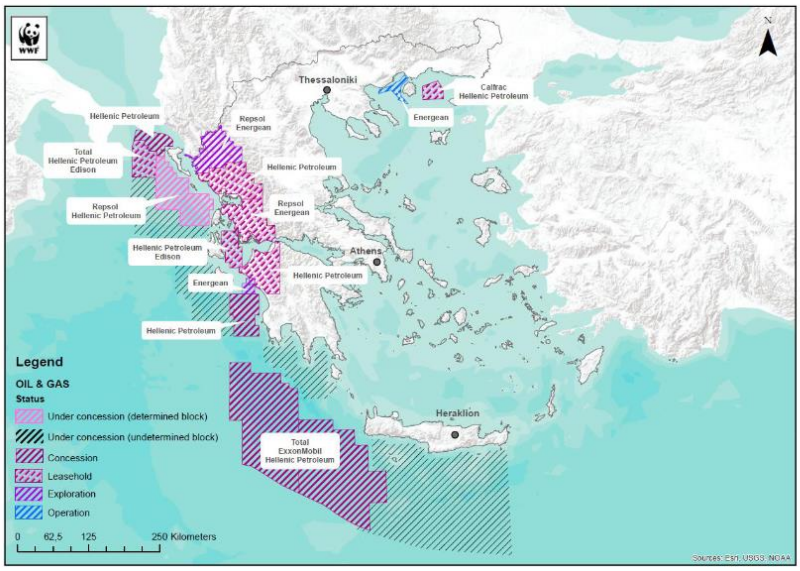

Figure 6.5.1: Concession areas currently leased or in operation in Greece by 2018 (Source: WWF Greece[75]).

72 www.energean.com/operations/greece/prinos-concession
73 www.icgb.eu/about/igb_project
74 www.igi-poseidon.com/en/eastmed
75 www.wwf.gr/images/pdfs/oil-gas-report.pdf

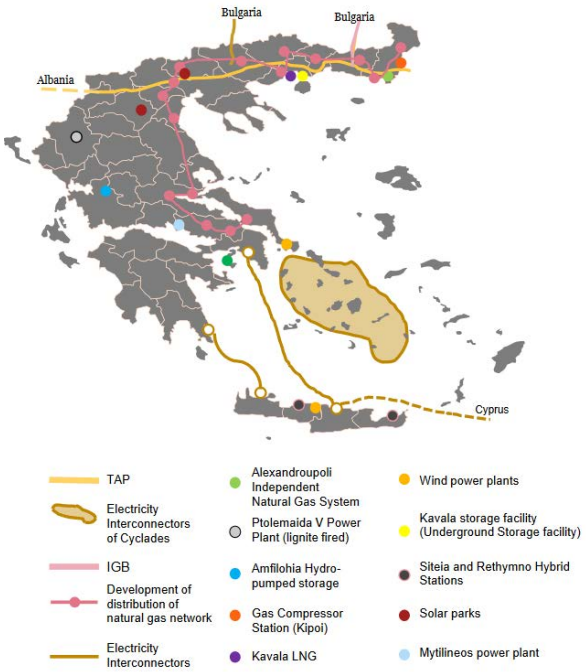

Figure 6.5.2: Overview of major energy infrastructure investments in Greece (Source: PWC[76]).

Table 6.5.1: Overview of the energy sector in Greece and comparison with the EU-average.

Category	Greece	EU	Unit	Source / Year
Primary energy consumption	2.09	3.03	toe/capita	2018 / [1]
Energy dependence	70.7	55.7	%	2018 / [1]
Renewable energy share	18.0	18.0	%	2018 / [1]
GHG emissions	8.98	8.57	ton CO_2-eq/capita	2018 / [1]
Bioenergy in RE	37.8	69	%	2017 / [2]
Bioenergy in total energy	6.4	10.6	%	2017 / [2]
Biofuels prod. Capacity	0.098	0.051	ton/capita	2018 / [3]
CHP	3.90%	11.27%	% gross electricity generation	2017/ [1]
District heating	658	160,785	km	2012 / [4]
	0.06	0.31	m/capita	

Sources:
[1] Eurostat
[2] Bioenergy Europe Statistical Report 2019
[3] Bioenergy Europe Statistical Report 2020
[4] https://ec.europa.eu/energy/sites/ener/files/documents/mapping-hc-final_report-wp2.pdf

[76] www.pwc.com/gr/en/publications/greek-thought-leadership/infrastructure-in-greece/infrastructure_2018_en.pdf

6.5.1 Power generation

Since the 1950s, the development of the Greek electricity sector was inextricably connected with mining and utilization of indigenous brown coal – lignite. Primarily mined in Western Macedonia and to a lower extend in Megalopolis, Peloponnese, at its peak lignite production in Greece reached more than 77 million short tons[77] while the installed capacity amounted to more than 4.5 GWe (net). Greek lignite is a very poor quality fuel, with high shares of moisture (more than 55 % in most cases) and quite high ash content. Combined with the old age and low efficiency of older power plants, the carbon intensity of lignite-fired power generation in Greece was quite high and as a result profitability of lignite power generation was dramatically affected by rising CO_2 prices in the European Trading Scheme (ETS).

This situation prompted the Greek government, through the Prime Minister Kyriakos Mitsotakis, to announce a coal phase-out in the UN Climate Action Summit (23rd September 2019). This decision was also integrated in the final NECP for Greece, submitted to the European Commission in early 2020. The plan is to phase-out all lignite0-fired operating units until 2023; the currently under-construction Ptolemaida V power plant would operate with lignite from its commissioning till 2028, at which point it would change its fuel. The fate of this unit is a major issue for Public Power Corporation S.A., since it represents a total investment of 1.4 billion €.

By 2030, the major contributors to the electricity system in Greece are foreseen to be PV and wind plants; natural gas will also play a major role as a "transition" fuel with an increased of both its installed capacity as well as its total electricity production. Already, at least 5 large private companies are planning investments in new, state-of-the-art combined cycle gas turbine (CCGT) natural gas plants, with a total capacity of 3.5 GWe[78].

Table 6.5.2: Installed capacity and electricity production in Greece (Source: NECP, Greece).

Electricity sector	2016		2030	
	Installed Capacity (GW)	Electricity (GWh)	Installed Capacity (GW)	Electricity (GWh)
Lignite	3.9	14,800	-	-
Oil (incl. refineries)	1.7	5,381	0.3	828
Natural gas	5.2	13,218	7.0	18,304
Bioenergy	0.1	253	0.31	1,575
Hydropower	3.4	5,603	3.7	6,392
Wind	2.4	5,146	7.0	17,112
PV	2.6	3,930	7.7	12,117
Solar thermal	-	-	0.1	260
Geothermal	-	-	0.1	631
Total	19.3	48,339	26.2	57,220
New storage systems	-	-	0.7	-
Imports	-	8,796	-	4,578
Emissions (Mt CO_2)	31.3		6.6	
Carbon intensity (gCO_2/kWh)	648		115	

[77] https://knoema.com/atlas/Greece/topics/Energy/Coal/Production-of-lignite-coal
[78] https://energypress.gr/news/koyrsa-gia-5-nees-ependyseis-stis-monades-fysikoy-aerioy-poy-tha-paixoyn-rolo-gefyras-stin

The biomass contribution to the Greek electricity system is quite small. As of 2018, the installed capacity amounted to 82 MWe, of which 70 MWe corresponded to biogas and the remaining 12 MWe to solid biomass; their share in the gross electricity generation in the country was only 0.6 %. The NECP foresees that installed biomass capacity will reach 300 MWe by 2030. However, a reduction of the prices in the feed-in premium scheme in spring 2020 makes reaching the target questionable, according to the Hellenic Biomass Association[79].

6.5.2 Residential sector and solid biomass consumption

The residential sector amounts to around 25.5 % of the Greek final energy consumption. The final energy consumption in the sector is foreseen to remain fairly stable till 2030 according to the NECP. Advancements in the decarbonisation of the residential heating sector are foreseen to be achieved through the substitution of heating oil with natural gas and expansion of solar energy and heat pumps.

Table 6.5.3: Final energy consumption for the residential sector of Greece (Source: NECP, Greece).

Final energy consumption – Residential sector	Unit	2016	2030
Oil	ktoe	1,266	433
Natural gas	ktoe	329	673
Electricity	ktoe	1,719	1,748
District Heating	ktoe	51	39
Biomass	ktoe	728	860
Solar	ktoe	192	377
RES for heat pumps	ktoe	39	336
Total	ktoe	4,326	4,465
Emissions	Mt CO_2	4.7	2.9
Carbon intensity	gCO_2/MJ	25.95	15.51

The onset of the Greek financial crisis and the fiscal measures associated with the increase of heating oil taxation had a major impact on the development of a biomass heating market. Indeed, a survey of the Hellenic Statistical Authority for the household energy consumption in 2011-2012[80] indicated that firewood became the 2nd largest contributor to the thermal energy consumption of residential buildings (23.8%), behind heating oil (60.3%) and ahead of natural gas (7.4%). Wood pellets also started to make an appearance in the market, while exhausted olive cake and other biomass assortments had a minor role in rural heating consumption. Unfortunately, biomass utilization on the household level often took place in improper installations (e.g. poorly designed, open fireplaces, inefficient stoves) and in many cases with improper fuels, even chemically treated wood, causing increased PM emissions in many urban areas[81] – including Athens – on cold winter days. This is acknowledged by the NECP and the overall contribution of biomass in the energy consumption of the residential sector remains fairly stable.

[79] https://energypress.gr/news/eleaviom-den-horaei-kamia-meiosi-timon-anaforas-gia-viomaza-kai-vioaerio-eimaste-poly-piso-apo

[80] www.statistics.gr/documents/20181/985219/Energy+consumption+in+households

[81] K. Florou et al. (2016) The contribution of wood burning and other pollution sources to wintertime organic aerosol levels in two Greek cities. Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2016-721. Available online at: www.atmos-chem-phys-discuss.net/acp-2016-721/acp-2016-721.pdf

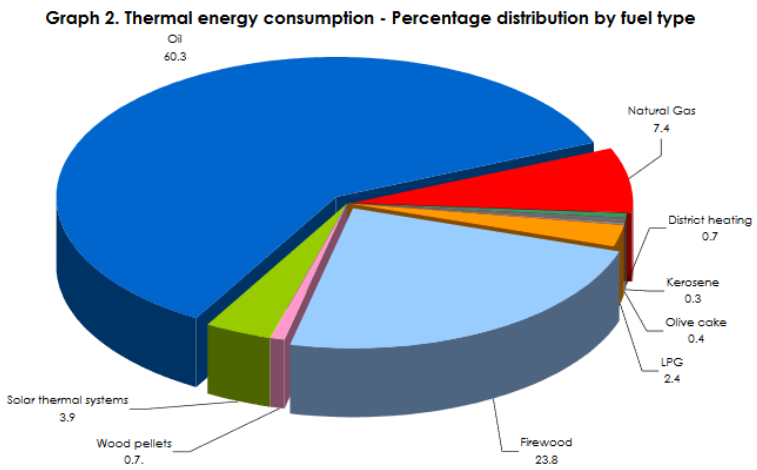

Figure 6.5.3: Thermal energy consumption in the residential sector, 2011-2012 (Source: ELSTAT).

6.5.3 Transportation and Biofuels

The transport sector amounts to around 40% of the Greek final energy consumption; this percentage is foreseen to remain fairly stable till 2030, although the total energy demand will increase. The table below summarizes the main energy sources used for transport in 2016 as well as the provisions of the Greek NECP for 2030.

Table 6.5.4: Final energy consumption for the transport sector of Greece (Source: NECP, Greece).

Final energy consumption – Transport sector	Unit	2016	2030
Oil products	ktoe	6,592	6,439
Biofuels	ktoe	149	371
Natural gas	ktoe	19	102
Electricity	ktoe	28	154
Total	ktoe	6,789	7,066
Emissions	Mt CO_2	17.1	19.9
Carbon intensity	gCO_2/MJ	60.16	67.27

Biofuels currently contribute to about 2.2 % of the transport sector energy demand; this share is foreseen to increase to 5.5% by 2030. However, the relative expansion of the use of natural gas and electricity will be much higher. At the moment, the Ministry of Energy and Environment places electrification in the transport sector very high in its political agenda; the Greek parliament is expected to vote on a law offering major incentives for the purchase of electric vehicles within 2020.

At the moment, only biodiesel is produced and used in Greece as a transport biofuel. In 2019, 16 producers and 5 importers were granted distribution quotas[82]. Major producers are AGROINVEST S.A. (www.agroinvest.gr), PAVLOS N. PETTAS S.A., (www.pnpettas.gr), GF Energy (www.gfenergy.gr), New Energy S.A. (www.newenergy.gr) and Elin Verd (www.elinverd.gr). The raw materials used for biodiesel production are primarily oil seeds (sunflower, rapeseed and soya – 58.6%), cotton seeds (13.6%) and various used vegetable oils, cooking oils and

[82] Ministry of Energy and Environment, Decision 46361/1521.

animal fats (27.8%). The installed biodiesel production capacity in Greece is 1,045 thousand tons and far exceeds the current production. It is estimated that in the future, the production capacity could be used for development of export markets for biodiesel and/or for fulfilling higher blending mandates[83].

Regarding the oil refining sector, two company groups and four refineries are operating in Greece: Hellenic Petroleum S.A. (www.helpe.gr, operating in Aspropyrgos, Elefsina and Thessaloniki) and Motor Oil Hellas S.A. (www.moh.gr, operating in Corinthos). The oil refinery capacity in Greece is about 528,000 barrels per day (ref. year 2018), enough to meet domestic demand and to establish Greece as a net exporter of petroleum products when domestic consumption decreased[84].

6.5.4 CHP and District Heating

The average share of CHP is the Greek gross electricity generation was only 3.9% in 2017, much lower than the EU-28 average of 11.3%. In total, the installed capacity of CHP plants in Greece is 332 MWe / 940 MWth, of whuch 290 MWe / 563 MWth are related to high-efficiency CHP plants. The fuel inputs for CHP are as follows: 54.8% natural gas; 22.9% oil and oil products; 12.8% coal; 8.9%; other fuels; 0.6% renewables[85]. The largest high efficiency CHP plant in Greece is natural gas-fired and serves the production facilities of Aluminium of Greece[86]. Other smaller CHP plants can be found in industries, greenhouses as well as in the service sector.

At the moment, five District Heating (DH) networks operate in Greece. Apart from the privately owned network at Serres (fueled by natural gas and oil), all the other DH systems (Kozani, Ptolemaida, Amyntaio, Megalopolis) get their heat from steam extracted from nearby lignite-fired power plants. The recent announcement of the coal phase-out (2023 for operating units, 2028 for the under-construction Ptolemaida V) places major challenges to the DH operators, which are in all cases municipal companies, and also poses questions about the future of the under developmemt DH network in Florina (also originally foreseen to get heat from the Meliti lignite-fired power plant). The situation is still unclear and different scenarios are under consideration. At the moment, Megalopolis and Florina seem to go in the direction of exchanging the DH network with a natural gas grid, while Kozani and Ptolemaida look for more "central" solutions, possibly with the installation of high-efficiency CHP natural gas-fired plants. The Municipal DH Company of Amyntaio[87] has already started the construction of 2 x 15 MW biomass heating boilers with a total budget of around 12.5 mil. €. Operational start-up is foreseen for autumn 2020, making Amyntaio the first biomass-fuelled DH network in Greece; it is estimated that around 20,000 tons of biomass will be needed per heating season.

[83] BIOFIT (2019) Deliverable 2.5 "Framework conditions for retrofitting Europe's industry with bioenergy". Available online at: www.biofit-h2020.eu/D2.5_BIOFIT frameworks_2019-08-02-final-updated-acknowledged.pdf
[84] BIOFIT, ibid.
[85] Source: Eurostar, Combined Heat and Power data (last updated: 29 August 2019)
[86] www.mytilineos.gr/en-us/combined-heat-and-power-plant/about
[87] http://detepa.gr/dhca/

6.6 Summary and conclusions in relation to SWOT elements

Greece's geographical position in the Southeastern corner of Europe poses both major challenges and offers unique advantages. On the one hand, Greece is located far away from the major markets of Western Europe. On the other hand, it serves as an entry into European space of products arriving from the East and South and aims to expand its position as a logistics centre and exporting hub. When it comes to transportation, the major road network is almost complete and thoroughly modernized, while the competitive position and importance of harbours is increasing. The railway network is still underdeveloped, but several upcoming investments aim to transform and upgrade its role.

Major developments are currently taking place in the energy sector. By adopting a very ambitious coal phase-out plan and aiming to explore its significant wind and solar potential, Greece aims to become a frontrunner in renewable electricity production. Bioenergy / bioeconomy is foreseen to place a small but relative part in this transition. Major challenges will arise from the decarbonisation of other sectors as well as from the final role that natural gas will place as a transition fuel. It is also still unclear whether the utilization of hydrocarbon reserves found in Greece will proceed and how they will fit into the overall country strategy.

Table 6.6.1: SWOT analysis of Infrastructure, logistics and energy sector of Greece

Strengths	Weaknesses
Modern motorway network Developed ports, serving also as entry points for several SEE countries Established, operating industrial fossil refineries	Railway network still not well developed Numerous non-designated industrial areas / outdated infrastructure in designed ones Lack of inland waterway network
Opportunities	**Threats**
Coal phase-out may create significant possibilities for development of regional bioeconomy in former mining areas Under-utilized capacity of biodiesel producers may prompt interest in bioeconomy	Private sector investments may not materialize Geopolitical implications in wider geographical neighbourhood may affect country risk Natural gas investment lock-in, may become more than a transition fuel Biomass for energy may be further marginalized in favour of electrification / natural gas

7 Skills, education, research and innovation potential

7.1 Research infrastructure

The research sector in Greece is monitored by the General Secretariat for Research and Technology (GSRT), currently under the auspices of the Ministry for Development and Investments. GSRT supervises 11 research centres and 3 technology bodies, while launching competitive research projects highlighting economic performance and a socially fair allocation of outcomes.

The performance of Greek partners in H2020 is consistently high, with the country being in the top-10 list of member states[88] and several partners making it in the top-50 list of research organizations in terms of funding[89]. Some of the most relevant research organizations in Greece are presented below.

Centre for Research and Technology Hellas – CERTH (www.certh.gr) is the largest research centre in Greece and No 1 in terms of H2020 participations. CERTH employs more than 700 people, with an average annual turnover of around 25 million EUR, mostly coming from competitive research projects (> 60 %), but also from bilateral industrial research contracts (>30%) and government institutional funding (<10%). Based in Thessaloniki, CERTH is currently organized in five institutes, of which two are of direct relevant to the bioeconomy sector:

- Chemical Process & Energy Resources Institute – CPERI (www.cperi.certh.gr) includes in its scope the following: Sustainable & Clean Energy, Environmental Technologies, Chemical & Biochemical Processes, Advanced Functional Materials. CPERI has various laboratories and pilot facilities that are of relevance for the bioeconomy sector: catalytic processes, solid and liquid fuel characterization laboratories, various process laboratories, etc.
- Institute for Bio-Economy and Agri-Technology – iBO (https://ibo.certh.gr/) focuses on agricultural intelligence systems (e.g. robotics, AI), circular economy and energy systems in agricultural production and ergonomics-biomechanics.

Hellenic Centre for Marine Research - CHMR (www.hcmr.gr) and especially two of its institutes, the Institute of Marine Biology, Biotechnology and Aquaculture and the Institute of Marine Biological Resources and Inland Waters, are relevant actors for the blue bioeconomy, having relevant laboratory infrastructure and equipment for field measurements.

Center for Renewable Sources and Saving – CRES (www.cres.gr) is a technology center, supervised by the Ministry of Environment and Energy. The Biomass Department of the Division of Renewable Energy Sources has significant experience in the field of novel crops for energy, food, fiber and other applications, being involved in several EU-funded projects and managing pilot plantations with a total surface of around 20 hectares.

Foundation for Research and Technology Hellas - FORTH (www.forth.gr) is one of the largest Greek research centers, with activities in the fields of Molecular Biology and Genetics, Biotechnology, Bioinformatics, Precision Medicine, Systems Biology among many others. FORTH has founded the PRAXI Network (www.praxinetwork.gr), a technology transfer unit that is the National Contact Point for the BBI-JU in Greece.

The Hellenic Agricultural Organization (HAO) DIMITER (www.elgo.gr) is supervised by the Ministry of Rural Development and Food. The Organization is along others active in agricultural research, farmers vocational training and analysis of agricultural products.

It should also be noted that several academic institutions play a major role in bioeconomy research and education in Greece. Details are provided in the following section.

88 https://ec.europa.eu/programmes/horizon2020/sites/horizon2020/files/h2020_threeyearson_a4_horizontal_2018_web.pdf

89 http://edz.bib.uni-mannheim.de/edz/pdf/swd/2017/swd-2017-0221-2-en.pdf

7.2 Education infrastructure

The Greek higher education system includes 24 public universities and polytechnic schools. The table below summarizes the ones that are most relevant for the bioeconomy.

Table 7.2.1: Universities relevant to the bioeconomy sector in Greece.

University	Website	Relevant schools / departments
Aristotle University of Thessaloniki	www.auth.gr	Engineering (Chemical)
National Technical University of Athens	www.ntua.gr	Engineering (Chemical)
Hellenic Mediterranean University	www.hmu.gr	Agriculture
Agricultural University of Athens	www.aua.gr	Agriculture (plant, animal, environment and agricultural engineering, food and nutrition, applied biology / biotechnology, applied economics)
National and Kapodistrian University of Athens	www.uoa.gr	Agriculture, Sciences (biology, chemistry)
University of West Attica	www.uniwa.gr	Food science, Engineering (industrial design and production)
University of Patras	www.upatras.gr	Agriculture, Engineering (Chemical), Natural Sciences (chemistry, biology, materials)
University of Crete	www.uoc.gr	Sciences and Engineering (material science, biology)
Technical University of Crete	www.tuc.gr	Engineering (Production & Management, Environment)
University of Ioannina	www.uoi.gr	Engineering (Material science), Agriculture
Dimocritus University of Thrace	http://duth.gr/	Engineering (Environmental, Process), Agriculture, Forestry
University of Thessaly	www.uth.gr	Technology (Wood products, Environment, Energy), Agriculture (Agronomy, Forestry, Aquaculture, Food)
University of Piraeus	www.unipi.gr	Industrial Management / Technology
University of Western Macedonia	www.uowm.gr	Engineering (Product and system design, chemical), Agriculture
University of Peloponnese	www.uop.gr	Agriculture, Food
University of the Aegean	www.aegean.gr	Engineering (Product & System design), Environment (including Marine environment, food & nutrition)
Harokopio University	www.hua.gr	Environment, Ecology
University of West Attica	www.uniwa.gr	Food science, Engineering (industrial design and production)
University of Patras	www.upatras.gr	Agriculture, Engineering (Chemical), Natural Sciences (chemistry, biology, materials)

Numerous departments / schools offer post-graduate courses that are of relevance to the bioeconomy sector, covering various fields, from sustainable development, to renewable energy production, agriculture and others.

One that can be singled out is the Master of Science in Bioeconomy, Circular Economy and Sustainable Development (https://bioeconomics.edu.gr), organized by the Bio / Circular Economy and Sustainabile Development Laboratory of University of Piraeus / Department of Economics.

As aforementioned, Greek universities are very active in research as well. The National Technical University of Athens (NTUA), the Aristotle University of Thessaloniki, the University of Patras and the National and Kapodistrian University of Athens are among the top-10 Greek institutions in terms of H2020 funding according to the H2020

dashboard. Moreover, as described in Section 5.4, NTUA and the Agricultural University of Athens are active on ongoing BBI projects.

7.3 Environment for start-ups

The Greek start-up scene has started its evolution during the time of the financial crisis and has exhibited continued growth during that period. The estimations of the number of start-ups varies, from 562 to around 2,000[90].

Some key facts on the Greek start-up scene[91]:

- 17.1 % operate in the Industrial Technology / Production Hardware category.
- Main business models: "mainly B2B with some B2C" (20%), "mainly B2B" (17.1%) and "mainly B2C with some B2B" (17.1%).
- Revenue generation: 52.8% domestic market, 32.1% European market, 15.1% (worldwide).
- Annual revenues (out of those that generate them): 71.5% up to €50,000 (lowest position among European countries in total), 14.3% between €50,000-€150,000, 14.3% between €150,000-€500,000.

More than half of the Greek start-ups generate revenue in the domestic market (52.8%), while 32.1% in European countries and a 15.1% worldwide. Greece presents a high degree of internationalisation (43.8%). Out of the startups that are already having some revenue, the majority (71.5%) are earning up to €50,000, holding the lowest position among European countries overall. Another 14.3% earned €50,000-€150,000 and 14.3% had an annual revenue of €150,000-€500,000 in the past year.

Several co-working spaces are available, mostly in Athens, some options are also available in Thessaloniki and Heraklion:

- The Cube Athens (https://thecube.gr/)
- Found.ation (https://thefoundation.gr)
- Orange Grove (https://orangegrove.eu/)
- Impact Hub Athens (https://athens.impacthub.net/)
- Stone Soup (www.stonesoup.io)
- Romantso (www.romantso.gr)
- HIGGS - Higher Incubator Giving Growth & Sustainability (https://higgs3.org/)
- Tzaferi 16 (http://www.tzaferi16.gr/)
- Athens Place (www.athensplace.gr)
- AIC – Athens Investment Center (http://www.aic-business.gr)
- pom (www.po-meeting.com) / Heraklion
- coho (www.coho.gr) / Thessaloniki
- MAKE creative services (www.make.gr) / Thessaloniki

[90] https://www.enterprisegreece.gov.gr/files/pdf/startup2019/5-The-Greek-Startup-Scene_2019.pdf
[91] https://thefoundation.gr/wp-content/uploads/2020/05/Foundation_EIT_Startups_Greece_report.pdf

Incubators / Accelerators in Greece often use the term interchangeably. A list of the most important ones can be found in the list below.

- IT Climate-KIC Hub Greece (www.climate-kic.org/countries/greece/) in Athens. The Greek Hub us fynded by the following partners: Athena Research and Innovation Center (ATHENA RC); Academy of Athens (AA) -Research Centre for Atmospheric Physics and Climatology; European Regional Framework for Co-operation (ERFC) Uni.Fund and supported by the associate Partners: United Nations Sustainable Development Solutions Network (UN SDSN-Greece, hosted by ICRE8: International Center for Research on the Economy and the Environment); Foundation for Economic and Industrial Research (IOBE); Eunice Energy Group.
- Metavallon (https://metavallon.vc/) / Athens
- Starttech Ventures (www.starttech.vc) / Athens
- Venture Garden (www.venturegarden.gr) in Athens & Thessaloniki
- IQbility (www.iqbility.com)
- egg – enter.grow.go by Eurobank (www.theegg.gr)
- Corallia (www.corallia.org)
- Lefkipos Attica Technology Park (http://lefkippos.demokritos.gr/) / Athens
- Thessaloniki Technology Park (http://www.thestep.gr)
- Athens Digital Lab (www.athensdigitallab.gr)
- Innovathens (www.innovathens.gr)
- Th.E.A. - The Athens Startup Business Incubator (https://theathensincube.wordpress.com/)
- ACE.in – Athens Center for Entrepreneurship and Innovation (https://acein.aueb.gr/)
- Microsoft Innovation Centre – Greece (https://www.microsoft.com/el-gr/mic)
- Step-C – Science and Technology Part of Crete (http://www.stepc.gr/)
- Industry Disruptors-Game Changers (ID-GC) (http://industrydisruptors.org)

Various financing tools for start-ups are also available and are further outlined in Section 9 of this report.

Several framework developments favour the growth of the start-up sector. In 2018, Athens was selected as the "European Capital of Innovation 2018"[92], earning a 1 million EUR price, thanks also to establishment of innovation hubs such as the Athens Digital Lab. The Greek Government has also announced that it will launch in August 2020 the National Registry for Start-ups, "ElevateGreece", which will also serve as mapping / monitoring tool for the sector as well as to facilitate various government services, matchmakings / job offers and investments. Moreover, it is intended to set in place tax incentives for angel investors (as physical persons) in start-ups, allowing up to 50 % of their contributions to be deducted from taxable income.

A relevant start-ups for bioeconomy sector might be BIOMAS (www.biomasmarket.com). It aims to develop an integrated, online system for the real time management and auctioning of the biomass products and services. As of July 2020, its platform is still under development.

7.4 Public private partnerships

Public Private Partnerships (PPPs) have emerged as a major tool for investments in infrastructure in Greece. Stakeholders such as the SEV (Hellenic Federation of Industries) are advocating in favor of expanding PPPs as a counterbalance to decreased public investments due to the financial crisis, while also expanding their scope beyond the "traditional" sectors of transport infrastructure and waste management[93].

[92] https://ec.europa.eu/commission/news/athens-european-capital-innovation-2018-2018-nov-06-0_en
[93] www.sev.org.gr/Uploads/Documents/51639/Weekly_01_11_2018.pdf

According to the World Bank[94], Greece ranked 3rd out of 135 countries in PPP competition procedures. Greece was also the first member state to combine European Investment Bank and JESSICA funds for PPPs[95] and several PPPs projects have received national, European and international awards. Law 4635/2019 will also treat all PPPs as "strategic projects", eligible for a fast-track licensing procedure.

In the period of 2009 – 2019, 14 PPP projects have been implemented, with a total value of 882 million EUR; these include 5 integrated waste management systems in Serres, Western Macedonia, Epirus, Ilia and Peloponnese. 18 PPPs of a total value of 2.36 billion EUR have also been approved, including the integrated waste management systems of the island of Rhodes (44 million EUR) and Central Macedonia (130 million EUR). Further PPPs for the waste management system of Attica are also anticipated[96].

7.5 Clusters and associations

Numerous professional associations are operative in Greece, aiming to represent their members' interests. Several of these belong to sectors that are of direct relevance to the bioeconomy: agriculture, food processing / production, packaging materials, pharmaceuticals production, chemical production. It is interesting to note that as of July 2020, only the Association of the Greek Manufacturers of Packaging & Materials (AGMPM) has joined the Bio-based Industries Consortium as an associate member.

Regarding the organization of promotional / dissemination activities on the bioeconomy, among most active organizations is the Hellenic Biomass Association (Hellabiom) and the Greek Bioeconomy Forum (GBF).

Inter-professional associations (also known as IBOS: Interbranch organisations IBOs) are state-recognized, private associations that bring together key actors from all the value chain steps of agricultural commodities. The oldest such association in Greece is EDOAO, operating in the grape and wine sector. Others IBOs operate in the olive oil, meat, edible olives and tobacco sectors, while in spring 2020 IBOs for rice and stonefruit / pears were established.

The European Cluster Collaboration Platform (www.clustercollaboration.eu) lists 11 cluster organizations operating in Greece of which at least 4 are of direct or indirect relevance to the wider bioeconomy sector. The BIONIAN Cluster and Hellenic BioCluster have a stronger focus on biotechnologies and pharmaceuticals, while the Chorus Cluster and CLuBE emphasize on environmental technologies and process, renewable energy production and others. Indicatively, CLuBE is involved in the SCALIBUR H2020 project[97] aiming to cut urban biowaste and replace it with a new production chain of biomaterials, forming a partnership of end users to recover and transform biowaste into value added products; activities in Greece are implemented in the city of Kozani.

The establishment of clusters in the agro-food sector is one of the main activities of various projects in Greece, such as AgroLabs[98] and FOCUS[99].

The table below presents a detailed list of the main such associations, clusters and networks that mostly operate on the national level. It should also be noted that relevant stakeholders operate also on the regional / local level.

[94] https://ppp.worldbank.org/public-private-partnership/library/procuring-infrastructure-ppps-2018
[95] www.sdit.mnec.gr/sites/default/files/assets/Presentation%20on%20Public%20Private%20Partnership.pdf
[96] www.sdit.gov.gr/sites/default/files/assets/PPPs_0.pdf
[97] SCALABLE TECHNOLOGIES FOR BIO-URBAN WASTE RECOVERY: www.scalibur.eu
[98] AgroFood Innovation Clusters: www.interreg-balkanmed.eu/approved-project/31
[99] Strengthening competitiveness of agri-food SMEs through transnational Clusters: www.interreg-balkanmed.eu/approved-project/28/

Table 7.5.1: Clusters and associations relevant to the bioeconomy sector in Greece.

Organization name	Website	Description
Association of the Greek Manufacturers of Packaging & Materials (AGMPM)	www.pac.gr	Established in 1999, its members include industries producing packaging material from paper/carton, glass, wood, metals, plastics, flexible synthetic materials and natural materials.Member of WPO (World Packaging Organization). Associate Member of BIC (Bio-based Industries Consortium) since April 2020.
Association of Greek Olive Oil Refining Industries (SEVITEL)	http://www.sevitel.gr	Represents industries from the olive oil refining sector.
Association of Olive Kernel Oil Producers of Greece (SPEL)	N/A	Representing the pomace mills in Greece. Member of the European Federation of Olive-Pomace Oil and Olive Biomass.
Association of Greek Agricultural Cooperatives and Enterprises (SASOEE)	http://sasoee.com.gr	Established in 2017, with around 100 agricultural cooperatives and enterprises as members.
Association of Hellenic Plastics Industries (AHPI)	http://www.ahpi.gr	Established in 1958, its members encompass about 80% of Greek plastics production. Member of EuPC (European Plastics Converters) and participant in PlasticsEurope.
BIONIAN Cluster	N/A	Established in 2013, the cluster focuses on (a) Biomedical Sciences, with a focus on applied clinical research, clinical pharmacology and therapeutics, and (b) the Environmental Health Sciences.
Central Cooperative Union of Vine Products (KEOSOE)	www.keosoe.gr	Represents 35 primary and secondary agricultural cooperative organizations from the grape and wine sector in Greece.
Cluster of Bioeconomy and Environment of Western Macedonia (CLuBE)	www.clube.gr	Established as a legal form by 21 initial members from the Public sector, R&D and Entrepreneurship, covering the entire triple helix of the regional bioenergy and environment sector, with a focus in the region of Western Macedonia. Active in H2020 projects.
Chorus Cluster	www.chorucluster.org	Located at CERTH's premises in Thessaloniki, Chorus Cluster focuses on clean processes, energy efficiency, resource efficiency, green transportation and renewable energy.
Federation of Hellenic Food Industries (SEVT)	www.sevt.gr	SEVT represents the Greek Food & Drink Industry on national, European and international level. It consists of food and drink companies and sector associations. Active in national and European research projects.
Greek Bioeconomy Forum (GBF)	www.bioeconomyforum.gr	Platform / think-tank where individuals interested in bioeconomy and circular economy come together. The vision of the forum is to raise awareness about bio-economy & circular economy and promote the advantages and opportunities presented at local, regional and national level, including among other actions the transfer of know-how and experience in the EU and world-wide.
Greek Canners Association (EKE)	www.eke.com.gr/	Established in 1996 as a professional association, representing today 15 food processing companies producing fruit compote (mostly peach), but also fruit juice and fruit salads.
Greek Wine Federation (SEO)	http://greekwinefederation.gr	Established in 1995. Its members encompass more than 70% of Greek wine production and account to more than 90% of relevant exports.

This project received funding from the BBI JU under the EU Horizon 2020 research and innovation programme under grant agreement No.838087

Organization name	Website	Description
Hellenic Association of Biogas Producers (HABio)	www.habio.gr	Established in 2018, brings together biogas producers in Greece and associated members. Member of EBA (European Biogas Association)
Hellenic Association of Chemical Industries (HACI)	http://haci.gr	Established in 1994 by the 28 largest companies working on production, storage and sales of chemical products in Greece. Full member of CEFIC (European Chemical Industry Council).
Hellenic Association of Pharmaceutical Companies	www.sfee.gr	Established in 1982, representing 62 member companies – 20 Greek and 42 multinationals, encompassing more than 95% of the pharmaceutical industry operating in Greece. Member of EFPIA (European Federation of Pharmaceutical Industries and Associations).
Hellenic Biomass Association (HellaBiom)	www.hellabiom.gr	Continuation of the first organized association in the renewable energy sector in Greece. Member of Bioenergy Europe, the European Bioenergy Association.
Hellenic BioCluster	http://hbio.gr	Established in 2006, HBio is the first biosciences cluster in Greece bringing together the innovation leaders of Greece in the sectors of Pharmaceuticals, Biotechnology, Diagnostics, Medical Devices and Specialised Services.
Hellenic Feed Industry Association (SEVIZ)	www.seviz.gr	Representing the Greek feed industries.
Hellenic Green Chemistry Network (HGCN)	http://hgcn.chem.upatras.gr/en/	The main aim of HGCN is to promote Green Chemistry in Education, Research, Industry and Society. Brings together Departments of Chemistry in the Universities of Patras, Thessaloniki, Ioannina and Athens.
Hellenic Timber Association	http://htca.gr/	Member of the European Timber Trade Federation.
Interprofessional Association of Table Olives (DOEPEL)	https://doepel.gr/	Established in 2014, brings together producer groups, cooperatives, processing industries and exporters of table olives.
National Rural Network (EAD)	https://ead.gr/networking/national-rural-network/	Member of the ENRD and the EIP-AGRI, the network brings together 186 organizations involved in the rural / agricultural sector: government services, associations, regional authorities, NGOs, research / academic institutions and others.
National Interprofessional Organization for Grapes and Wine (EDOAO)	www.newwinesofgreece.com	Oldest interprofessional organization in Greece, bringing together KEOSOE and SEO.
National Interprofessional Organization for Meat (EDOK)	https://edokhellas.com	Established in 2014 to bring together actors from the meat value chain. Represents Greece in the European Livestock and Meat Trades Union (UECBV).
National Interprofessional Organization for Olive Oil (EDOE)	www.edoe.org	Brings together value chain actor associations from the olive oil value chain: NEA PASEGES, SASOEE, SEVITEL, PASEL, SPEL.
NEA PASEGES	www.neapaseges.gr	Continuation of PASEGES (Panhellenic Confederation of Unions of Agricultural Cooperatives (PASEGES) that was established in 1936 as the main national representative of the Greek agricultural cooperative movement and agricultural cooperatives.
Panhellenic Association of Olive Mils (PASEL)	www.pasel.gr	Established in 2014, representing the olive mills in Greece.

7.6 Summary and conclusions in relation to SWOT elements

An often-used phrase in Greece is that "our country's strength is its people"; considering the successes of the research / academic sectors in attracting European research funds as well as their relatively high scoring in competitive indices, it is clear that there is quite a lot of truth behind this saying. The Greek financial crisis has exacerbated the brain drain; with about 500,000 people estimated to moving abroad during the worst years[100]. Coupled with bad demographics, this is a major issue for the long-term development of the country.

The Greek financial crisis has also dealt a tremendous blow to the country economic development, however new ways of doing business – both in small scale (start-ups) and large-scale (PPPs) are promising to mitigate some of its negative impacts.

Collaboration-wise, numerous organizations and associations operate in the Greek framework conditions. However, the overall abundance may hide the true picture of limited cooperation between their members, limited representation or other operational and organizational issues.

Table 7.6.1: SWOT analysis of Skills, education, research and innovation potential of Greece.

Strengths	Weaknesses
Competent and internationally recognized research centres and universities Strong framework for PPPs Several associations well integrated and represented in the wider European context	Limited government funding in key areas, with worsening situation during the financial crisis Often, lack of true cooperation spirit
Opportunities	**Threats**
Subsidy schemes to repatriate Greeks working abroad Projects and funding for the establishment of clusters Emphasis on start-up support by the state	Brain drain and loss of skilled professionals Limited emphasis on bioeconomy in PPPs beyond the scope of waste management Limited emphasis on bioeconomy also in start-ups, despite a few successful examples

[100] www.politico.eu/article/greece-reverse-brain-drain-skills-young-people-financial-crisis

8 Policy framework: Regulations, legislation, rule of law & taxes and tariffs

8.1 Introduction

As of July 2020, Greece does not have a national bioeconomy strategy.

Certain policy measures related to the development of the bioeconomy are outlined in key policy and strategic documents, the most important being:

- The Greek Smart Specialization Strategy
- The National Energy and Climate Action Plan for 2030 and the 2050 Roadmap
- The National Strategy on Circular Economy and the upcoming ban of single-use plastics

There is no specific support framework for the development of the bioeconomy in Greece. There are some general measures for supporting investments (e.g. the Investment Law) or specialized measures within the Rural Development Programme, the feed-in premium scheme for renewable power generation, etc., which are described in more detail in the following section of this report.

8.2 Greek Smart Specialization Strategy (2014-2020)

Greece has a National Research and Innovation Strategy for Smart Specialisation (RIS3) as well as 13 Regional strategies. The National Strategy has been drafted by the General Secretariat for Research and Technology (GSRT), now under the Ministry of Development and Investments, while the Regional ones were drafted by the corresponding regional authorities[101].

The sector priorities and their description, as captured by the "Eye@RIS3" Tool[102] are presented in the table below.

Table 8.2.1: Overview of the priorities in the Greek RIS3.

Priority Name	Description
Agrifood-nutrition	Emphasis on high value-added, high nutritional quality, internationally competitive goods, modernized production systems, contributing to economic prosperity and quality-of-life. The link with health/cultural/dietary/gastronomic aspects will be pursued.
Health and pharmaceuticals	Biomaterials, tissue engineering, functional foods and nutraceuticals, diagnostic techniques, drug-delivery mechanisms, customized medication, biosensors, bioinformatics and nanomedical applications, telemedicine.
Informatics and telecommunicatio n services	Focus on outward-looking competitiveness, on exploring links with horizontal, enabling technologies, and transversal applications throughout the Greek economy (e.g. energy, logistics, agrifood, environment, health, tourism and culture). Key emerging technologies and aspects will be pursued (big data, gamification, future internet structures, 5G technologies, data mgmt. and computational models, learning technologies, human-machine interaction, 'smart' transversal applications).
Energy and its cross-cutting implications (transport, industrial production, etc.)	Emphasis on renewables, efficiency enhancement technologies, cost-reduction of energy as a key input, outward-looking competitiveness, environmental impacts, smart grids, fuel cells, renewables-sourced energy storage, etc.)

[101] www.espa.gr/el/pages/staticRIS3.aspx
[102] https://s3platform.jrc.ec.europa.eu/regions/EL

Priority Name	Description
Environment and sustainability	Pursue 'green' innovation and entrepreneurship, recycling, integrated waste management, climate change and environmental impact mitigation, disaster prevention and mitigation, oil spill fighting technologies, smart networks, reduction of carbon footprint, biodiversity protection, etc.
Transport and logistics	Emphasis will be given on completion of a national transportation and logistics system, interconnectivity with the rest of the EU, outward-looking competitiveness, collaboration across the value chain and exploitation of interlinkages with other activities, smart and logistics systems, enhanced interoperability, accessibility and territorial cohesion/connectedness, sustainable transport.
Materials and Construction	Enhanced outward-looking competitiveness, expansion of the value chain towards new materials (nanomaterials, advanced materials, polymers, etc.), smart materials, biomedical use materials, self-repairing materials, exploration of uses of new star materials such as graphene, multi-functional materials, 'hardware'-promising materials (thermomechanical features) and 'software'-promising ones (smart, self-repairing, feedback-providing, info-processing).
Culture, Tourism and Creative economy	Explore and foster interactions across parallel value chains (tourism, culture, creative industries), exploiting the possibilities afforded by ICTs, imaging technologies, open innovation, branding, 'experience' tourism, holistic approach to tourism and cultural heritage, experimentation with living labs (virtual or not), etc.

It is interesting to note that the word "bioeconomy" as such does not appear in the National Smart Specialization Strategy document[103]. However, there are interesting possibilities offered in several of the priority sectors identified. The following table provides a summary.

It should also be noted that with valorization of bio-waste and biomass (including energy crops) is a RTD priority for almost all Greek Regions, unlike the other energy priorities which are mostly handled on a National level.

Table 8.2.2: RTD priorities in the Greek RIS3 with direct impact on bioeconomy development.

Priority	RTD priorities relevant to the bioeconomy	Intervention level
Agrifood-nutrition	Productivity increases for plants & animal production and processing	National & Regional
Agrifood-nutrition	Sustainable development of primary production and processing: Decrease of the environmental impact and ecosystem protection	National & Regional
Health and pharmaceuticals	Development of synergies with food sector, cosmetics, materials and environmental technologies Development of new pharmaceutical products	National & Regional
Informatics and telecommunication services	Platforms for social sensitization regarding sustainability and social innovation, Priority areas (Safe, clean and efficient energy production / Smart, ecological and unified transportation)	National
Energy and its cross-cutting implications (transport, industrial production, etc.)	Renewable energy production: energy production from bio-waste, energy crops and biomass	National & Regional
Environment and sustainability	Waste & residue management: solid municipal waste, agricultural residues and waste, etc.	National & Regional
Environment and sustainability	Environmental protection: rehabilitation of soils, protection of biodiversity, especially in areas of touristic and agrofood activities	National
Environment and sustainability	Climate change adaptation, mitigation of impact in economic activities, especially in areas of touristic and agrofood activities	National

[103] https://s3platform.jrc.ec.europa.eu/documents/20182/223684/GR_RIS3_201508_Final.pdf

Priority	RTD priorities relevant to the bioeconomy	Intervention level
Environment and sustainability	Ecosystem approach to sustainable development Supporting and optimizing agricultural production	National
Transport and logistics	Development of agrologistics for supporting the distribution of agricultural products in the market	National
Materials and Construction	Bio-based materials: development of "ecological" paints and coatings from organic materials, other bio-materials	National

8.3 Energy and Climate Strategy for 2030 and 2050

The final version of the National Energy and Climate Plant (NCEP) for Greece[104] was submitted to the European Commission in December 2019. It includes several differences compared to the draft NCEP of January 2019[105]; one of the most important is the pledge for a complete coal phase-out for power production by 2028. It also includes more ambitious targets for RES, in particular a minimum share of 35% RES in gross final energy consumption by 2030. The minimum share of RES per sector is 60% for the gross final electricity consumption, 40% for heating and cooling needs and 14% for the transport sector.

The Greek NCEP proposes a series of measures to promote biomass for energy production:

- Priority in the use of waste (agri-livestock units and industries, urban)
- Supply chain organisation and land planning of sites for temporary storage of agricultural/forest residual biomass
- Maintenance and extension of the sustainability certification scheme for biofuels, bioliquids and solid fuels
- Sustainable forest management
- Strengthening the primary sector through the promotion of energy crops of woody biomass or coppice plantations
- Creation and enhancement of the domestic bioethanol market
- Development of the biomethane market

An increase in the biopower production is foreseen, by expanding the installed capacity to around 310 MWe (less than 88 MWe in 2016) and increasing its contribution to the net electricity production to 2.75 % (0.52 % in 2016). Increased use of biomass in the industry and transport sectors is foreseen, both in absolute amounts and relative contributions. The use of biomass in the residential sector is foreseen to have a slight increase, but its overall contribution will subside.

The Long-term Strategy for 2050[106] outlines the national strategy for 2050 following the requirements of the Regulation on the governance of the energy union and climate action (EU/2018/1999. The Strategy considers different scenarios for the Greek energy system in order to contribute to the overall EC goals for climate neutrality by 2050. Generally, further expansion of RES in the power sector is foreseen. Increased shares of RES penetration in the transport sector is achieved through electrification and advanced generation biofuels from lingo-cellulosic biomass, while for the heating and cooling sector, electrifications and heat pumps are considered instrumental.

In a dedicated section, the Long-Term Strategy recognizes the critical role of biomass in a low-carbon / zero-carbon economy and anticipates that the expansion of biomass supply and use compared to the current one will be required in order to reach the Greek targets for 2050. Expansion is foreseen to come mostly from lingo-cellulosic biomass resources, including dedicated energy crops, in order to avoid impacts on the food and feed

[104] https://ec.europa.eu/energy/sites/ener/files/el_final_necp_main_en.pdf
[105] https://ec.europa.eu/energy/sites/ener/files/documents/ec_courtesy_translation_el_necp.pdf
[106] https://ec.europa.eu/clima/sites/lts/lts_gr_el.pdf

market. The land allocated to energy crops in 2050 is foreseen to range from 385 to 480 thousand hectares compared to 127 thousand hectares in 2015. Biomass is foreseen to be used as a provided of renewable gases, transport biofuels as well as a fuel for power production and the industry.

8.4 National Strategy on Circular Economy / Single-use Plastics

A National Strategy on Circular Economy was adopted in December 2018 by the Ministry of Environment and Energy[107]. The Strategy foresaw a number of interventions along four main priority lines, which are summarized in the table below.

Table 8.4.1: Implementation Actions in the National Strategy on Circular Economy.

Implementation Action categories: 1. Regulatory and Legislative Reforms; 2. Financing and financial incentives; 3. Know-how and Information Actions; 4. Governance
1.1 Completion of the legislative framework for waste management
1.2 Drafting a National Action Plan for the promotion of Green Public Contracts and the preparation of a national policy
1.3 Processing proposals for reducing food loss
1.4 Adjustment of the framework for public and private construction projects
1.5 Clarification of the distinction between waste and products facilitating the transition to the use as secondary raw materials
1.6 Re-usage of water and use of the sludge from waste water purifying plants
1.7 Developing innovative applications and cutting edge technology for waste management in the RIS3 context
1.8 Indicators of Circular Economy
1.9 Developing a methodology to measure and monitor food waste
1.10 Developing ecological design criteria
1.11 National standards for the environment and circular economy
1.12 Incorporation of the dimension of circular economy into the assessment of environmental impact studies
1.13 Promotion of using brokerage, as a non-remunerated, consulting service, at the level of regions or cities to promote circular economy
1.14 Creation of urban spaces as 'creative re-use centres' through the use of Green Points/KAEDISP [Centre for recycling, training and sorting at source], turning them into "Green Centres"
1.15 Promoting the use of waste as secondary fuel in industry
1.16: Establishing an institutional regulatory framework to facilitate the production of bio-methane (green gas) from organic waste and its injection into the natural gas grid or its use as vehicle fuel
1.17: Drafting a Joint Ministerial Decision for compost from pre-selected organic waste
1.18: Upgrading and Reinforcement of Bio-economy sectors. Drafting a National Action Plan for national policy making
1.19: Developing the potential of the institutional framework of Law 4513/2018 on Energy Communities at the local level, through RES technologies and improvement of Energy Efficiency
1.20: Management, development of potential and reuse of wasteproducts
1.21: Adaptation of cost types so as to estimate the costs of the life cycle span of a public or private project
1.22:Incorporation of the principles of circular and sharing/cooperativeeconomy in Sustainable Urban Mobility Plans (SVAK)
1.23: Circular Economy and Ports
2.1: Possibilities for financing actions for Circular Economy
2.2: Circular tax incentives

[107] circulareconomy.europa.eu/platform/sites/default/files/national_circular_economy_strategy.pdf

Implementation Action categories: 1. Regulatory and Legislative Reforms; 2. Financing and financial incentives; 3. Know-how and Information Actions; 4. Governance
3.1: Forum for the development of circular economy
3.2: Development of a Guide for the circular city
3.3: Special programmes for informing -raising awareness on food waste
3.4: Creating and promoting Guides for improving energy efficiency in productive procedures
3.5: Formulation of proposals and measures to enhance knowledge and information on various issues of circular economy
3.6: Promotion of the Cooperative Economy
4.1: Secretariat Establishment and Operation
4.2: Administration Education and Training Programmes
4.3: Establishment of an Observatory for the Circular Economy

An Inter-Ministerial committee as well as a National Council on Circular Economy have been established; their 2nd and 3rd meetings have been held on 7th February and 26th May 2020 respectively. A Circular Economy Roadmap is expected to be drafted by July 2020. Some of the key items discussed according to the press releases of the Ministry of Environment and Energy[108] are the following:

- Establishment of environmental criteria for certain product categories that will be included in the National Plan for Green Public Procurements.
- Consultation with productive stakeholders involved in the production and use of single-use plastics.
- Need to establish sustainability criteria for the funding and use of biomass projects. The Ministry will establish relevant supporting sub-working groups with the inclusion of relevant stakeholders.

Especially regarding single-use plastics, the Ministry is actively engaged in incorporating Directive (EU) 2019/904 on the reduction of the impact of certain plastic products on the environment. Legislative action is expected within 2020, with the aim to ban the use of single-use plastics from July 2021; earlier adoption by the public sector is also anticipated. Through this action, Greece is planning to be in the European forefront of such developments.

In order to inform and prepare Greek stakeholders and the Greek market for the upcoming ban on single-use plastics, the Ministry of Environment and Energy and the A.C. Laskaridis Charitable Foundation have set up the campaign "SUPFREE Greece" (www.supfree.gr). The website of the campaign includes information on the environmental issue, the Directive, proposed actions for consumers and examples of good practices. One of those example is Matrix Pack (www.matrixpack.gr), a Greek company that is the market leader in eco-friendly (paper, biodegradable) drinking straws. It is quite clear that the banning of single-use plastics will create market opportunities for more types of bio-based products as well.

8.5 Taxes and tariffs

The standard VAT rate in Greece is 24 %. Among many others, it applies to the use of biomass as fuel: firewood, wood pellets, exhausted olive cake, etc.

A reduced VAT of 13 % is applied to several food products as well as many agricultural inputs.

[108] www.ypeka.gr/el-gr/%CE%A5%CF%80%CE%BF%CF%85%CF%81%CE%B3%CE%B5%CE%AF%CE%BF/%CE%93%CF%81%CE%B1%CF%86%CE%B5%CE%AF%CE%BF-%CE%A4%CF%8D%CF%80%CE%BF%CF%85/%CE%94%CE%B5%CE%BB%CF%84%CE%AF%CE%B1-%CE%A4%CF%8D%CF%80%CE%BF%CF%85/ID/552

An extra reduced VAT of 6 % applies to certain energy products (electricity, natural gas and heat from district heating) and pharmaceuticals.

Plastic bags used for transportation of goods with a thickness between 15 to 50 μm are subject to an environmental tax of 0.09 EUR per bag. The Ministry of Environment and Energy is considered imposing an environmental tax to all plastic bags, regardless of thickness, with the exception of biodegradable and compostable plastic bags.

8.6 Summary and conclusions in relation to SWOT elements

The bioeconomy is referenced in increasing frequency in policy and strategic documents in Greece and this can be taken as a sign of increased awareness. On the other hand, most of the references are generic and do not seem to lead to any specific goals. A key issue is that the development of a robust bioeconomy has cross-sector implications and there is limited coordination among policy makers from the established sectors of agriculture, energy, transportation, industry, etc. This is a serious weakness that needs to be overcome. Rising environmental concerns raise more and more opportunities arise for the bioeconomy; however, the lack of a comprehensive Green Public Procurement strategy limits the potential of the Greek state, regional authorities and municipalities to transform into exemplary consumers of bio-based products.

Table 8.6.1: SWOT analysis of Bioeconomy Policy Framework of Greece.

Strengths Several sectors related to the bio-economy highlighted in the Greek RIS3 strategy Role of biomass considered in the 2050 long-term strategy for energy and climate	Weaknesses Lack of a dedicated bio-economy strategy Lack of coordination among policy for different sectors (e.g. agriculture, energy, etc.) Lack of specific financial incentive/ subsidies to foster bioeconomy development High VAT rate for biomass as fuel
Opportunities Ambitious energy and climate strategy Ban of single use plastics presents opportunities for bio-based alternatives Development of circular economy strategy New CAP emphasizing environmental issues	Threats Possible reduction of subsidies in the new CAP scheme may have a major impact on the Greek agricultural sector Role of biomass / bioeconomy in reaching policy goals may often be overlooked Still no clear rules / strategy on Green Public Procurement

9 Financing

9.1 Introduction

The Greek financial crisis is bringing to the light several structural difficulties for mobilizing capital: credit squeeze, declining savings, nonperforming loans, and dwindling "soft" financing[109]. Investment needs for the period of 2017 – 2022 were estimated at 270 billion EUR, while total financing (including direct forest investment, state investment, own funds and loans, EC financing) are estimated to be 115 billion EUR, leaving an annual financing gap of 19 billion EUR that would have to be covered by additional own funds, credit extension and "soft" financing[110]. This is prompting some analysis to say that the Greek recovery will be a "creditless" one.

Still, there are several possibilities for investors in Greece to finance their projects: state/ EC support, Public Private Partnerships (see Section 7.4 for more details), venture capital and financial institutions[111].

9.2 State and European funding

9.2.1 Partnership Agreement for the Development Framework 2014-2020

The Partnership Agreement for the Development Framework 2014-2020 (Greek: ESPA, www.espa.gr) constitutes the main strategic plan for growth in Greece with the contribution of significant resources originating from the European Structural and Investment Funds (ESIF) of the European Union. Its vision is stated as follows:

"To contribute to revitalising the Greek economy through the recovery and upgrading of the productive and social fabric of Greece and the creation and maintenance of the sustainable jobs, spearheaded by outward looking, innovative and competitive entrepreneurship and on the basis of reinforcing social cohesion and the principles of sustainable development."

The development planning of the Partnership Agreement has been based on the Greek RIS3 and targets the eight sectors that have been singled out by it: agri-food; health – medicines; ICT; energy; environment and sustainable development; transport; materials – construction; tourism, culture, creative industries.

The ESPA 2014 – 2020 comprises of 20 Programmes, 7 are Sectoral and 13 Regional, one for each Greek region and addressing regional issues and challenges. The 7 Sectoral Programmes address national challenges as follows:

1. Operational Programme "Competitiveness, Entrepreneurship and Innovation" (EPAnEK). Mainly supported by the ERDF (European Regional Development Fund), as well as the ESF (European Social Fund), in order to ensure that, in tandem with investments, the needs for training human resources and administrative reform are met.
2. Transport Infrastructure, Environment and Sustainable Development Operational Programme (YMEPERAA). Financed by ERDF and CF, this sector program targets mostly core transport (including TEN-T) and environment infrastructures.
3. Human Resources Development – Education and Life Long Learning Operational Programme. Financed by the ESF.
4. Reform of the Public Sector Operational Programme, aiming to introduce reforms throuw new technologies and IT in the public sector. Financed by ERDF and ESF.

[109] www.pwc.com/gr/en/publications/greek-thought-leadership/investments-in-greece-recession-recovery.html
[110] www.pwc.com/gr/en/publications/greek-thought-leadership/investments-greece.pdf
[111] www.enterprisegreece.gov.gr/en/greece-today/why-greece/access-to-financing

5. Technical Assistance Operational Programme. Multi-financing (ERDF, ESF and CF) aiming to support the operation and implementation of all the other Operational Programmes.
6. Rural Development Programme (RDP). Further details are provided in the section below.
7. Fisheries and Maritime Operational Programme, funded by the European Maritime and Fisheries Fund (EMFF), aiming to increase the competitiveness of the aquaculture and processing sectors, the viability of the sea fisheries sector and the sustainable development of traditionally fisheries-dependent areas, while also addressing protection and rehabilitation of the marine environment.

The total public funds for ESPA 2014 – 2020 (Sectoral + Regional Programmes) amount to 25.6 billion EUR, of which around 80 % is EU contribution and 20 % national contribution.

In addition, the European Territorial Cooperation (ETC) supports territorial cooperation both in the European framework as well as with third countries. The 2014 – 2020 framework includes 5 bilateral programmes, of which 3 with member states (Cyprus, Bulgaria and Italy) and 2 with candidate members (Albania and North Macedonia), financed by the ERDF and the Instrument for Pre-Accession Assistance (IPA) respectively. The total public funds for bilaterial programmes amounts to 435.6 million EUR, of which 85 % is contributed by the European Union and the rest from state funds.

The ETC also includes six multilateral Territorial Cooperation Programmes, in which various Greek regions participate: Adriatic – Ionian (transnational); MED (transnational); MED ENI CBC (cross-border); Black Sea basin ENI CBC (cross-border); INTERREG EUROPE (interregional); Balkan Mediterranean (transnational).

9.2.2 Rural Development Program (2014-2020)

The Rural Development Programme (RDP) 2014-2020 (http://www.agrotikianaptixi.gr/) for Greece manages total public funds in the range of 5.8 billion EUR and is co-funded by European Agricultural Fund for Rural Development (EAFRD) and national contributions. RDP 2014-2020 is managed by the General Secretary of Agricultural Policy and Management of Community Funds of the Ministry of Rural Development and Food. Measures of the RDP can be grouped as follows:

1. Private Investments / Entrepreneurship
2. Agro-environmental
3. Training/Consulting/Cooperation (horizontal interventions)
4. Public Investments
5. LEADER/CLLD (local development interventions leaded by local communities)
6. Technical Assistance
7. Continuation of Actions from the previous RDP 2007-2013

Several sub-measures are of interest in the context of bioeconomy development. Information on the most relevant related to productive investments is presented below.

Sub-measure 4.1.3[112] provides support for the investment in RES at agricultural holdings, on the basis of covering their energy demands, good practices for the handling of wastes and by-products and their utilization for energy production. The budget for applications can be up to 200,000 EUR for physical persons and companies and up to 500,000 EUR for collaborative schemes, while the funding rate may reach up to 85 % depending on conditions.

Sub-measure 4.2.1[113] concerns the processing, trade and development of a final agricultural product from various sectors. Support is provided mostly to very small, small, medium and large enterprises and the total investment budget can be from 100,000 up to 10,000,000 EUR. The level of support can go up to 75 % or even

[112] www.agrotikianaptixi.gr/el/content/drasi-413-ylopoiisi-ependyseon-poy-symvalloyn-sti-hrisi-ape-kathos-kai-stin-prostasia-toy
[113] www.agrotikianaptixi.gr/el/content/drasi-421-metapoiisi-emporia-kai-anaptyxi-me-teliko-proion-entos-toy-parartimatos-i-georgiko

up to 90 % under certain conditions. Investments in energy production systems from renewable energy sources are eligible as part of the total investment scheme.

Sub-measure 4.2.2[114] concerns the processing, trade and development of a final product beyond Annex I (non-agricultural product). As such, it is especially relevant for investment schemes related to various categories of bio-based products. The sub-measure concerns the following sectors:

- Tobacco processing
- Beer brewing
- Honeycomb products
- Essential oils
- Olive pomace mills
- Distillation of fruits, vegetables and grapes
- Pharmaceutical and nutritional products
- Production, trade and packaging of plant nutrition products
- Production of cheese whey and concentrates
- By-product valorization
- Cotton and other fibers
- Processing of fiber cannabis and flax

Support is provided to very small, small and medium enterprises with a total level of investment from 100,000 up to 5,000,000 EUR. The investment support varies from 45 to 65 % depending on the level of investment, size of the company, etc.

Finally, Sub-measures 16.1-16.2 16.1-16.5 which aim to promote cooperation for enhancing the competiveness of primary sector (agricultural holdings) and food sector enterprises and for the development of new agricultural and production practices aiming to protect the environment and adapt to climate change respectively. Both sub-measures foresee the creation of Operational Groups which can include members beyond the primary sector, including research organizations. Cooperation for the production of bio-based products is not included in the scope of the measures. However, the submeasures' scope includes among others production of animal feed and energy from agricultural / animal by-products, use of RES for the reduction of fossil fuel inputs and recycling and management of waste and effluents.

9.2.3 The Investment Law

The Investment Law was first established in 2004, aiming to support new investments in Greece, both domestic as well as direct foreign investments. It latest installment is established by Law 4399/2016[115], which offers the following types of aid:

- Tax exceptions
- Investment subsidies
- Leasing subsidies
- Wage subsidies (for jobs created)
- Financing instruments (capital participation, loan)
- Fixed corporate income tax rate

[114] www.agrotikianaptixi.gr/el/content/drasi-422-metapoiisi-emporia-kai-anaptyxi-me-teliko-proion-ektos-toy-parartimatos-i-mi
[115] www.espa.gr/elibrary/an4399_gr.pdf

- Fast licensing procedures

The maximum level of support for an investment scheme is up to 5 million EUR, while accumulated support cannot exceed 10 million EUR for a single enterprise and 20 mllion EUR for connected / collaborating enterprises.

The state aid schemes are as follows: 1. Machinery and equipment; 2. General Entrepreneurship; 3. New Independent Small and Medium Enterprises (SMEs); 4. Innovative SMEs; 5. Synergies and Networking; 6. Financial intermediation and capital funds; 7. Integrated spatial and sectoral plans - Value Chains; 8. Major Investments. The level and type of state aid varies depending on the scheme, size and type of company and geographical region where the investment materializes.

The Investment Law can be used for productive investments in energy, but they have to be connected with renewable energy of high-efficiency CHP. Regarding biorefineries, the Investment Law can support both new facilities for production of sustainable biofuels, as long as they are not based on edible plants and are not subject to supply or blending obligations, as well as the retrofitting of 1st generation biofuel production plants based on edible plants to the category above.

9.3 Venture Capital

The Hellenic Venture Capital Association (www.hvca.gr) was established in 2003 in Athens and currently lists 25 members on its website. It is estimated that its members manage approximately 1.2 billion EUR[116].

EquiFund (www.equifund.gr) is a "fund of funds" established in 2018 by the Greek state and the European Investment Bank (EIB). It aims to invest up to 1 billion EUR in innovation window, early stage window and growth window funds, through co-financing of around 300 million EUR from EU and national funds, as well as funding from the EIF and the European Investment Bank (EIB) through the European Fund for Strategic Investments (EFSI), and private venture capital. Strategic partners such as the Onassis Foundation and the National Bank of Greece have also committed to EquiFund supported funds. Innovation and early stage windows favour the deeptech and ICT sectors respectively, but the growth window favours all. The indicative investment amount for the growth window phase is between 2 and 12 million EUR (including follow-up investments)[117].

The Hellenic Development Bank – HDB (www.etean.com.gr) was founded in 2019, as a successor to the Hellenic Fund for Entrepreneurship and Development (ETEAN SA). ETEAN was established in 2011 as an financial institution fully owned by the Greek State bearing an initial share capital of Euro 1.7 billion, of which Euro 1.5 billion in Greek Government Bonds (GGBs) and approximately € 213 million in cash and was itself a successor of the Guarantee Fund for Small and Very Small Enterprises (TEMPME SA). In early 2020, HDB announced that it will launch a call for venture capital / private equity funds in order to support "green" investments in Greece; HDB will contribute 400 million EUR of own funds, aiming to leverage an additional 600 million EUR of private funds. Targeted investments include renewable energy production (solar, wind, small hydro power, biomass and biogas), ESCOs, recycling, energy storage, electric mobility and others[118].

9.4 Financial institutions

The Hellenic Bank Association – HBA (www.hba.gr) has 9 regular members and 8 associated one. The four "systemic" banks are Alpha Bank, Eurobank Ergasias, National Bank of Greece and Piraeus Bank, while several more smaller banks, mostly cooperative, as well as Greek branches of foreign banks operate in Greece.

Greek banks offer various financing tools for enterprises. It should be noted that private banks has financing around 3 billion EUR in RES projects in the past, with around 1 more billion EUR in the pipeline.

[116] www.enterprisegreece.gov.gr/en/greece-today/why-greece/access-to-financing
[117] https://equifund.gr/wp-content/uploads/2018/02/EquiFund-Brochure.pdf
[118] www.kathimerini.gr/1064714/article/oikonomia/ellhnikh-oikonomia/panw-apo-1-dis-eyrw-gia-prasines-ependyseis-apo-thn-ellhnikh-anapty3iakh-trapeza

In February 2020, the European Investment Bank (EIB) announced together with the National Bank of Greece and Piraeus Bank the first, targeted agricultural investment scheme in Greece. With a total value of 560 million EUR, of which 200 will be contributed by EIB and the rest from the two Greek banks, aims to support new investments by new investment by farmers, agribusiness, food and bioeconomy companies across the country[119].

9.5 Summary and conclusions in relation to SWOT elements

With limited credit available from state sources and traditional banking institutions, financing in Greece has relied in the last years in the use of EU funds. Lack of alternatives has led to very high absorption rates, but it is cautioned that this should not happen at the expense of effectiveness, added value and quality of investments[120]. The Greek state is assisting in developing tools and funding instruments aiming to attract private sector investments.

Regarding the bioeconomy sector, opportunities seem to emerge over the last year. However, they often target the "traditional" sectors of farming and food production / processing, while leaving out of the picture the potential offered by biorefinieries and production of novel bio-based materials.

In general, effective financing will be a major challenge and bet for Greece in the coming years, having to struggle both with the legacy of the financial crisis as well as with the most recent effects of the Covid-19 pandemic.

Table 9.5.1: SWOT analysis of Bioeconomy Financing of Greece.

Strengths Access to EU funds through various instruments Good absorption rate of EU funds Various venture capital schemes available	Weaknesses Impact of crisis on financing / credit availability Limited financing support to bioeconomy activities beyond farming and food processing Use of EU funds at the expense of effectiveness, added value and quality of investments
Opportunities Dedicated funding schemes for bioeconomy emerging New initiatives for mobilizing venture capital	Threats Uncertainties on risk level of bioeconomy investments Uncertainties over financing sources beyond 2020

[119] www.eib.org/en/press/all/2020-054-eib-national-bank-of-greece-and-piraeus-bank-launch-eur-560-million-agriculture-investment-scheme
[120] www.europarl.europa.eu/news/en/press-room/20180906IPR12108/special-measures-for-greece-100-absorption-rate

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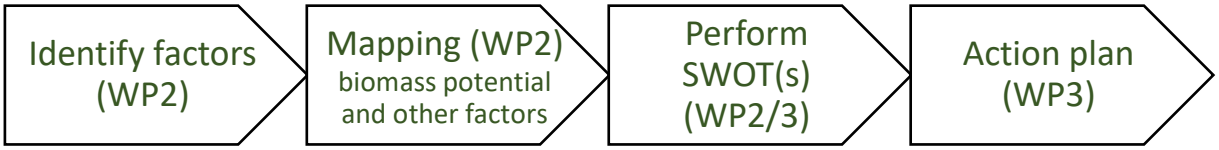
Annex 1 Approach guiding the structure and contents of this report

Identification of factors that are important for establishing bio-based production chains in a country

One of the objectives of the CELEBio project is to map opportunities in the target countries for setting up bio-based business activities. This includes the mapping of the biomass feedstock potentials, and other key success factors for establishing bio-based production chains, e.g. business activities, what bio-based products can be generated, and what is the market demand of these products.
The BBI is focused on the next bio-based products and markets: Chemicals, Plastics (polymers, materials, packaging), Specialties (surfactants, lubricants, pharmaceuticals, nutraceuticals, cosmetics), Textiles, Food ingredients and feed, Advanced biofuels.

To be able to perform SWOT(s) and generate action plans, the first step is to identify which factors are important. These factors should be determined based on the perspective of both entrepreneurs/business developers and governments. The identified factors should be mapped and will be the basis for performing a SWOT (Strength, Weakness, Opportunity and Threat) analysis for development of biobased production chains.



Based on input from industry and business developers a logical set of factors was identified that guide the choice of investing in the bio-based economy and location of conversion plants (Van Dam et al., 2014). This set is expanded/updated (amongst others based on the BBI project BIOFOREVER (bioforever.org)). Via an interview sheet, different stakeholders (15) from different countries (the Netherlands, Croatia, Czech Republic, Hungary, and Slovenia) were asked to comment on the factors and rank them.

Highest ranked factors:

- Feedstock supply: price, security of supply, quality
- Product market: price, off-take security
- Regulations, legislation, and rule of law

Medium raked factors:

- Financing: investors, subsidies, guarantees, risk minimization options
- Taxes and Tariffs
- By-product valorization: heat, CO2, fodder, lignin

Lowest ranked factors:

- Infrastructure: what part of the chain is already available (harbor, industries)
- Logistics: cost, reliable
- Technology: TRL, robustness, yield, CAPEX, OPEX
- Sustainability: economical, environmental, and social aspects

Overall, the ranking of the factors only differed slightly. Most of the experts mentioned that all the identified factors are important and that a system approach is key in developing biobased initiatives. If one link in the chain is missing, the biobased initiative will not succeed.

According the experts the most important stakeholders for establishing biobased production chains are:

- Producers/suppliers of biomass
- Chemical industry
- Energy industry
- R&D organizations
- Regulatory authority
- Environmental organizations
- Public

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Annex 2 Explanation of the S2BIOM approach to assessing lignocellulosic biomass potentials from agriculture, forestry and waste

In S2BIOM project the core biomass cost supply data was generated in WP1 for 37 European countries at regional level. Lignocellulosic biomass assessed by S2BIOM includes biomass originating from the following:

- Primary residues from agriculture
- Dedicated cropping of lignocellulos biomass on agricultural area
- Wood production and primary residues from forests
- Other land use
- Secondary residues from wood industry
- Secondary residues of industry utilising agricultural products
- Waste collection/ tertiary residues

Data have been assessed for 2012, 2020 and 2030. They are provided for several 'potentials' including: a technical potential; a base potential considering currently applied sustainability practises; and further potential levels that are determined considering changing sustainability restrictions, mobilisation measures and different constraints to account for competing use.

The technical potential represents the absolute maximum amount of lignocellulosic biomass potentially available for energy use assuming the absolute minimum of technical constraints and the absolute minimum constraints by competing uses. This potential is provided to illustrate the maximum that would be available without consideration of sustainability constraints.

The base potential can be defined as the technical potential considering agreed sustainability standards for agricultural forestry and land management. The base potential is thus considered as the sustainable technical potential, considering agreed sustainability standards in CAP (Common Agricultural Policy) for agricultural farming practices and land management and in agreed (national and regional) forestry management plans for forests (equivalent to current potentials described in EFSOS II). This also includes the consideration of legal restrictions such as restrictions from management plans in protected areas and sustainability restrictions from current legislation. Further restrictions resulting from RED (Renewable Energy Directive) and CAP are considered as restrictions in the base potential as well. CAP sustainable agricultural farming practices include applying conservation of Soil Organic Carbon (SOC) (e.g. Cross Compliance issues of 'maintaining agricultural land in good farming and management condition' and avoiding soil erosion).

The user-defined potentials vary in terms of type and number of considerations per biomass type. Following the general nomenclature of potentials the user defined potentials can also be considered as sustainable technical potentials but differ in the constraints considered vs the base potential and among each other. The user can choose the type of biomass and the considerations he would like to employ and calculate the respective potential accordingly. This flexibility is meant to help the user to understand the effect on the total biomass potential of one type of consideration against the other. These can include both increased potentials (e.g. because of enhanced biomass production) or more strongly constrained potentials (e.g. because of selection of stricter sustainability constraints).

Technical, base and one user defined (UD) potential has been assessed for all biomass groups. For forest biomass many more user defined potentials were quantified. See underneath:

Table A2.1: Overview of agricultural residual biomass potential types and considerations in S2BIOM.

	Area/ Basis	Yield, Growth	Technical & environmental constraints on the biomass retrieval (per area)	Consideration of competing use	Mobilisation
Technical (straw & stubbles)	Area in 2012, 2020, 2030 with cereals, rice, sunflower, rape, corn maize	Growth based on regional growing conditions & management. Yield according to regional averages including expected developments in yield towards 2020 and 2030	Maximum volume of straw and stubbles that could be harvested in 2012, 2020 and 2030	None	None
Technical (prunings permanent crops)	Area in 2012, 2020, 2030 with fruit trees, vineyards, olive & citrus	Growth based on regional growing conditions & management. Yield according to regional averages including expected developments in yield towards 2020 and 2030	Maximum volume of prunings and cuttings that could be harvested in 2012, 2020 and 2030	None	None
Technical (sugarbeet leaves & tops)	Area in 2012, 2020, 2030 with sugar beet	Growth based on regional growing conditions & management. Yield according to regional averages including expected developments in yield towards 2020 and 2030	Maximum volume of sugarbeet leaves and tops that could be harvested in 2012, 2020 and 2030	None	None
Base (straw & stubbles)	As for technical potential	As for technical potential	Only the biomass part can be removed that is not needed to keep the SOC stable. This is assessed according to carbon content that is removed with the residue and the SOC level in the soil that has to be maintained.	None	None
Base (prunings permanent crops)	As for technical potential	As for technical potential		None	None
Base (sugar beet leaves & tops)	As for technical potential	As for technical potential	Removal of leaves and tops from field is only allowed in Nitrate vulnerable zones where nitrogen surplus needs to be declined through removal of nitrogen rich biomass.	None	None
User potential (straw & stubbles)	As for technical potential	As for technical potential	As in base	In cereal straw a subtraction is applied according to demand for straw for animal bedding & feed . For rice straw, corn stover and sunflower and rape stubbles no competing uses are assumed.	None
User potential (prunings & cuttings)	As for technical potential	As for technical potential	All pruned material is available that is currently according to real practices NOT used to maintain the SOC and fertility of the soil. So the part that is now removed to the side of the field for energy uses or that is burned with & without energy recovery is seen as potential and can be removed. This follows the common treatment practices of prunings as assessed in the EUROpruning project.	None	The potential that is NOT used for SOC and fertility maintenance according to current practices needs to be mobilised gradually as it requires a change in management. It is therefore assumed; it becomes available from 50% in 2012 to 60% in 2020 and 70% in 2030.

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Table A2.2: Overview of woody biomass potential types used in S2BIOM.

	Area/ Basis	Yield, Growth	Technical & environmental constraints on the biomass retrieval (per area)	Consideration of competing use	Mobilisation
Technical	Forest area available for wood supply. This excludes protected and protective areas, where harvesting is not allowed according to protection purpose.	Growth based on regional to national growing conditions, including changes in biomass increment due to climate change. Yield according to regional management guidelines for age limits for thinnings and final fellings.	Maximum volume of stemwood that could be harvested annually during 50-year periods. Technical constraints on residue and stump extraction (recovery rate)	None	None
High	As for technical potential	As for technical potential	As for technical potential, but considering additional less stringent constraints (compared with base potential) for residue and stump extraction: Site productivity -Soil and water protection: ruggedness, soil depth, soil surface texture, soil compaction risk -Biodiversity (protected forest areas) -Soil bearing capacity.	None	None
Base	As for technical potential	As for technical potential	As for technical potential, but considering additional constraints for residue and stump extraction: -Site productivity -Soil and water protection: ruggedness, soil depth, soil surface texture, soil compaction risk -Biodiversity (protected forest areas) -Soil bearing capacity.	None	None
User potential - option 1	Reduction of FAWS by 5%	As for technical potential	Equivalent to increase of protected forest area by 5%.	None	None
User potential - option 2	Reduction of FAWS by 5%	As for technical potential	Increase of protected forest area by 5% and increase in retained trees by 5%.	None	Reduction in harvest by 5%
User potential - option 3	As for technical potential	As for technical potential	No stump extraction.	None	None
User potential - option 4	Reduction of FAWS by 5%	As for technical potential	Increase in protected forest by 5% plus increase in retained trees by 5% plus no stump extraction	None	Reduction in potentials by 5%
User potential - option 5	As for base potential	As for base potential	As for base potential	Roundwood production for material use (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Pulpwood, Round & Split + Other Industrial Roundwood) in period 2010-2014) subtracted from BP.	None
User potential - option 6	As for base potential	As for base potential	As for base potential	Roundwood production for material use excl. for pulp and paper and board industry (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Other Industrial Roundwood) in period 2010-2014) subtracted from UP4.	None
User potential - option 7	As for user potential - option 4	As for user potential - option 4	As for user potential - option 4	Roundwood production for material use (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Pulpwood, Round & Split + Other Industrial Roundwood) in period 2010-2014 subtracted from BP.	As for user potential - option 4

	Area/ Basis	Yield, Growth	Technical & environmental constraints on the biomass retrieval (per area)	Consideration of competing use	Mobilisation
User potential - option 8	As for user potential - option 4	As for user potential - option 4	As for user potential - option 4	Roundwood production for material use excl. for pulp and paper and board industry (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Other Industrial Roundwood in period 2010-2014) subtracted from UP4.	As for user potential - option 4

Table A2.3: Overview of potentials calculated for biowaste and wood waste.

Technical potential The Technical potential represents the amount of biomass assuming only technical constraints and a minimum of constraints by competing uses. In case of biowaste no constraints are considered in the technical potential. In case of post-consumer wood, the technical potential assumes that 5% of all wood waste cannot be recovered and used for energy application for technical reasons. Competing uses (current material application of the wood) are not taken into account.
Base potential This is the sustainable technical potential, considering currently agreed sustainability standards. In case of biowaste the base potential equals the technical potential. In case of post-consumer wood, the base potential takes into account the current material application of recovered wood, and assumes that this material application remains constant in 2020 and 2030
User defined potential The user-defined potentials vary in terms of type and number of considerations per biomass type. The user can choose the type of biomass and the considerations he would like to add and calculate the respective potential. This flexibility is meant to help the user to understand the effect on the total biomass potential of one type of consideration against the other. In case of biowaste no user-defined potentials have been developed. In case of post-consumer wood, one user-defined potential has been developed. This user defined potential on cascading use of post-consumer wood takes into account the current material application of post-consumer wood in 2012, and assumes that the material application of non-hazardous post-consumer wood will increase to 49.2% in 2020 and 61.5% in 2030, or remain stable if current (2012) material use is higher.

Primary agricultural residual biomass assessments

For the assessment in S2BIOM (like for Biomass Policies) land-use and livestock production levels are used based on the most recent CAPRI baseline run 2008-2050, providing intermediate results for 2010, 2020, 2030 and 2050.

The potential supply of agricultural residues was estimated for the period from 2012, 2020 and 2030. It uses as main input the cultivated land and main crop production and yield combinations made for these years by the CAPRI model. Residual biomass covered in S2BIOM from agriculture comes from primary residues from arable crops (straw and stubbles) and pruning, cutting and harvesting residues from permanent crops.

The assessment of residues from arable crops builds on methodologies and assessments already done in Biomass Policies and Bioboost. The assessment for vineyards, olive groves and fruit plantation residues bases builds on work done in EuroPruning project.

The aim of S2BIOM was to identify the part of the residues that can be removed from the field without adversely affecting the SOC content in the soil.

It is the carbon balance module in the MITERRA-Europe that has been further adapted in S2BIOM (and Biomass Policies) to take account of removal of straw (and also prunings, see next). This was done by incorporating the RothC model (Coleman and Jenkinson, 1999) into MITERRA-Europe. RothC (version 26.3) is a model of the

turnover of organic carbon in non-waterlogged soils that allows for the effects of soil type, temperature, moisture content and plant cover on the turnover process. It uses a monthly time step to calculate total organic carbon (ton C ha-1), microbial biomass carbon (ton C ha-1) and Δ14C (from which the radiocarbon age of the soil can be calculated) on a years to centuries timescale (Coleman and Jenkinson, 1999). For this study RothC was only used to calculate the current SOC balance based on the current carbon inputs to assess taking account of soil types (including Soil C levels) the sustainable crop residue removal rates at which the carbon C in the soil remains constant.

Primary forest biomass potential assessment

The potential supply of woody biomass was estimated for the period from 2012 to 2030 for stemwood; branches and harvest losses (further: 'logging residues'); and stumps and coarse roots (further: 'stumps') (Table 20). First, we estimated the theoretical potential of forest biomass supply in Europe based on detailed forest inventory data. This theoretical potential was defined as the overall, maximum amount of forest biomass that could be harvested annually within fundamental bio-physical limits (adapted from Vis and Dees 2011, Dees et al. 2012), taking into account increment, the age-structure and stocking level of the forests. Second, multiple environmental and technical constraints were defined and quantified that reduce the amount of biomass that can be extracted from forests for different biomass potential types. Third, the theoretical potentials from the first step were combined with the constraints for the biomass potential types.

This sequence of steps is based on the approach developed and applied within the EUwood and EFSOS II studies (Verkerk et al. 2011; UNECE et al. 2011; Verkerk 2015). The approach in S2BIOM differs from previous studies in several ways, with the main difference being that that woody biomass potentials have been estimated using a typology of potentials developed within S2BIOM. Other changes include (i) an updated of the forest inventory data used as a basis to estimate biomass potentials; (ii) extension of the geographical scope to include all 37 S2Biom countries; (iii) improvements to set the of constraints; and (iv) improve the potential estimates at regional level by spatially disaggregating estimated biomass potentials. All improvements are described below.

The large-scale European Forest Information SCENario model was applied (EFISCEN) (Sallnäs, 1990) to assess the theoretical potential of forest biomass at regional to national level. Versions 3.1.3 (Schelhaas et al. 2007) and 4.1 (Verkerk et al. 2016a) were used because the former version is included in a script to estimated biomass potentials Verkerk et al. (2011), while the latter version has the ability to directly store results in a database, which is used to run the EFISCEN disaggregation tool (Verkerk et al. 2016b). EFISCEN describes the state of the forest as an area distribution over age- and volume-classes in matrices, based on data on the forest area available for wood supply (FAWS), average growing stock and net annual increment collected from NFIs. Forest development is determined by different natural processes (e.g. increment) and is influenced by human actions (e.g. management). A detailed model description is given by Schelhaas et al. (2007; 2016).
National forest inventory data on area, growing stock and net annual increment are used to initialize the EFISCEN model.

The amount of wood that can be felled in a time-step is controlled by a basic management regime that defines the period during which thinnings can take place and a minimum age for final harvest. Age-limits for thinnings and final fellings were based on conventional forest management according to handbooks at regional to national level (Nabuurs et al. 2007) and by consulting national correspondents (UNECE-FAO 2011). The amount of stemwood potential removed as logs was estimated by subtracting harvest losses from the stemwood felling potential. Harvest losses were estimated using the ratio between fellings and removals as reported by UNECE-FAO (2000) for coniferous and broadleaved species separately.

Branches together with harvest losses represent logging residues that can be potentially extracted as well. In addition, stumps could potentially be extracted, separately from logging residues. The volume of branches, stumps and coarse roots was estimated from stemwood volume (incl. harvest losses) using age-dependent, species-specific biomass distribution functions (Vilén et al., 2005; Romano et al., 2009; Mokany et al., 2006; Anderl et al. 2009). We assumed no difference in basic wood density between stems and other tree compartments, due to lack of information.

Climate change is accounted using results from LPJmL (Sitch et al. 2003, Bondeau et al. 2007). Data are an average for several climate models for the A1b SRES scenario. Annual tree Net Primary Production (NPP) in gC/m2 for 3 individual years (2010, 2020, 2030) was calculated with LPJmL and used to scale the increment functions used in EFISCEN.

Secondary biomass potentials from agro-food industry

For an overview of the calculation methods and assumptions of secondary biomass sources from agro-food industries see the table below.

Table A2.4: Overview of assessment rules applied in S2BIOM to assess potentials for olive stones, rice husk, pressed grapes residues and cereal bran.

Biomass type	Area / Source	Residue factor	Technical & Environmental constraints
Olive-stones	CAPRI & national statistics: Area with all olive trees (table=oil olives) 2012, 2020, 2030	Olive pits make up between 10%-12.5% of the weight of olive according to Garcia et al. (2012) and Pattarra et al., (2010)	Base= pits from all oil olives + 30% of table olives
Rice husk	CAPRI & national statistics: Area with rice in Europe 2012, 2020, 2030	Rice husk is approximately 20% of the processed rice, with average moisture content of 10% ((Nikolaou, 2002)). It is assumed that all rice produced in the S2BIOM countries is locally processed	None
Pressed grapes residues (pressing residues & stalks)	CAPRI & national statistics: Area with vineyards in Europe 2012, 2020, 2030	Of the processed grapes 4.6% consists of dregs and 1.5% of stalks (FABbiogas (2015)- Italian country report)	None
Cereal bran	CAPRI total estimate of tons processed cereals per EU country	In wheat processing 20% to 25% wheat offals (Kent et al., 1994). Wheat bran represents roughly 50% of wheat offals and about 10 to 19% of the kernel, depending on the variety and milling process (WMC, 2008; Prikhodko et al., 2009; Hassan et al., 2008). . So the residue to yield factor used is 10% of cereals processed domestically.	None

For the calculation of the olive stones, rice husk and pressed grapes dregs we assumed that all domestic production would also be processed locally and that is no further processing of imported olives, rice and grapes. This implied that the residues would be available locally and that the regional distribution of the processing residues is a direct outcome of the cropping area distribution over regions in every country.

For cereal bran it is more logical to assume that the basis should be the total amount of cereals processed in every country. This implies that cereal bran needs to be calculated for a total net domestic cereal production and imports:

$$Domestic\ production_{cereals} - export_{cereals} + import_{cereals}$$

The data on total domestic production, exports and imports levels were available from CAPRI for 2010 (extrapolated to 2012), 2020 and 2030 for all S2BIOM countries except for Ukraine.

To come to a regional distribution of the cereal bran potentials in every S2BIOM country 2 assumptions were made:

1) The bran based on the net domestic production (=domestic production – exports) is distributed regionally according to cereal production area share.
2) The cereal bran based on processing of imported biomass is distributed over largest (port) cities per country as it is expected that processing industries are there where imports enter the country and where population is concentrated. The residues were spatially distributed to regions with the large and medium sized cities (>100,000 inh.), every city was equally weighted.

Method used to estimate secondary forest biomass produced in the forest processing industry

The EU-Wood study (Mantau, 2010) projects the demand for material use without considering competition with other sectors in order to explore if the increasing demand for energy will lead to a strong competitive situation where the demand substantially exceeds the supply. The EU-Wood project (Mantau, 2010) has aligned the prediction of the future demand to the real GDP (Gross domestic product) and thus the prediction that utilises the IPCC B2 scenario assumptions shows a strong increase (see figure below).

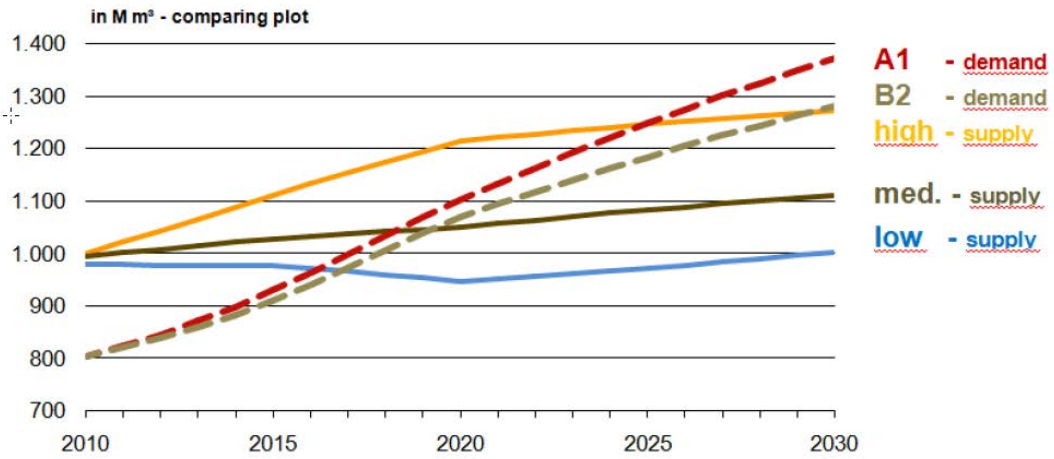

Figure 1-4: Development woody biomass potential demand and potential supply

Source: EUwood 2010

Figure A2.1: Future development of demand and supply as projected by the EU-Wood project for different scenarios (Mantau, 2010).

Thus, to constrain the potentials by such demand projection would constrain the potential with strong preference to material use. The recent trends of the forest products consumption index indicate that the production has changed its relation to the GDP (see figure below).

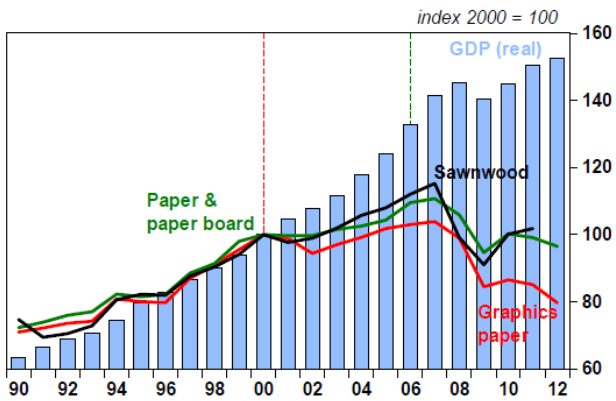

Figure 2.1.2. EU GDP (real) and forest products consumption index over the period 1990-2012 (2000 = 100). (Forest products data from FAO; GDP data from IMF, Gross domestic product based on purchasing-power-parity (PPP) valuation of country GDP).

Figure A2.2 EU GDP and forest products consumption index[121]

[121] Source: Birger Solberg, Lauri Hetemäki, A. Maarit I. Kallio, Alexander Moiseyev and Hanne K. Sjølie (2015) Impacts of forest bioenergy and policies on the forest sector markets in Europe – what do we know?

An alternative to use predict the future industry production results from modelling that considers economic competition. Such estimates are available from the EFSOS II study for 2010, 2020 and 2030. The trends of the EFSOS II study are utilised by S2BIOM. Figures 3 and 4 show for sawn wood and panels that the S2BIOM data for 2012 are close to EFSOS II reference scenario projections 2010.

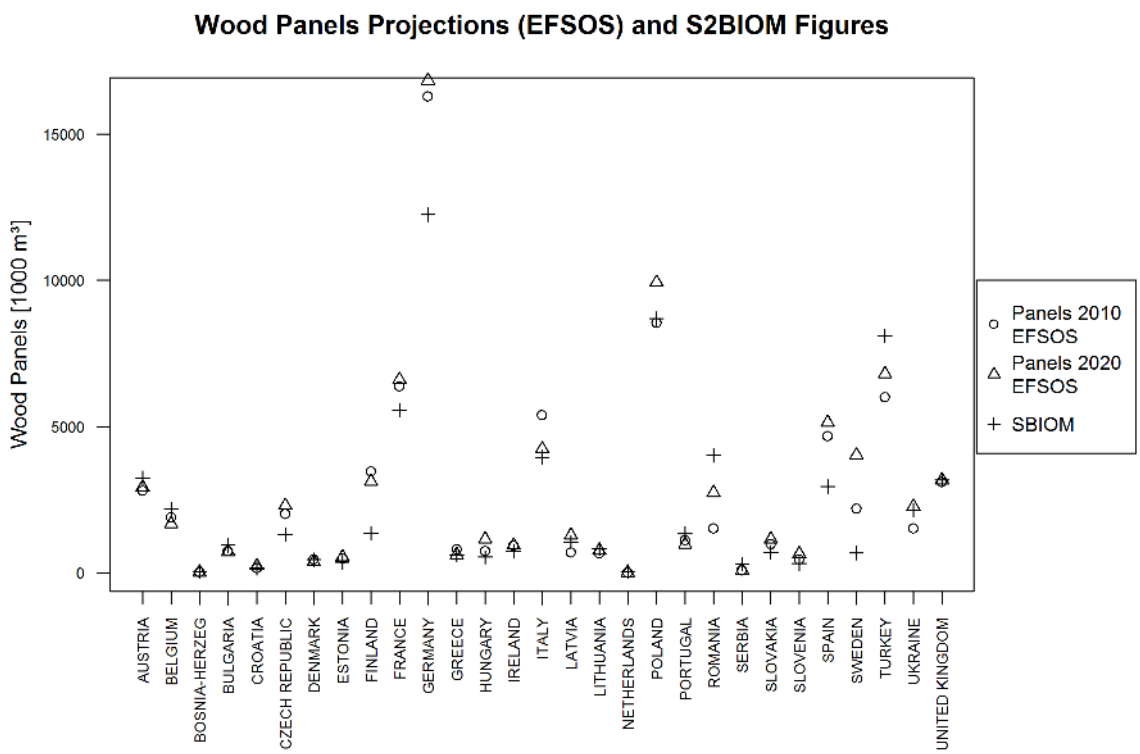

Figure A2.3 Wood panel production, EFSOS 2 reference scenario projections, and S2BIOM 2012 estimates

The S2BIOM residue and production figures of the timber industry were thus projected to the years 2020 and 2030 using the growth rates of the reference scenario of the UNECE European Forest Sector Outlook Study II (EFSOS II) for sawnwood and wood based panel production.

For the pulp and paper sector there was a huge difference between S2BIOM 2012 quantities and the EFOS reference scenario projections.

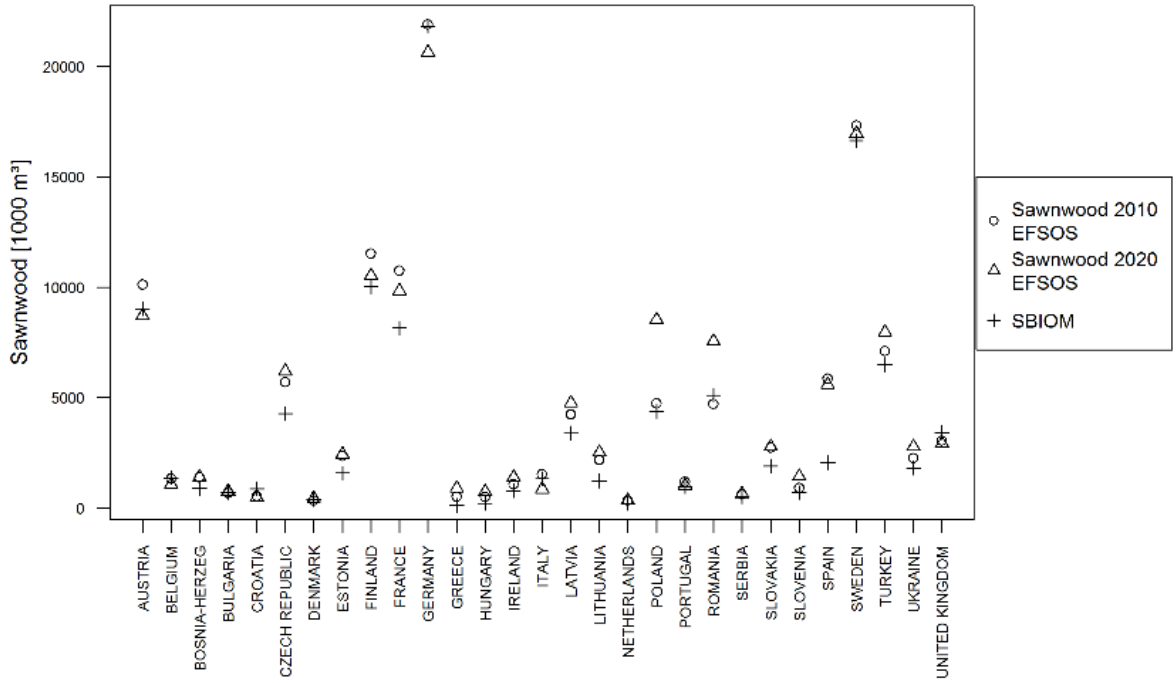

Figure A2.4 Sawnwood production, EFSOS 2 reference scenario projections and S2BIOM 2012 estimates

The visualisation of the figures from the "Historic Statistics" report of CEPI on pulp and paper production are shown in Figure 5. This figure shows the changes of pulp production for the CEPI member states which are: Austria, France, Netherlands, Romania, Sweden, Belgium, Germany, Norway, Slovak Republic United Kingdom, Czech Republic, Hungary, Poland, Slovenia, Finland, Italy, Portugal and Spain. It is for S2BIOM assumed that the changes in production after some bigger fluctuations in the past will be in 2020 and 2030 in the same dimension as in 2012. Hence the production quantities from 2012 are used for 2020 and 2030 as well.

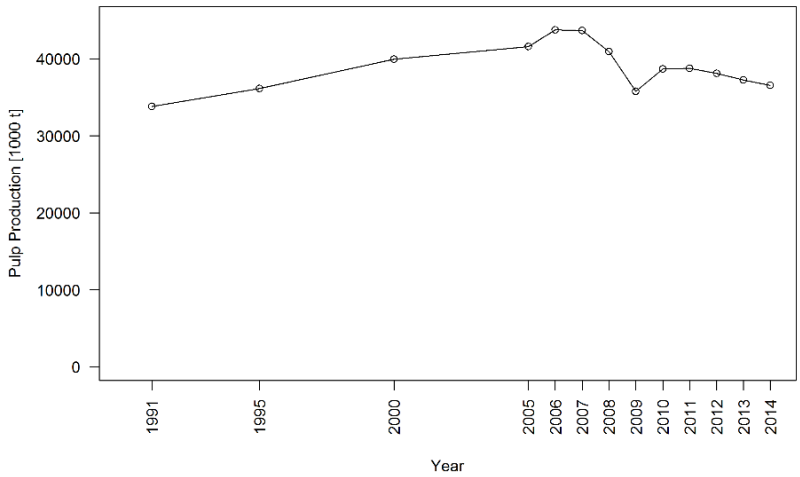

Figure A2.5 Development of Pulp production, CEPI data

The approach used is summarised by category in the table below.

Table A2.5: Approach used to estimate future production amount in the wood industry.

Sector	Approach
Saw mill residues, conifers	EFSOS II sawnwood, reference scenario
Saw mill residues, non-conifers	
Residues from industries producing semi - finished wood based panels	EFSOS II wood based panels production, reference scenario
Residues from further wood processing	EFSOS II sawnwood, reference scenario
Secondary residues from pulp and paper industry	Kept constant

Assessment of biowaste and post-consumer wood potentials

The availability of biowaste in 2012 on NUTS3 level was established as:

MSW generated per capita (kg/capita) x
biowaste fraction (%) x
population of the NUTS3 area (persons).

A further distinction has been made between the separately collected biowaste and biowaste as part of mixed waste.

In Arcadis and Eunomia (2010) projections have been provided of the shares of biowaste going to the different treatment options like landfill, incineration, MBT, composting, backyard composting, anaerobic digestion and others have been made for the years 2008-2020. It has been assumed that all countries meet the requirement of the landfill directive, e.g. that maximally 35% of the amount of biodegradable waste generated in base year 1995 is landfilled in 2020, even if current developments show that diversion from landfill has not been successful yet. Furthermore, the projections are based on policy views and current changes in treatment of biowaste in the member state concerned. For instance, some countries have a strong preference for MBT, others for incineration with energy recovery. For the year 2030 the same shares between treatment options are used as in the year 2020. Currently no policies are known that influence the production of biowaste after 2030, therefore it is assumed that the projected status quo in 2020 will be maintained in 2030.

Projections on the development of the total quantity of biowaste are assumed to be proportional to population growth. The main scenario on population development from Eurostat has been used to predict the population in 2020.

The calculation of the post-consumer wood potential is calculated according to the following formula:

$PCW_{technical\ potential} = PCW_{material} + PCW_{energy} + PCW_{disposed}$
$PCW_{base\ potential} = PCW_{energy} + PCW_{disposed}$

in which:

- $PCW_{recovered}$ = PCW used for materials like panels and chipboards
- PCW_{energy} = PCW used for energy production
- $PCW_{disposed}$ = landfilled and/or incinerated with MSW

Eurostat gives data on "wood waste", but this includes not only post-consumer wood but processing wastes from agriculture forestry and fishing sectors. Because of this mixture of secondary wood processing and tertiary

post-consumer wood within one category, Eurostat data could not be used to determine the potential of post-consumer wood. For S2BIOM, data on recovered wood were used from a forest biomass resource assessment done for the EUwood and EFSOS II studies (Mantau et al. 2010; UN-ECE/FAO 2011[122]). EUwood combines among others Eurostat and COST Action E31 data. The EFSOS II data on demolition wood is based on EU wood, but covers Europe as a whole instead of EU28. In order to determine the base potential PCW available for energy, it is necessary to estimate how much is used for material applications. In the Methodology report of the EUwood project[123], a table is given on the availability of *PCW recovered* [for material recycling] and *PCW energy* for 2007, page 119-120, which have been used in S2BIOM as well.

Assessment of cost levels for different biomass categories in S2BIOM

Because we are still in the early stages of a transition of fossil based feedstock towards bio-based feedstock there is hardly any information of enough quality to conduct a meaningful market analysis. In this light it is important to keep in mind that a distinction needs to be made between different types of cost and price levels specific per biomass type:

- Market prices exist for already traded biomass types (e.g. straw, wood chips and pellets based on primary and secondary forestry residues).
- Road-side-cost for biomass for which markets are (practically) not developed yet (e.g. many agricultural and forestry residues, dedicated crops for ligno-cellulosic and woody biomass and waste streams such as vegetal waste). These may cover the following cost:
    - Production cost (in case of dedicated crops, not for residues or waste)
    - Pre-treatment in field/forest (chipping, baling)
    - Collection up to road side/farm gate
- At-gate-cost which cover the cost at roadside plus transport and pre-treatment cost of biomass until the biomass reaches the conversion plant gate (e.g. bioethanol plant, power plant).

The cost assessed in S2BIOM are limited to the road-side cost. So, the cost from road side for transport and possible in-between treatment to the gate of the conversion installation or the pre-treatment installation are NOT included.

Cost assessment for agricultural biomass potentials

The overall methodology followed to gain insight in the minimum costs of production is the *Activity Based Costing* (ABC). It involves the whole production process of alternative production routes that can be divided in logical organisational units, i.e. activities. The general purpose of this model is to provide minimum cost prices for the primary production of biomass feedstock at the road side. ABC generates the costs of different components based on specific input and output associated with the choice of the means of production, varying with the local conditions and cost of inputs (e.g. labour, energy, fertilisers, lubricants etc.). Since the production of most biomass is spread over several years, often long-term cycles in which cost are incurred continuously while harvest only takes place once in so many years, the Net Present Values (NPV) of the future costs are calculated. This provides for compensating for the time preference of money. To account for the fact that the costs are declining in different periods of time in the future the Net Present Value annuity is applied. In this way annual, perennial crops and forest biomass cost are made comparable (=all expressed in present Euros).

The costs are automatically calculated for all field operations per year in a 60-year cycle in the case of agricultural biomass. The costs of wood production were not considered in this study as these costs need to be allocated to the main product, while here the focus is on the cost of the residues. Cost are presented as NPV per annum and expressed in € per ton dm or per GJ.

[122] UNECE (United Nations Economic Commission for Europe), FAO (Food and Agricultural Organization of the United Nations) 2011: The European Forest Sector Outlook Study II; Geneva
[123] EU Wood (2010) Methodology report, real potential for changes in growth and use of EU forests EUwood. Call for tenders No. TREN/D2/491-2008.

It is also important to note that the costs calculated in here are at the farm level cost. We are aware that the costs for the next link in the value chain might be higher because of rent seeking behaviour. However, in this approach we did not take account of it as we did not include a profit margin.
As explained in the former cost of agricultural biomass are calculated for *Net Present Value annuity* taking a 60-year coverage period. These 60 years are chosen to fit all possible cycles in the cost calculation as 60 is fully synchronizable to 1,3,5,10,15,20,30 and 60 years cycles. Cost differences after that period are negligible. In this way, cost for biomass from residues and from dedicated crops can be assessed with the same model and can be made comparable.

First the Net Present Values of all activities are calculated as follows:

Formula:
$NPv=Fv/(1+i)^n$
Where:

NPv = Net Present value
Fv = Future value
i = the interest rate used for discounting (set to 4%)
n = number of years to discount

Then the Net Present Value annuity is applied, assuming that the sum of NPVs cover the annual capital payments attracted against the same interest rate (4%) as the discount rate used for calculating the NPVs.

Formula:
$NPVa= \Sigma NPv*(1/((1-(1+i)^{-n})/i))$
Where:

NPVa = Net Present Value annuity
ΣNPv = sum of NPVs
n = number of years
i = the interest rate (set to 4%)

The cost also allow for national differentiation of cost according to main inputs having national specific prices levels. This organised through the **'Country inputs'** module in the ABC model. It contains detailed information concerning the prices of various resources needed as input for the production process of biomass specific per country. These are specified, either in absolute price levels or as an index related to the known price level in one or two specific countries (mostly Germany). This is necessary as prices of key production factors differ a lot at national level across Europe. National level price data (ex. VAT) included cover cost/prices for labour (skilled, unskilled and average), fuel, electricity, fertilizers (N, P2O5, K2), machinery, water, crop protection and land. Most of these data were gathered from statistical sources such as FADN (Farm Accountancy Data Network), Eurostat and OECD. Most cost levels were gathered for the year 2012.

The cost data elaboration also requires a feedstock specific approach. If costs are estimated for biomass that is specifically produced for energy or biobased products, i.e. in the case of dedicated crops the cost structure is clear and all cost can be allocated to the final product. All cost should include the fixed and variable cost of producing the biomass including land, machinery, seeds, input costs and on field harvesting costs. If the biomass is a waste, i.e. cuttings of landscape elements or grass from road side verges, the cost could be zero, as cutting and removing these cutting is part of normal management. However, bringing the biomass to the conversion installation requires some pre-treatment costs, e.g. for drying or densifying and then transport costs have to be made to bring it to the conversion installation. These costs will not be assessed here however as we concentrate on the road side cost.

Crop residues also require a separate approach as harvesting cost can usually be allocated to the main products, i.e. grain in the case of cereal straw, and not to the residue. However, the baling of the straw and the collection up to the roadside can be included in the costs.

For the elaboration of cost levels account also needs to be taken of the local circumstances and type of systems used for the production and harvesting of the biomass. This is particularly complex in the case of dedicated crops for which cost estimates are mostly and/or only available from pilot plots and practically no commercial plantations. Costs vary strongly per type of management, soil and climate zone. Furthermore, cost need to be allocated per ton harvested mass over the whole life-time of a plantation as harvest levels are very low in the first years and increase in time.
The costs are determined for 2012, the reference year and are kept constant in the future years 2020 and 2030. The reason for keeping cost constant in time has several advantages:

1) Estimations of future changes in prices for (fossil) energy (fuel & electricity), labour, and machinery are difficult to predict. If predictions are used this implies automatically adding additional uncertainties in the cost assessment.
2) If cost levels do not alter in time the uses of the cost-supply data in other models in and outside S2BIOM (e.g. Resolve and BeWhere) deliver results that can only be explained from the internal logic of the models and not by differences in cost level increases based on a large number of uncertainties.
3) The cost levels presented in S2BIOM can still be further adapted by other users applying their own assumptions on future cost level changes. This enables them to use the S2BIOM cost-supply data consistently with their own modelling assumptions.

Cost assessment for forest biomass

The estimation of harvesting and comminution costs is following the approach presented earlier by Ranta (2002, 2005), Ilavský et al. (2007), Anttila et al. (2011) and Laitila et al. (2015). In contrast to the cost estimates for energy crops, the production costs are not considered in the cost estimates.
The data are mostly determined by the S2Biom project. A survey of cost factors related to forest harvesting operations was carried out in cooperation with INFRES project (Dees et al. 2015).
The methodology can be divided into two main components: 1) the estimation of hourly machine costs, and 2) the estimation of productivity. All the cost estimations pertain to current cost level (year 2012).

The general work flow is illustrated in the figure below.

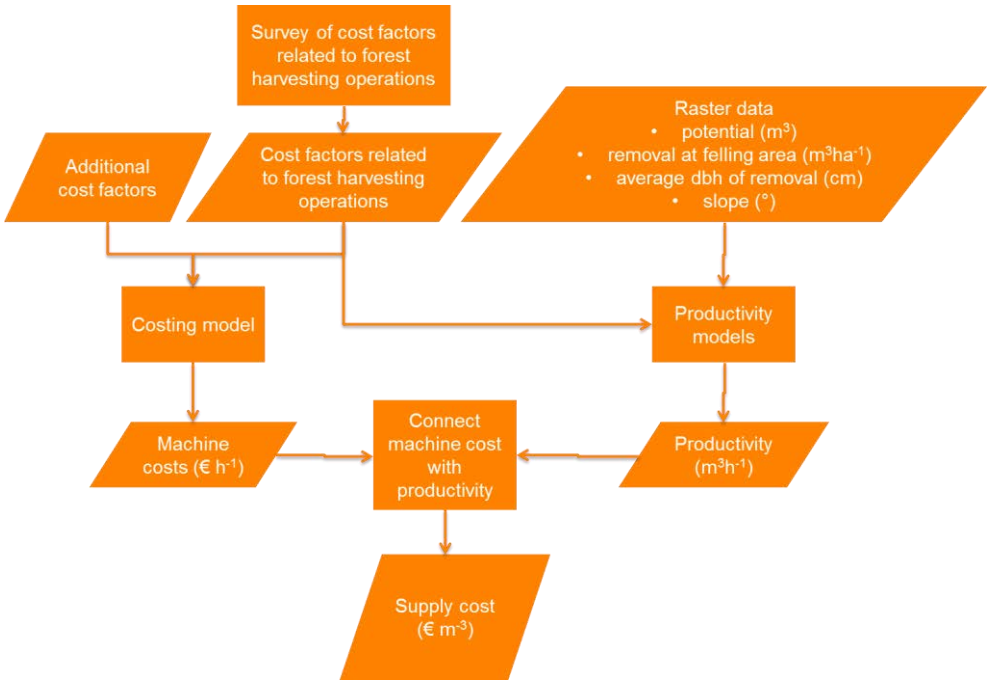

Figure A2.6 General work flow of the forest biomass cost calculations

Cost estimates for biowaste and post-consumer wood

This study follows the activity-based costing approach. In principle, the costs of harvesting collection and forwarding to the roadside need to be considered. The cost to put the biowaste in a container at roadside is assumed to be zero. The cost of further collection and processing is covered by the households and organisations that need to discard the biowaste, regardless its possible further application for energy production. Waste collection and treatment is part of the public tasks and the cost for it cannot be allocated to the processor of the waste. In case of biowaste we could define the municipal collection point as "at roadside". From this municipal collection point, the municipality can select which waste treatment option is preferred, within the framework of European and national policy, considering costs and sustainability of the treatment methods.

The cost of discarding post-consumer wood in a container at roadside is regarded zero. For instance, demolition activities are performed to make space for another building, and not with the purpose to generate wood waste. Demolition activities will follow legal instruction, i.e. put waste wood fractions in separate containers if this is required by law. For other sources of post-consumer wood such as packaging materials or household waste a similar approach can be applied. Packaging waste is of no value to organisations. Consumers bring wooden furniture to a central collection point, or put it at roadside for pick-up, not the sake of providing energy wood. Once collected and sorted, waste wood fractions have an economic value, which can be considerable if there is sufficient demand. However, as said, S2BIOM follows an activity based costing approach, considering the costs, not the economic value of the material. The roadside cost of demolition wood is therefore assumed zero.

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BBI JU

Bio-based Industries Consortium

CELEBio

D.2.2 Country report: Montenegro

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August 2020

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Summary

Montenegro has 256 000 hectares of agricultural land (about 18.55 % of the land calculated in relation to the total area). The forests are spread on 740 000 hectares, accounting for 54.0 % of the total area of the territory, with relatively small areas covering urban areas, but more than half of the population living in them. The population is slightly lower than the European average. GDP and purchasing power in the Republic Montenegro are well below the European average.

Montenegro is situated in the southeastern Europe and bordering Albania on the East, Serbia on the North and North east, Bosnia and Herzegovina on the west, Croatia on the south west, and the Adriatic Sea on the south.

Food production and agriculture still play an important role in the economic development of Montenegro. In Montenegro, the production of fruits and vegetables is prevailing, while commercial production of field crops, such as small grains, corn, sugar beet, oilseeds is limited. In particular, potatoes and vegetable crops are predominantly cultivated as well as fruit crops such as plums, apples, pears, peaches, and in the south even oranges, tangerines and figs. Recently, there has been an increasing production of grapes and wine. In the past ten years, the number of olive trees in Montenegro has been constantly growing. Livestock breeding is an important agriculture subsector. Traditional and fragmented household holdings, extensive modes of production, inefficient operations and inadequate utilization of available natural resources characterize this subsector. Industries processing the agricultural products in Montenegro are essentially wine production and oil production. Since for most agricultural residues no commodity market has developed yet it is very difficult to provide figures on prices.

The total stock of wood mass in the forests of Montenegro is estimated at 72 million m^3, out of which 29.5 million or 41 % represents coniferous, and 42.5 million m^3, or 59 % stands for deciduous forests. The annual forest increment in Montenegro is estimated at 1.5 million m^3, out of which 0.7 million m^3 are conifers and 0.8 million m^3 are deciduous. Both wood industry and forestry represent significant economic activities in Montenegro though their significance is mostly based on their potential and not accomplishments in these fields.

In Montenegro there are weak waste management systems implemented at the level of the municipalities (absence in most of the cases of weighbridge facilities to allow the accurate determination of waste flows and a shortage of reliable composition data) and there are major difficulties associated with solid waste data collection and processing. The waste management infrastructure is still under developed. Its development is part of the new National Solid Waste Management Plan. There are currently 9 recycling yards, 4 material sorting and 2 sanitary landfills.

Diversification of industry presents a very important segment of further development, in which direction plans and projections of development should be moving towards the production of ecologic food and beverages, construction, financial services, and production of products with a higher degree of processing. The potential lies in investments to renewable energy sources, construction of energy efficient buildings, sustainable organic agriculture.

Government of Montenegro recognized the following vision: "Montenegro recognized as a regional energy hub and a leader in production and use of energy from renewable energy sources". In the last decade Montenegro has used renewable energy source in the form of hydropower for electricity generation and biomass in the form of firewood. In addition to the use of RES in final consumption (firewood, pellets and briquettes, solar collectors, heat pumps as well as RES in transport - biofuels and electricity from RES), the strategy envisages intensive use of RES in electricity sector and heating sector (especially in district heating).

Montenegro does not have the integral strategy that would encourage the development of the bio economy. Although there is no such strategy, there are a number of other, sectoral, strategies that to some extent cover individual sectors of the bio economy. Strategies and regulations are being developed and harmonized within the process of association and accession to the European Union.

Due to a fact that Montenegro has substantial potential for new projects in the area of renewable energy, energy sector is one of most prospect sectors of industry in Montenegro (wind farms, small hydro plants, solar energy, biomass, oil and gas, etc.).

1 Introduction

1.1 Objectives and approach

The main objective of CELEBio is to contribute to the strengthening bioeconomy-related activities in Bulgaria, Czech Republic, Croatia, Serbia, Hungary, Slovak Republic, Slovenia and neighboring countries. To this end, one of the key activities is to develop seven comprehensive reports for the target countries and the wider neighboring region on the availability of sustainable biomass, logistics, costs and biomass business opportunities assessed through an analysis of the Strengths, Weaknesses Opportunities and Threats (SWOT).

This report aims to provide the necessary background information needed to evaluate the possibilities for setting up bio-based production chains in Montenegro.

The information structure and analysis presented in this report was developed by building on the method designed and applied by Van Dam et al. (2014) and was further refined through the execution of interviews with bio-based business developers and other experts. In these interviews further information was obtained on key factors that guide the choice of setting up bio-based activities in countries. Most of the experts stressed that all the identified factors are important and that a system approach is key in developing bio-based initiatives. If one link in the chain is missing, the bio-based initiative will not succeed. The identified factors are mapped in this report and will be the basis for performing a SWOT analysis for development of bio-based production chains.

In Annex 1 a further explanation is given of the approach used to set-up this country report.

1.2 Reading guide

This report is organized in 9 chapters. Chapter 1 gives an overview of the country's key characteristics. In the chapters 2, 3, and 4 the biomass production including its current uses and opportunities for what biomass can be additionally mobilized, is summarized for respectively the agricultural, forest, and waste sector. First the main traditional production and availability of biomass for food, feed, forest biomass and wood products are discussed and how this is handled in further processing industries and/or used for domestic markets and exports. Subsequently an overview is given of additional biomass potentials that are likely to be still unused or only partly used and that are a good basis for development of new bio-based activities. In Chapter 5 a description is given of the current bio-based industries and markets, advanced bio-based initiatives, and future biomass valorization options. Chapter 6 describes the infrastructure, logistics, and energy sector. Chapter 7 focusses on the innovation potential, particularly in the context of bio-based research and development options. The research and educational infrastructure are discussed and the potential for developing bio-based start-ups and Public-Private-partnerships will be taken into a consideration. Chapter 8 gives an overview of the policy framework and describes extensively what regulations, legislation, taxes and tariffs exist of relevance for the development of bio-based production chains. Additionally, attention will be paid to situations where regulation and support measures are actually missing, and to which extend the rule of law situation influences the establishment of new bio-based activities. In Chapter 9 potential financing options related to the development of bio-based production chains are discussed.

1.3 Short characteristics of country

Montenegro has a surface of 13 888 km². With 622 227 (2018) inhabitants its corresponding population density is given in Table 1.3.1. The average income level is below the European mean value.

Table 1.3.1: Main population, land surface, GDP and trade characteristics of Montenegro benchmarked against EU average [1, 2, 3, 4, 5]

Category	Montenegro	EU	Unit
Population	0.62	512.4	million (2018)
Area (total)	1.38	447	million ha (2018)
Agricultural Area	0.26	173.3	million ha (2018)
Forest area	0.74	164.8	million ha (2018)
Population density	45.4	115	n°/km² (2018)
Agricultural Area per capita	0.41	0.34	ha/ capita (2018)
Forest area per capita	1.17	0.32	ha/capita (2018)
GDP/capita	4 663	30 956	at current prices in 2018
	4 517	30 956	GDP at purchasing power in 2018
GVA by Agriculture, forestry and fishing	6.73 %	1.6 %	% of total GVA (2018)

GDP = Gross Domestic Product; PPS = Purchasing Power Standard; GVA = Gross Value Added; UAA = Utilized Agricultural Area
Source: Eurostat most recent statistical data sources (Accessed August/September 2019) (https://ec.europa.eu/eurostat/data/database) and statistical factsheets (https://ec.europa.eu/agriculture/statistics/factsheets_en)

Montenegro has 256 000 hectares of agricultural land (about 18.55 % of the land calculated in relation to the total area). The forests are spread on 740 000 hectares, accounting for 54.0 % of the total area of the territory, with relatively small areas covering urban areas, but more than half of the population living in them. The population is slightly lower than the European average. GDP and purchasing power in the Republic Montenegro are well below the European average.

Montenegro covers the area of 13 812 km². It is dominantly a mountainous country incised by river gorges and deep valleys. Plains are found only in the southern parts of the country. The proportion of the land whose slope is smaller than 5% amounts to about 3.7 % of the total area of Montenegro [3]. The climate in Montenegro is determined by its latitude, altitude, the presence of large water areas (the Adriatic Sea, the lake of Skadar), deep incision of the sea into the land (the gulf of Boka Kotorska), moderately high mountain hinter land in the vicinity of the coast (Orjen, Lovcen, Rumija), the field of Ulcinj in the extreme south east and the mountain massive of Durmitor, Bjelasica, and Prokletije.

There are 23 municipalities on the territory of Montenegro which are divided into three regions: Southern, Central, and Northern region. The region considered within this project is somewhat wider than the Northern region and includes virtually all forest area in Montenegro. It refers to the economically less developed part of Montenegro with the population greater than 300 000 inhabitants. However, this area could overcome this economic disadvantage with better utilization of the natural resources at disposal.

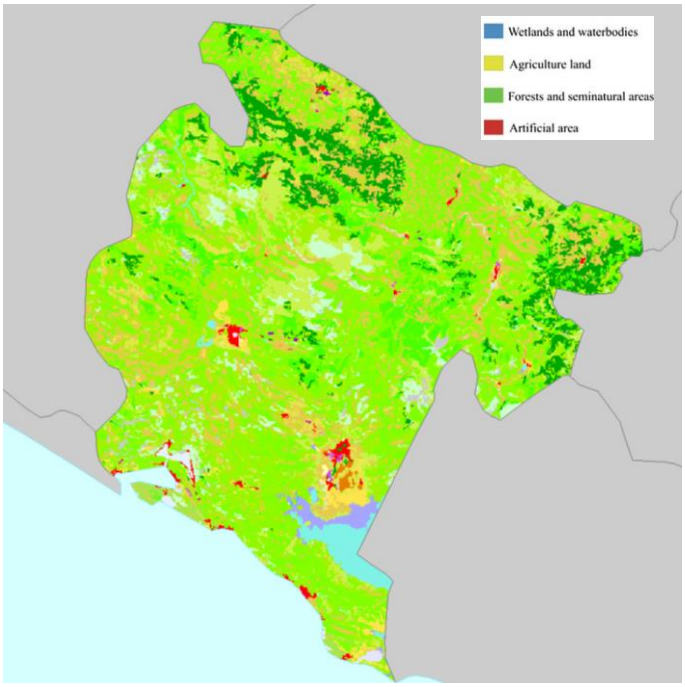

Figure 1.3.1: Main landcover distribution over Montenegro. [1]

Montenegro is situated in the southeastern Europe and bordering Albania on the East, Serbia on the North and North east, Bosnia and Herzegovina on the west, Croatia on the south west, and the Adriatic Sea on the south (Figure 1.3.2).

Figure 1.3.2: Montenegro and its bordering countries [2]

Montenegro is connected with European countries by road, rail, air and water traffic (Figure 1.3.3). The total length of road in Montenegro is about 7 800 km (Figure 1.3.4) and railways about 300 km (Figure 1.3.5). The Montenegro has 5 airports (Podgorica, Tivat, Nikšić, Berane and Ulcinj) and 12 commercial harbors at Adriatic Sea (Figure 1.3.6).

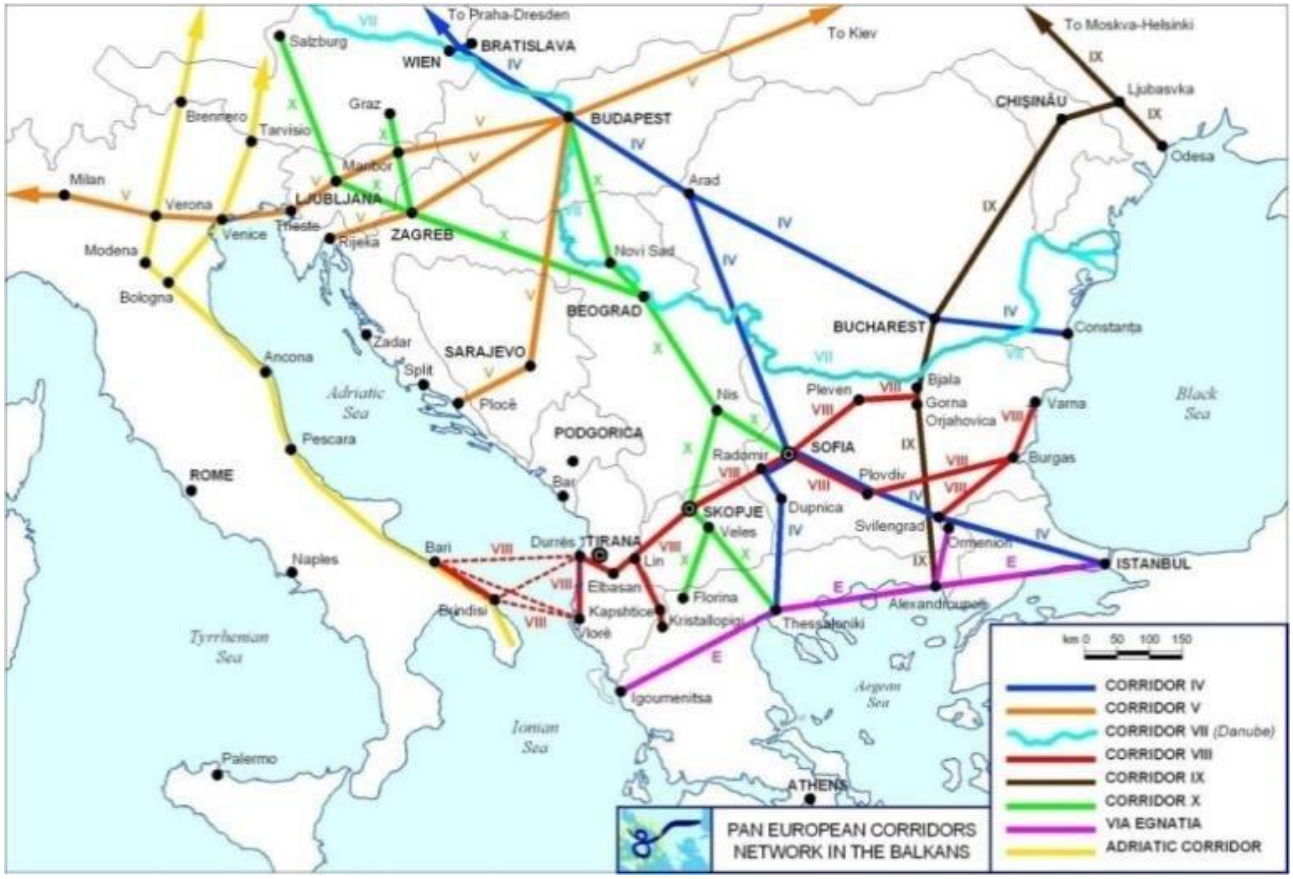

Figure 1.3.3 Position of Montenegro in the Trans-European Transportation Network [3]

Figure 1.3.4 Road transport connections of Montenegro [4]

Figure 1.3.5 Rail transport connections of Montenegro [4]

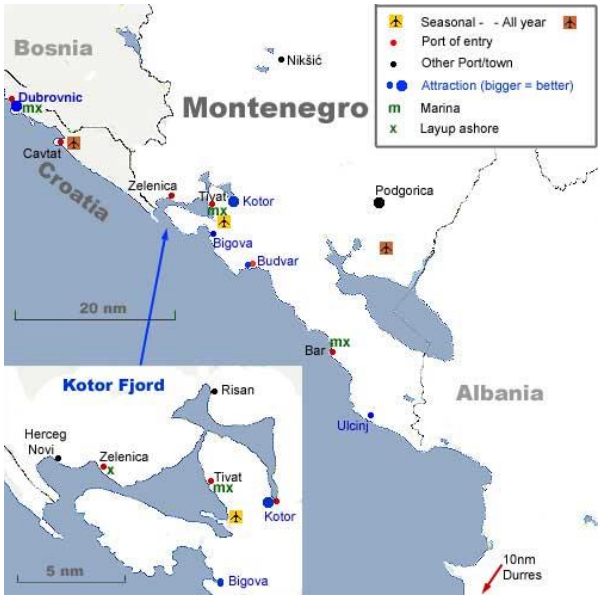

Figure 1.3.6 Airports and commercial harbors of Montenegro [5]

2 Biomass supply: agriculture

2.1 Introduction

In this chapter the agricultural biomass production and main uses is described. A distinction will be made between the main economic products produced and their main process chains and residual biomass potentials from primary production and available as by-products of food processing industries. In addition to presenting the main biomass production attention will also be paid to the importance and the structure of the agricultural sector and to the main environmental challenges associated with agriculture in Montenegro.

Agricultural land in Montenegro in 2018 was 256 808 hectares, where 242 113 ha are perennial meadows and pastures and all other uses (utilized kitchen gardens and/or gardens, utilized arable land, orchards – plantations and extensive, nurseries) are 14 695 ha. In accordance with the Agricultural Census of 2010 the average size of utilized agricultural land per holding in Montenegro is 4.6 ha. It should be taken into account that 72 % of agricultural holdings possess up to 2 ha of land. In addition, the used agricultural land is divided into small parcels, which makes it more difficult to fully utilize [6].

Cereal production in Montenegro

Montenegro has such land areas where it is not easy to improve agricultural production. The largest area is occupied by soils with favorable agropedological properties and high potential fertility, but their discontinuity on limestones or extremely steep slopes on silicates do not allow the formation of large plots or unhindered application of mechanization. According to some estimates, the chance of Montenegrin agriculture is in the economy of quality and not quantity.

According to the 2010 census, there are 46 registered business entities in Montenegro, utilizing 8 573.2 ha and 48 824 family agricultural holdings utilizing 212 724.4 ha [7].

Based on climate, relief and land characteristics as natural conditions that determine the directions of agricultural production, Montenegro can be divided into 5 basic agroecological regions:

1. The Coastal region, with 50 815 ha (9.8 percent of the total) of fertile agricultural land, which consists of deep alluvial - talus and brown anthropogenic land; This region is suitable for fruit and vegetable production as well as raising small ruminants. In addition, it is rich in terms of honey plants and herbs, and wild fruits, such as figs, pomegranate and so on.
2. The Zeta-Bjelopavlici region with 78 997 ha (15.3 percent) is the lowland region of up to 200 m above sea level, suitable for different types of crop production, including vegetables, fruits and wine as well as cattle breeding.
3. The Karst region covers 74 320 ha or 14.3 percent of the total, with an altitude of 700-800 m. Arable land is scarce and is found mainly in karst fields, hollows and valleys that dominate the waterless regions. The most important agricultural sectors are livestock, especially goats, sheep followed by cattle, and beekeeping.
4. The North mountainous region with 184 528 ha at altitude above 800 m (35 percent of the total area) is characterized by numerous highlands and plateaus; suitable for growing grains, potatoes and cabbage, as well as for the development of livestock due to large areas of meadows and pastures.
5. The Polimlje-Ibar region, which covers 25 percent of the total area or 129 804 ha is located at 1 000 m above sea level. Due to the fertile land and springs, this region is important for vegetable and fruit cultivation as well as cattle breeding.

2.2 Characterization of current agriculture sector

Food production and agriculture still play an important role in the economic development of Montenegro. The share of agriculture, hunting and forestry in total GDP of Montenegro was 11.3 % in 2004, and dropped to 8.1 % in 2015 [2]. The share of food, beverages and tobacco in total household expenditures in Montenegro (average number for total number of households), is relatively high with trends reducing from 56.6 % (2000) to 48 % (2004). Despite being a development and economic priority, together with the tourism sector, according to official statistics, agriculture employs only 1.4 percent of all employed people in Montenegro (2015). However, according to the Labor Force Survey, the number employed in the sector is higher.

Table 2.2.1 Key characteristics for the agricultural sector in 2018 [6],

Category	Montenegro	EU average	Unit
Employment in Agriculture	1.4[1] (7.1[2])%	3.9 %	% of total employment 2017
Agricultural area per capita	256,807.7/622,227	0.34	ha/capita
Cereal yield	3.31	5.2	t/ha

Detailed summary of agriculture production is provided in Table 2.2.2 for year 2015 [8].

Table 2.2.2 Summary of agricultural production in 2015 [8],

Crop	Area planted (ha)	Output (t)	Geographical distribution
Apples	139.7	2 816.8	Central/North MNE
Plums	227.3	1 259.2	Central/North MNE
Mandarins	143.4	2 574.7	South MNE
Pears	35.0	365.5	Central/North MNE
Grapes	2 634.1	23 085.6	Central/South MNE
Potato	2 114.1	35 444.7	Central/North MNE
Peaches	92.5	1 491.9	Central/South MNE
Wheat	736.5	2 110.5	North MNE
Corn for grain	629.4	2 700.2	Central/North MNE
Olives	88.7	244.3	South MNE
Watermelons	482.7	20 194.2	Central/South MNE
Barley	370.1	952.0	North MNE
Cabbage	318.4	10 623.2	Central/South MNE
Oats	202.7	555.5	North MNE
Peppers	180.6	4 499.6	Entire MNE
Rye	178.2	338.8	North MNE
Onion	126.9	2 341.6	Entire MNE
Tomatoes	114.3	3 935.8	Entire MNE
Beans	100.5	855.5	Entire MNE
Melons	53.8	1 368.9	Central/South MNE
Cucumber	49.9	1 821.7	Entire MNE

The place agriculture takes in the economy is hard to evaluate due to obvious flaws in the sector statistics. The discrepancy between the share of agriculture in GDP and the share of employed people in agriculture is evident, since statistics monitor movements of employees in agricultural enterprises, but not in agricultural

[1] Employment from administrative sources
[2] Labor Force Survey MONSTAT

households [7]. Some tendencies of labor market movement and structure of the active population are presented through data on the share of active agricultural population in total number of active population. According to these data in period between 1961 and 2003, the share of the active agricultural population in the total number of active population has been reduced from 53.6 % to 8.8 %. There are also considerable changes in labor force structure, as well as large-scale migrations of population from rural to urban areas of Montenegro, economically motivated, above all.

In Montenegro, the production of fruits and vegetables is prevailing, while commercial production of field crops, such as small grains, corn, sugar beet, oilseeds, are limited. In particular, potatoes and vegetable crops are predominantly cultivated as well as fruit crops such as plums, apples, pears, peaches, and in the south even oranges, tangerines and figs. Recently, there has been an increasing production of grapes and wine.

Agriculture is the most important sector for those residing in the rural areas of Montenegro, in particular livestock breeding is an important agriculture subsector. Traditional and fragmented household holdings, extensive modes of production, inefficient operations and inadequate utilization of available natural resources characterize this subsector. Livestock breeding allows Montenegro to exploit less productive areas (pastures and meadows), which are predominant in the structure of total agricultural area in Montenegro (roughly 88 percent).

In terms of the products imported and exported products, no major changes were recorded over the years. The most important imported products are fresh meat, cereal-based products, various foodstuffs (including variety of sauces, spices, ice-cream, etc.), followed by carbonated (sparkling) soft drinks (beverages), milk and dairy products and live animals.

Regarding the exports, wine is still one of the main export products. In total export of agricultural products, wine participated with 29 percent in total value of export of agricultural products. The total value of wine exported in 2015 amounted to € 15.4 million. The wine sector is recognized as a very important sector for Montenegro. Besides wine, meat preparations, such as cured meat products, have become one of the country's main export products. The development of the meat industry in Montenegro has resulted in a significant change in both imports and exports, such as the growth of imports of fresh pork meat used as raw material, the decrease in imports of cured meat products due to higher consumption of domestic products and an increase in the export of these products.

2.2.1 Crop production

According to MONSTAT, total agricultural utilized land in 2018 was 256 808 ha of which 7 200 ha were arable land and only 2 447.5 ha used for production of cereals for grain.

The main cereal crops are: wheat, maize for grain, barley, oats and ray. Total harvested area of these crops was 2 204.4 ha with total production of 7 300.5 tonnes of listed cereals.

Potatoes are the most important product after cereal production, covering a harvested area of 1 618.5 ha (on arable land) and 540.8 ha (kitchen gardens and/or gardens) with production of 26 098.1 and 8 789.6 tonnes respectively in 2018.

More important vegetables produced in Montenegro are: cabbage, tomatoes, peppers, onion, watermelons and melons. Total harvested area of arable land and kitchen gardens and/or gardens in 2018 was 1 453 ha, with yield ranging from 20.1 to 33.3 tonnes per hectare.
Fruit and olive production in Montenegro are dominantly based on plums and apples, followed by mandarins and pears with peaches and olives at the end. Plums, apples and pears are dominantly produced on gardens, while mandarins and peaches are dominantly produced on extensive orchards. Olive production is balanced although the extensive orchards are in a small advantage compared to gardens. In 2018, total production in tonnes of plums was 11 835.8, apples 7 583.4, mandarins 3 645.4, pears 2 298.0, peaches 1 291.6 and olives 521.3.

In the past ten years, the number of olive trees in Montenegro has been constantly growing. Also, the number of bearing trees is constantly growing. It is important to note that Montenegro has been a member of the International Olive Council (IOC) since 2007. Membership in this organization provides Montenegrin olive growing with benefits such as encouraging international technical cooperation in research and development of projects, staff training and technology transfer, encouraging international trade in olive oil and olives, improving quality standards, etc. According to data obtained from the IOC (International Olive Oil Council) survey from 2011, there are young plantations (up to 5 years of age) on an area of about 150 ha, plantations from 5 to 15 years on an area of about 100 ha while the old plantations, with over 50 years of age, occupy an area of over 800 ha. However, 2/3 of the area under olive trees is still over 200 years old. It is known that olive groves are characteristic of the coastal belt, i.e. the southern region of Montenegro. However, a certain number of hectares is also located in the central part of Montenegro - 21 ha in Podgorica and 12 ha in Danilovgrad (according to the 2010 census). The trend of increasing the number of olive trees in this region has continued in the last 6-7 years, which are not included Census. Plantation production, which is gaining momentum in the Mediterranean countries, in Montenegro in 2010 occupied only 77.1 ha. The average size of olive groves on plantations (excluding the former plantation Agroulcinj) is 0.42 ha. Of the total number of olive trees on plantations, 97.40 % are olives for oil production. The largest number of young olive trees was recorded in Bar (7,505) and Ulcinj (5,855). Olives for canning are mostly obtained from a small number of trees in the backyards and are not recorded in this census.

Vineyards and production of grapes are very important part of agriculture production in Montenegro with total productive area of 2 790.2 ha and 10 629 873 number of grapevines of productive age. Total production of grapes in 2018 was 25 770.2 tonnes of which 24 440.6 was produced on plantations. In total export of agricultural products, wine participates with approximately 25-30 % in total value of export of agricultural products.

Fodder

Fodder production in Montenegro is still developing. Garant from Spuž is the only domestic fodder factory in Montenegro. Production capacity is about 50 000 tonnes and there are good chances for export. Modern plant was built whose technology enables the production of extremely high-quality products. Over EUR 2 million was invested in the adaptation and equipping of the factory. This factory produces high quality and affordable feed mixtures for the needs of the Montenegrin market and export. The annual production is 25 000 tonnes . The capacity of the factory is about 50 000 tonnes of fodder per year, as are the needs of domestic farms for this commodity.

2.2.2 Livestock production

Montenegro has significant livestock production. In 2018, in total there were 4 005 horses and 83 264 cattle, 666 339 poultry, 187 021 sheep, 29 040 goats, 23 651 pigs and 67 908 beehives.

Livestock production is performed in enterprises and collective farms and on private farms. Dominant number of cattle and horses is located on private farms (97 and 100 %), while poultry is distributed evenly between enterprises and collective farms and on private farms (47.37/52.62 %). For sheep, goats and pigs, situation is the same as for cattle, dominant numbers are on private farms ranging from 98 to 99 %.

2.3 Biomass potentials from agricultural residues and unused lands

Agriculture is not a strong industry in Montenegro. Consequently, the agricultural residues from and unused land doesn't make a significant potential of biomass. Best available data (Annex 2) provided quantities of dry biomass residues available in Montenegro. Those data are presented in Figure 2.3.1.

As it is presented, the grassy biomass from road side verges (unused land) is dominant and almost equal to total quantity of the two following sources - residues from fruit tree plantations (apples, pears and soft fruit) and maize stover. After them, only cereals straw represents important source of agricultural residues, while all other are almost negligible.

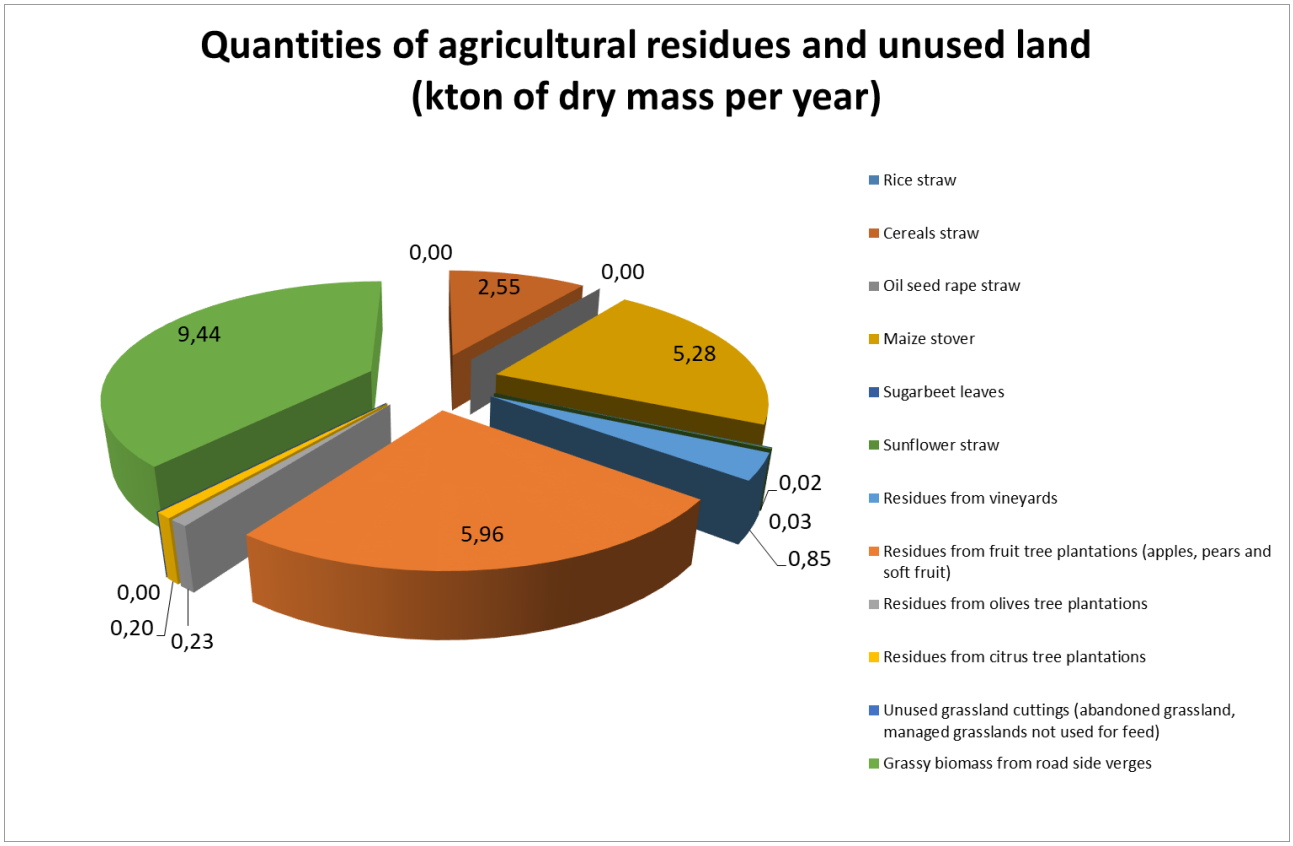

Figure 2.3.1: Available quantities of agricultural residues and unused land in Montenegro for 2020 (see Annex 2 explaining how these potentials were assessed)

2.4 Secondary agricultural residues from processing industries

Industrial production in Montenegro is divided in two categories: heavy industry – which includes energy, mining, metal processing industry and chemical industry, and light industry – which includes food processing industry, textile industry, wood processing industry, graphic industry and construction materials industry.

A report by the Ministry of Agriculture and Rural Development in Montenegro says that the sub-sectors of the manufacturing sector in the country do not take part and do not contribute in an equal way to the overall results of the processing industry. "The statistical data show that the sub-sector of food products, drinks and tobacco is the most casually linked to the global trends, due to its traditional orientation towards the domestic market and closest regional markets", the report elaborates.

Industries processing the agricultural products in Montenegro are essentially wine production and olive oil production. Quantities of residues available from those industries are 0.14 and 0.92 ktonnes per year respectively (S2BiOM, but only focussing on cereals, olive and grapes (vine) processing industries).

COMPANIES PER SECTORS

Meat and meat products (traditional and new products):

- Meat Industry Franca doo Bijelo Polje
  Private company doo "MESO-PROMET" was founded on December 10, 1990 in Bijelo Polje. The main activity of the company is the purchase, production, processing and sale of meat and meat products. (http://www.franca.me)
- Meat Industry Goranović, doo, Nikšić
  The Goranović company is privately owned by the Goranović family, which has been engaged in this type of activity since 1986. The main activity performed by the Goranović Meat Industry is the production of final meat products. With a daily production capacity of 40 000 kg of cured meat products and meat products, Meat Industry Goranović is the leading business entity in the production of final meat products in Montenegro. (https://www.migoranovic.com)
- Niksen trade, Čavor
  NIKSEN-TRADE-ČAVOR is an established limited liability company that has been operating and developing on the Montenegrin market since 1995. The company has developed from a small family dryer to one of the strongest producers of the famous and widely known Njegusi prosciutto and cheese.(http://www.niksentrade.com)
- Martex, Cetinje
  The company MARTEX from Cetinje is one of the largest private producers of dried meat products in Montenegro. He pays great attention to the improvement and modernization of the production process with new technologies in production as well as the expansion of the range of dried meat products, all in order to fully meet the needs of modern consumers. (http://www.martex.co.me)
- Interprodukt – Mesna industrija Cetinje,
  The company INTERPRODUCT is engaged in the processing of animal and poultry meat. It was founded in 1998 with a clear vision of its future business. From the very beginning, the company adheres to its program of high-quality products, which has contributed to gaining an enviable number of customers and the constant expansion of the sales market. (http://www.interproduct.me)

Dairy products: traditional and new products:

- Lazine Dairy, Lazine
  Lazine Dairy is the first private dairy in Montenegro, present on the market since 1998 and has been the absolute leader of Montenegrin dairy for several years. Since its establishment, its products have been recognized and recognized as a leader in quality in the dairy industry of Montenegro. (https://mljekaralazine.me)
- Šljukić CO Mljekara Srna, Nikšić
  Privately owned dairy located in Nikšić, Founded on December 1, 1999.

- Dairy Nika, Nikšić
  Dairy "Nika" in Nikšić has a tradition of more than five decades. In the sixties of the last century, a dairy was built on the site where it is still located today, and it operated as part of a large agricultural and trade complex. The dairy was reconstructed in 1986, when Alpha - laval equipment was installed, the highest quality equipment for the dairy industry. With the privatization of "AGROPRODUKT" a.d. Nikšić from January 1, 2005, the dairy operates within "BOOSTER" d.o.o. Nikšić, and from April 12, 2006 independently under the name Mljekara "NIKA" d.o.o. Niksic. Within the company F.M.L. production started on August 7, 2017. The dairy has the ability to process about 50 000 liters of milk per day.
- Cheese factories Montebianca, Katunjanka, etc.
- Miljanić farm, Ćipranić and other goat cheese producers

Production and processing of vegetables and fruits, including products from wild-type fruits:

- Veletex – Kalija (nursery, agriculture), hotel, plantation, more than 100 employees
- Farmont – pharmacy and production of aronia and raspberry jams, teas.
- Pirella – juice factory, Danilovgrad
  Pirella juice factory from Danilovgrad was founded in 1999, starting its own production. From the beginning, the company's policy was based on product quality and good relations with partners, which contributed to Pirella being maintained as a market leader in Montenegro, despite strong competition. (http://www.pirellajuices.com)

Wine production sector:

- AD 13. jul Plantaže
  Company "13. July - "Plantation" for more than half a century is one of the largest and most important producers of grapes, wine and grape brandy in Southeast Europe, which owns a unique vineyard with an impressive area of 2 310 hectares in one complex. Today, over 40 different wines and four types of grape brandy are produced from 26 wine grape varieties. The leading position in the region is confirmed by the production of about 22 million kilograms of wine and table grapes, as well as the placement of more than 17 million bottled products per year (among which – 90 % are wines) in 35 countries.
- Ravil – wine, hotel, vineyards, agritourism
  Vineyards of the Lipovac Winery are located in the most scenic place of Montenegro. Građani slopes surround Lake Skadar, the famous nature reserve of the country. These Balkans lands have always been famous for its wine. However, it was limited to domestic consumption only. Today, the Lipovac Winery is developing a large-scale enological project. (http://lipovacwines.com)
- About 70 small family wineries

Honey and other bee products (pollen, propolis, wax, etc.):

- Independent honey producers

Olive oil and other olive products (cosmetic products, souvenirs, etc.):

- Moric DOO, Luštica
  The Moric family is the only certified manufacturer of organic olive oil in Montenegro.
- Oil Factory Metović, Stari Bar
  The property of the Metovic family is located under the walls of Stari Bar in the immediate vicinity of the "Kajnak" spring. It is engaged in the production of olive oil in a traditional and modern way by processing the indigenous variety "Barska zutica" which has been growing in the gentle valley of Bar for over 2000 years. (http://www.mdsuljara.me)

Growing and collection of medicinal, aromatic herbs and mushrooms (production of oil, cosmetic products, pharmaceuticals, spa products, spices, beverages etc.):

- AgroLife – distillery of aromatic oils, immortelle
- Herbal Montenegro – immortelle, purchase, essential oils.
- Flores Mojkovac

- Eko promet Bijelo Polje
- Interfood Rožaje

Production of potatoes and related cereals and buckwheat (integral flour, a wide range of products, etc.):

- "Sjeme", Kolašin
- KD "Tuko", Nikšić
- ZZ "Vrbica", Berane
- Nikšićki mlin, Nikšić
  Nikšićki mlin AD was founded in 1951, with its headquarters in Nikšić and is engaged in the procurement, production, processing and sale of cereals and grain products. Since 2008, the majority owner is the company Agroglobe from Novi Sad, which is not satisfied with the existing capacities and decides to enter the construction of a completely new mill, start renovating buildings, exterior decoration of the company, renovation of the administrative building, construction of a warehouse of 1500 m^2. (http://www.niksickimlin.me)
- Inpek
- Primat
- Dondon

2.5 Cost of main biomass source

Since for most agricultural residues no commodity market has developed yet it is very difficult to provide figures on prices. Instead cost estimates can be presented building on the S2BOM methodology and assessment. The cost refers to *Roadside cost* and these cover all biomass production collection and pre-treatment cost up to the road where the biomass is located. The roadside costs are only a fraction of the total 'at-gate-cost.' The road side costs are presented in Table 2.5.1 below; for further details on the cost calculation in S2BOM see Annex 2.

Table 2.5.1: Road side cost levels (€/tonne d.m.) for agricultural biomass sources based on S2BIOM cost calculations (see Annex 2 for explanation of approach) [16]

Road side cost for agricultural biomass	**Average (€** tonne dm) (2020 cost level)
Maize stover	10.54
Residues from vineyards	-
Residues from fruit tree plantations (apples, pears and soft fruit)	107.88
SRC unused lands	26.14
Dedicated crops on unused lands	26.14

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2.6 Summary and conclusions in relation to SWOT elements

Strengths	Weaknesses
• *High quality, preservation and fertility of the soil* • *Favorable climate for many types of products* • *Tradition in agricultural production practices* • *Biodiversity, presence of autochthonous species and varieties in agriculture,* • *Good conditions for organic production* • *Sufficient work force that seeks additional opportunities for employment* • *Obvious changes in the institutional framework during the recent period* • *Obvious positive changes in production processes (adoption of new technology, introduction of standards etc.)*	• *Large part of production non-competitive in price* • *Poor mechanization* • *Low level of technology and specialization applied in production* • *Small and fragmented holdings* • *Low levels of production per household unit* • *Relatively high input prices that influence the final price of products* • *Lack of organization and cooperation in the production chain* • *Insufficient quality assurance standards (hygiene and environmental)* • *Inefficiency and non-competitiveness of processing industry (low levels of production, obsolete technology, lack of investment, market inefficiency)* • *Unfavorable age and social structure in rural areas,* • *Poor infrastructure in major parts of rural areas* • *Low budget support* • *Insufficiently developed IT systems, statistics and analyses in agriculture* • *Weak promotion and marketing* • *Lack of storage capacity* • *Poor connections with the Tourism Sector* • *Low levels of education and lack of knowledge in farmers* • *Low levels of application of good agricultural and environmental practice*
Opportunities	**Threats**
• *Strengthening agriculture through tourism, additional food demand* • *Availability of state and EU support, particularly for rural development* • *Increasing markets for organic production* • *Strengthening local production and markets* • *Increase of exports of competitive products (wine, lamb, vegetables)* • *Positive international market tendencies, including Middle East market* • *Efficiency of additional budget support* • *Faster technological development, strengthening of professional skills and institutions supporting agricultural development* • *Growing demand for high-quality products* • *Development of cooperation*	• *Opening of the market will increase competitiveness which may endanger major parts of commercial production* • *Due to low levels of production and quality, as well as preferences for foreign goods, the penetration of large trade systems will further endanger the economic position of certain sectors* • *Concentrated development of other economic branches in certain parts of the country, without agricultural development, may further affect depopulation and the under-utilization of natural resources* • *Huge dependence on imports,* • *Lack of public awareness regarding the benefits of local products* • *Difficulties in accessing finance for farmers (loans)*

3 Biomass supply: Forestry

3.1 Introduction

The diverse climate in Montenegro has a large influence on forests and forest areas. It can be distinguished between numerous different forest associations in Montenegro depending on geographic and climate conditions. Due these facts the Montenegro is considered a high-forested country (Figure 3.1.1).

Figure 3.1.1: Forest ecosystems of Montenegro [9]

Total area of forests is around 740 000 ha, and the percentage of forest cover is 54.0 %, which is higher than the average percentage of forest cover in Europe. The area of forests managed by the State Enterprises amounts is around 83 % of the area of forests and other wooded land in Montenegro. The remaining forest area is managed by private owners, other social enterprises and National Parks.

In Table 3.1.1 the main characteristics of Montenegrin forests are presented.

Table 3.1.1: Montenegrin forests in numbers, 2018 [10]

Forrest area	710 000 - 740 000 ha
Forestation	51 - 54 %
Growing stock	72 056 699*m^3 or 86.8 m^3/ha
Annual increment	1 489 189* m^3
Possible cut	815 697 m^3
Coniferous trees	422 691 m^3
Deciduous trees	393 006 m^3
Length of forest roads	1 729 km
Length of forest borders	-

*data for 2007

The main commercial tree species in the Montenegrin forests are the conifers: fir (abies alba), spruce (Picea abies), Scotts pine (pinus sylvestris) and Austrian pine (Pinus nigra). The most important broadleaves in the Montenegrin forests are: beech (fagussylvatica) and oak (Quercus sesiliflora). The other valuable species are found in smaller quantities. The main species make up mixed or single-species forests. Forests and forest lands in Montenegro cover about 710 000 to 740 000 hectares or 51 % to 54 % of the territory of Montenegro. The

total stock of wood mass in the forests of Montenegro is estimated at 72 million m³, out of which 29.5 million or 41 % represents coniferous, and 42.5 million m³, or 59 % stands for broad-leaved forests [3, 4] (see tab. 3.1.2).

Table 3.1.2: Wood stocks in Montenegro, 2018 [10, 11]

Ownership	Conifers (m³)	Broadleaves (m³)	Total (m³)	%
State Forests	28 355 635	31 275 245	59 630 880	82.76
Private Forests	1 171 920	11 253 899	12 425 819	17.24
Total	29 527 555	42 529 144	72 056 699	100.00

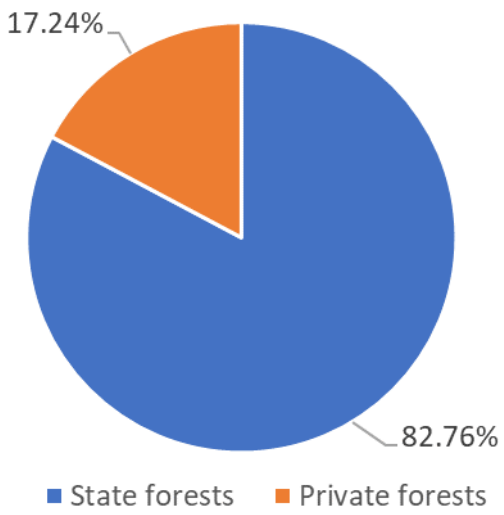


Figure 3.1.2: Ownership in Montenegrin forests

As for the ownership, around 60 million m³ (59 630 880 m³) of the forest fund is state owned. Economic forests cover the largest area (89.05 %) whereas the rest belongs to protective forests and national parks, 7.7 % and 3.25 %, respectively.
The structure of the wood stocks in the state forests is the following:

- conifers 28 355 635 m³, i.e. 47.55 % of the total wood mass in the state forests, and
- broadleaves 31 275 245 m³, i.e. 52.45 % of the total wood mass in the state forests.

Wood stocks in private ownership amount to 12 425 819 m³ where wood stocks of broadleaves dominate amounting to 90.57 % of the total wood mass. The rest consists of conifers. The annual forest increment in Montenegro is estimated at 1.5 million m³, out of which 0.7 million m³ are conifers and 0.8 million m³ are broadleaves. The structure of the forest increment in Montenegro is presented in tab. 3.1.3

Table 3.1.3: Annual forest increment in Montenegro, 2018 [10, 11]

Ownership	Conifers (m³)	Broadleaves (m³)	Total (m³)	%
State Forests	664 792	575 589	1 240 381	83.29
Private Forests	30 144	218 664	278 808	16.71
Total	694 936	794 253	1 489 189	100.00

The largest part of the increment (83.29 %) originates from the state forests which make up 67.25 % of forests and forest land in Montenegro and possess about 82 % of the total wood mass. Based on assets it is prescribed how much wood over a certain time must, or can be cut in some stand (Asset – wood stock or surface area foreseen for cutting by the management foundations in a certain year is called annual assets). The prescribed annual assets in Montenegro amount to slightly more than half the annual increment.

Table 3.1.4: Annual assets in Montenegro, 2018 [10, 11]

Ownership	Conifers (m^3)	Broadleaves (m^3)	Total	%
State Forests	406 813	264 494	671 307	82.30
Private Forests	15 878	128 512	144 390	17.70
Total	422 691	393 006	815 697	100.00

By comparison of the increment and assets (see tab. 3.1.3 and tab. 3.1.4) the following conclusions can be made:

- the ratio between assets and increment in the forests of Montenegro amounts to about 55%,
- the ratio is approximately similar in the state forests (54.1 %),
- the assets for the conifers in the state forests are somewhat higher and amount to 61.2 % of the increment, while for the broadleaves they are about 50 %,
- the ratio of the assets and the increment in private forests is higher and amounts to about 58 %, and
- in private forests, the assets of broadleaves amount to 58.8% of the increment, and with the conifers about 52.7 %.

The forests owned by the state in Montenegro are given for utilization to the legal subjects registered for performing activities in forestry, as well as for other activities as determined by the Law on Forests of Montenegro, under the conditions and in the way foreseen by this Law, through the system of concessions. The data on concessions for the year 2007 are given in tab. 4 (420 688 m^3). In addition, certain quantities should be added for sanitary cuts (3 233 m^3) as well as for the cuts that the local rural population would use as a fuel. There are no such elaborate data for the private forests as there are for the state forests. It can only be assumed that the same state policy is applied for the private forests as well. It means that the plan of felling in the private forests is around 70 % of the established assets.

Table 3.1.5: Calculated gross volume of forests in the north of Montenegro planned for felling in 2007, 2018 [11]

Ownership	Tree species volume (m^3)		
	Conifers	Broadleaves	Total
State forests (concessions + needs of the rural population; fuel + expected sanitary cutting in 2017)	264 763	198 871	463 634
Private forests	11 115	89 958	101 073
Total	275 878	288 829	564 707

The calculation has been made under the assumption that the wood from the sanitary felling and the fuel wood for the population originate from the broadleaved forests.

This project received funding from the BBI JU under the EU Horizon 2020 research and innovation programme under grant agreement No.838087

3.2 Primary biomass resources from forestry

In the Montenegro forestry sector, the amount of wood that could be used for heating was calculated taking into account bulky branch substance, stacked wood, whole trees from sanitary cuts, and specially cuts for fuel for the local rural population. Table 3.2.1 represents the data on the calculated heat at disposal which might be reached by burning this wood, as well as the equivalent energy value in oil.

Table 3.2.1: Available energy value of wood that will be at disposal for burning in Montenegro in 2007, 2018 [11]

Origin	Species				Heat at disposal [GJ]	Equivalent tonnes of oil
	Broadleaves		Conifers			
	Volume [m³]	Mass volume [t]	Volume [m³]	Mass volume [t]		
Long-term concessions	60 029	54 026	77 426	45 294	1 012 259	24 101
Short-term concessions + private forests	123 421	111 079	40 807	23 872	1 351 294	32 174
Total	183 451	165 106	118 233	69 166	2 363 561	56 275

The values in Table 3.2.1 have been obtained on the basis of the following assumptions:

- the volumes of the bulky branch substance and the stacked and cellulose wood at disposal have been calculated on the basis of the Proposal of the Decision on Concessions from the year 2007 and the data given in,
- the moisture content of the felled wood is 60 %,
- density of the raw broadleaves (beech taken as representative) amounts to 900 kg/m³,
- density of the raw conifers (fir taken as representative) amounts to 585 kg/m³,
- lower heating value of raw broadleaves (beech taken as representative) amounts to 9.90 MJ/kg,
- lower heating value of raw conifers (fir taken as representative) amounts to 10.54 MJ/kg,
- lower heating value of crude-oil amounts to 42 00 MJ/kg,
- forest residue makes 40 % of mass of trunk of broadleaves, and
- forest residue makes 30 % of mass of trunk of conifers.

For the rest (tiny branch wood, stumps, and roots), however attractive it might be at first sight, there are neither technical nor human resources potentials, nor economic justification to exploit it. However, it is still possible in the future to be utilized with according changes in the legal regulations, state policy, and the public attitude toward the renewable energy sources.

3.3 Secondary biomass resources from wood processing industries

Both wood industry and forestry represent significant economic activities in Montenegro though their significance is mostly based on their potential and not accomplishments in these fields. The raw material resources and numerous previously constructed capacities are a basis for considerably higher level of production and more significant proportion within the domestic product, export, and employment. The mentioned plants were mostly built or modernized in the eighties and until recently they have all been in the hands of the state. Over the last few years the priorities of the Government of Montenegro, in the area of wood processing, are the restructuring and privatization of these enterprises but also the stimulation of development of small and medium enterprises in the rural areas which would be based on other products of forests, apart from processing of technical wood.

The key enterprises of the wood processing in Montenegro refer to the privatized companies, once bearers of the wood industry. The quoted firms in the year 2007 processed approximately 300 000 m³ of timber, which is

more than 50 % of the total wood mass (from the state and private forests) foreseen for cutting in the year 2007. The raw material that they utilize mostly comes from the state forests based on long-term concessions. The situation in these firms varies and depends on the time elapsed from the instant of privatization, the state at the time of privatization, human resources situation, as well as the plans and ambitions of the new owners. The best firms have already activated the existing technologies and they are on the way to return to the former volume of the production. The others mostly engage in sawmill processing, while their works and energy installations are still in the reconstruction phase. At the moment, they dispose of surplus wood residue which might be used for production of solid biofuel. In addition, these firms dispose of a certain quantity of stacked wood which they have pulled out of the forest together with the logs, and which they are now selling to the population and other enterprises. It is important to remark that the quantities of wood residue and stacked wood for selling will be decreasing, due to increasing degree of material use in the wood industry.

The wood residue in the wood processing is divided into: bulky, tiny, and bark. Table 3.3.2 represents the data on the proportion percentage of the residues at wood processing in different technologies of the latter. These percentages do not include the bark and a part of the wood residue which is specially designated for different reasons and cannot be used (scatter, shrinking, and similar).

Table 3.3.1: Available wood residue in wood processing (average values)

Wood processing technology	Typical final product [%]		Available wood waste [%]	Losses* [%]
Sawmilling broadleaves	Sawn timber	50	43	7
Sawmilling conifers	Sawn timber	65	30	5
Veneer production	Veneer	47	45	8
Plywood production	Plywood	41	53	6
Particleboard production	Particleboard	90	5	5
Final processing of wood	Furniture	35	65	–

* The wood residue that for different reasons cannot be used (scatter, shrinking, and similar)

Each mechanical or chemical processing is directed to production of certain assortments and products and it has its production balance with respect to the input raw material. When calculating the available wood residue, it has been assumed that all the available technical wood is processed only into sawn timber. Wood residues from the production of veneer, panels, furniture, joinery, etc. are excluded from the calculations. In these enterprises there is usually a balance between the technological needs of thermal heat and energy potential of wood residues that occur there [11]. Amounts that remain are low and decrease with increasing degree of finalization of these plants.

The values in the tab. 3.3.2 have been obtained on the basis of the previously given assumption in calculating the energy value of forest biomass.

Table 3.3.2: The assumed energy value of the wood residue in the sawmills in 2007 [11]

Wood species	Volume of the wood residue [m³]	Mass volume [t]	Available heat [GJ]	Equivalent tonnes of oil
Broadleaves	47 420	42 678	422 515	10 060
Conifers	55 176	32 333	340 789	8 114
Total	102 596	75 011	763 304	18 174

The available quantities of the wood residue from forestry and the primary processing are not particularly large (see tab. 3.3.3).

Table 3.3.3: The assumed energy value of the wood biomass from forestry and the sawmills in Montenegro in 2007 [11]

Origin	Volume [m³]	Available heat [GJ]	Equivalent tonnes of oil
Forestry	301 684	2 364 806	56 305
Wood processing	102 596	763 304	18 174
Total	404 280	3 128 110	74 479

Besides, it is almost evenly distributed across the whole territory of the area considered. An exception is Pljevlja where almost 30 % of the total residue from the primary processing of wood is concentrated. All this should be taken into account when making potential plans about its utilization.

The wood processing industry in Montenegro is one of the oldest sectors in the country. In the last over 130 years it went through interchanging development and stagnation periods which merely depended on the different social circumstances in the observed time.

The wood industry of Montenegro was until 1989 characterized with significant product capacities for the sawmill industry, manufacture of veneer, wood-based panels and final processing of wood. The major number of companies was registered in the north and north-east part of Montenegro in the areas with the most wood resources.

The present-day wood industry sector in Montenegro is made up of 90 % of primary and secondary production and 10 % of the final production. Cut timber, plywood boards, slabs, latoflex slats, laminated three-sided billets, ship`s floor and paneling are the main products of primary wood processing.

The total number of companies in the wood industry in Montenegro in 2012, according to data from MONSTAT, amounts to 400. In the sector wood processing and wood products there were 313 entities registered, and in the furniture production there were 87 active companies. In relation to the manufacturing industry 20.4 % of the total number of companies was in the wood industry in 2012 [12].

According to the "Development Strategy of the Manufacturing Industry in Montenegro", the wood industry, which in most of the strategic and planning documents is marked as one of the strategic areas, which together with tourism and agriculture should present the main development driver of Montenegro. "It is expected that during the process of structure changes in the wood industry of Montenegro (numerous) small companies will vanish whose business philosophy is based on the principle "selling wood raw materials (any of them) without processing".

The assessment of the roundwood and primary residue potentials in S2BIOM was made by using the EFISCEN model and using national forestry inventory data as an input. The secondary forestry residues from saw mills and wood processing industries build on the potentials assessed in EUWood and S2BIOM in combination with some updated data from national sources.

Primary and secondary biomass potential from forests and wood processing industry in Montenegro in 2020 is presented on Table 3.3.4.

Table 3.3.4: Primary and secondary biomass potential from forests and wood processing industry in Montenegro in 2020, Source: S2BIOM (Dees et al., 2018, see also Annex II for explanation on approach)

	Primary biomass potential from forests [kt of dry mass]	Secondary biomass potential from wood processing industry [kt of dry mass]
Biomass potential	1 003.47	83.90

3.4 Summary and conclusions in relation to SWOT elements

Table 3.4.1 summarizes SWOT elements in relation to biomass supply from forestry.

Table 3.4.1: SWOT elements in relation to biomass supply from forestry

Strengths • Significant biomass potential regarding large forest area relative to the total country area, • Accessibility of unused land for growing the fast-growing plantations for energy use, • Decrease in CO emissions, • Support of development of forestry and wood-processing industry, • Generation of significant amount of energy from RES, • Generating energy surplus • Proximity to raw materials • Availability of medium and high skilled labor force • Excellent wood quality	**Weaknesses** • Dominant ownership structure, with unsatisfactory proportion of forest ownership. • Lack of research of bioenergy resource potential, • Very poorly developed forestry, • Very poorly developed wood-processing industry • Lack of own financial resources, • Lack of program for potential investors, • Lack of adequate regulatory stimulation, • Lack of knowledge and public information about energy potential of biomass Opportunities Threats • Low level of processing • Obsolete technology • Lack of funding • Inadequate design capabilities • Little diversity of products
Opportunities • Improving energy stability, • Direct replacement for fossil fuels, • Export of energy, • Increase of national product: • New employment options • Development of local businesses • Use of investment from Kyoto protocol • Market proximity	**Threats** • Fossil fuel might be cheaper • Intensive energy generation from: sun, wind or geo potential • No conducive concession system • Poor road infrastructure for transport

4 Biomass supply: Waste

4.1 Introduction

The institutional framework for waste management in Montenegro is organized at the state and local levels (there is no regional governance level in place). The Sector for Environment and Spatial Planning, located within the Administration for Inspection Affairs, and communal inspectors are responsible for the enforcement of sanctions relating to waste management. Communal inspectors are authorized to monitor local waste management companies and public utility facilities to ensure that they comply with the relevant laws and regulations [13].

In 2016, the total waste generated in Montenegro by all economic activities and households amounted to 1 685 006 tonnes [13]. When expressed in relation to population size, the average, 2.7 tonnes per inhabitant of waste excluding major mineral wastes was generated in 2016. The share of different economic activities and of households in total waste generation in 2016 is presented on Figure 4.1.1 [13]. In the Montenegro, construction contributed 37.4 % of the total in 2016 and was followed by mining and quarrying (19.2 %), energy (18.1 %), households (13.5 %) and other economic activities (9.9 %); the remaining 1.9 % was waste generated from manufacturing. The waste generation by waste category is shown on Figure 4.1.2 [13]. Mineral and solidified waste is dominant (75.5 %), followed by mixed ordinary waste (16.2 %), animal and vegetal wastes (3.6 %), common sludges (2.1 %) and all other categories are neglected.

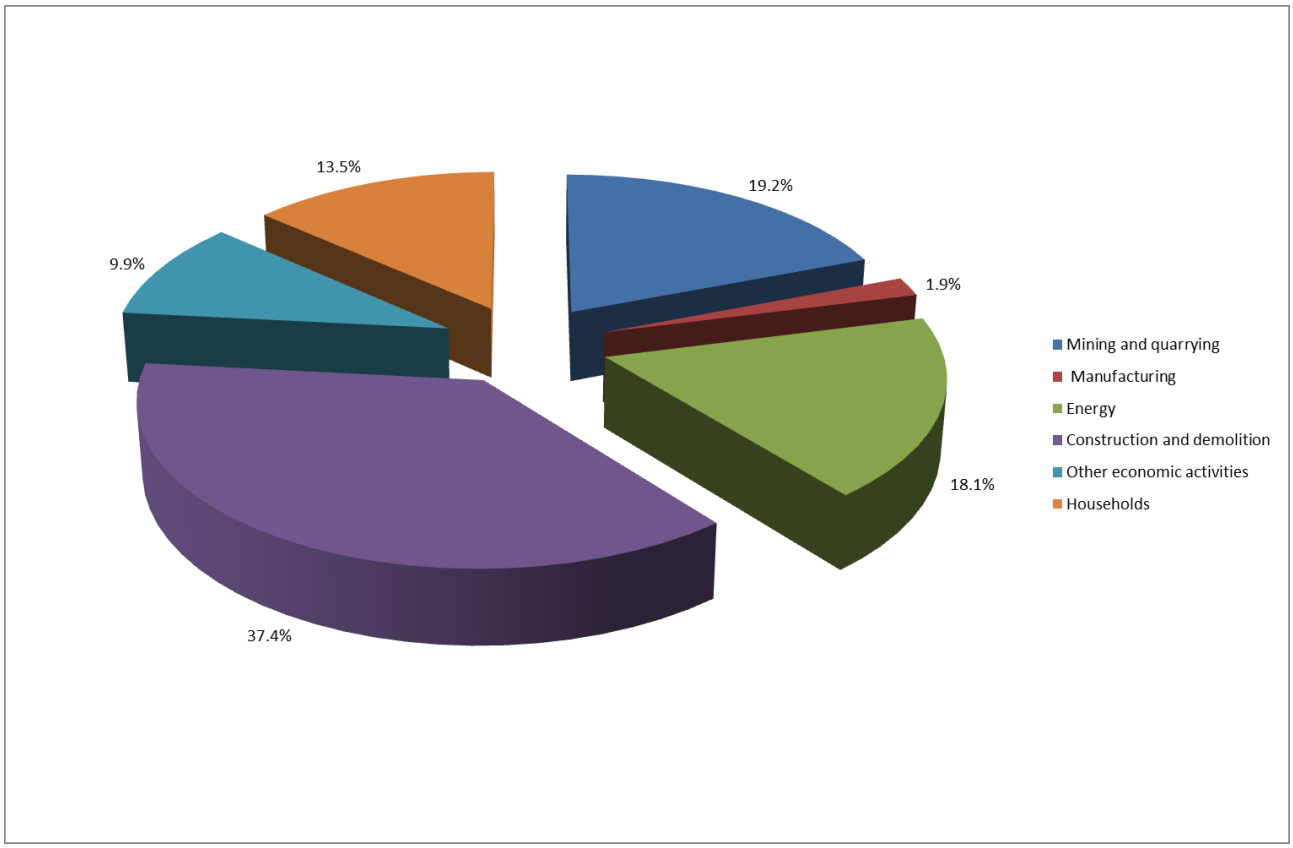


Figure 4.1.1: Waste generation by sector in Montenegro, 2016 year [13]

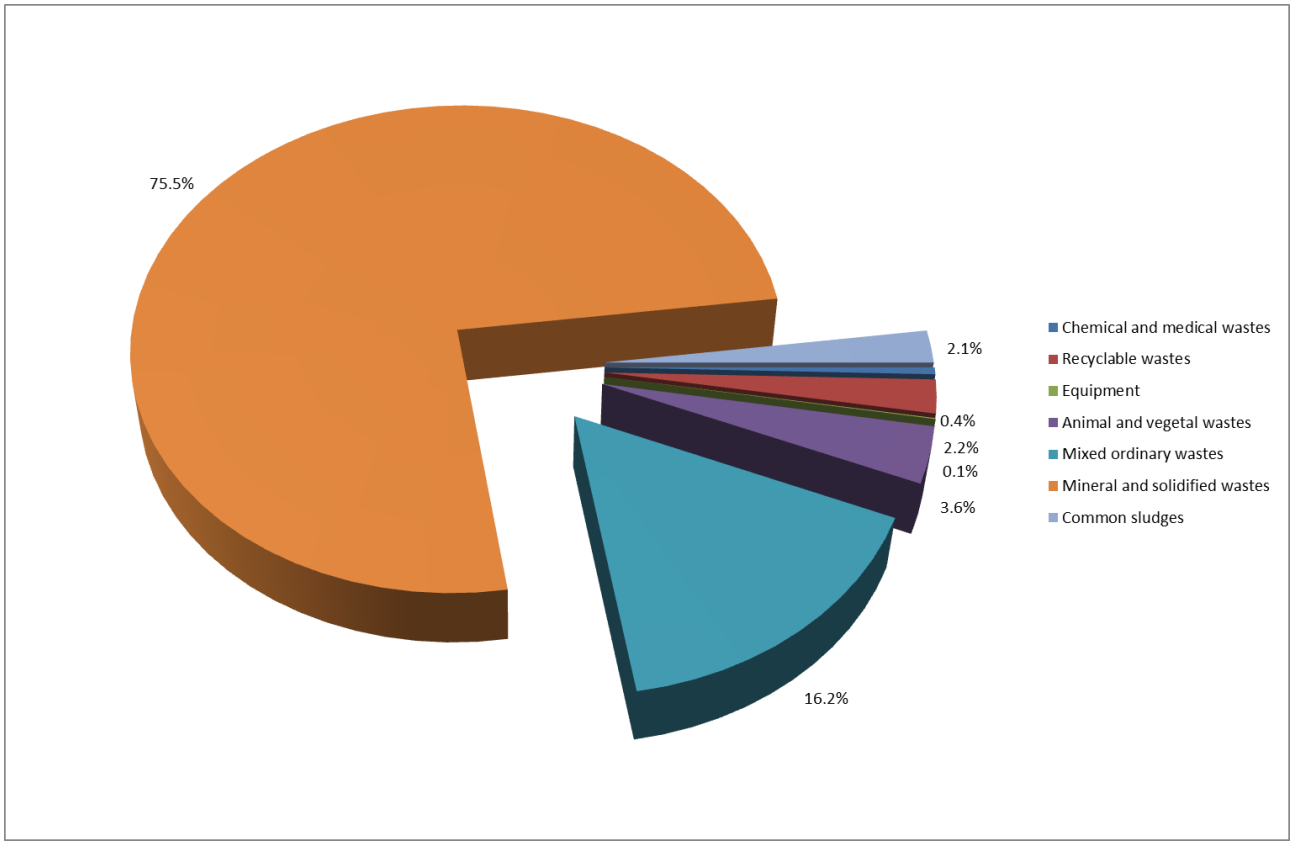


Figure 4.1.2: Waste generation by category in Montenegro, 2016 year

4.2 Waste from biological resources

There are two national lists of waste in Montenegro, which are harmonized with the EU list of wastes and the Basel Convention annexes with a few additions.

In Montenegro, data on waste generation are mainly based on several sources [14]:

- Local government reports supplemented with Ministry estimates where municipalities have not submitted data;
- Ministry reports on the implementation of the National Waste Management Plan;
- Modelled estimate – model estimates are from the design plans for the Lovanja and Livade landfill sites;
- MONSTAT - Statistical Office of Montenegro.

The overview of data from different sources is shown in the Tables 4.1.1 and 4.1.2 [14].

Table 4.2.1: Estimates of Annual Waste Generation

Data Source	Annual Waste Generation (tonnes)			
	2010	2011	2012	2013
Local government reports supplemented with Ministry estimates where municipalities have not submitted data	262 700	360 000	280 774	Not specified
Ministry reports on the implementation of the National Waste Management Plan	262 700	260 000	216 938	243 941
Modelled estimate	212 216	214 229	215 232	216 004

Table 4.2.2: Data on Collected Municipal Waste from MONSTAT

Year	2010	2011	2012	2013	2014	2015	2016
Number of municipalities collecting the waste	21 (of total 24						
Total annual quantities of generated waste – tonnes	464 617	329 610	297 428	279 667	286 378	330 433	326 477
Number of households covered by waste collection				622 008	622 777	621 521	622 099
Total annual quantities of generated waste – kg/per capita					514	532	525
Total annual quantities of collected municipal waste – tonnes					288 387	303 758	303 697
Total annual quantities of collected municipal waste by Public utility enterprises – tonnes					284 365	286 886	293 842
Total annual quantities of collected waste – tonnes					286 378	286 886	
Total annual quantities of collected municipal waste by enterprises and natural persons – tonnes					4 022	16 872	9 855
Total annual quantities of collected municipal waste – kg/per capita					464	489	472

Data presented in the tables differ greatly from several reasons [14]:

- The quality of data on the quantities of municipal waste generated in a large number of municipalities is not reliable. This is because data is not regularly recorded and the professional staff dealing with waste estimates does not have the necessary capabilities. In many cases, data reported by municipalities are not correct, and are adjusted using the responsible person's judgement in the Ministry of Sustainable Development and Tourism.;
- Data obtained from municipalities differ greatly from data supplied by the Ministry, due to differences in methodologies. For the purposes of the National Waste Management Plan, for the year 2012, further analysis of available data was carried out in order to better determine the amount of waste produced. The calculation methodology was taken from the Report on the Implementation of the National Waste Management Plan, and used official population data, and data on the number of overnight stays by tourists. The waste data presented in the above-mentioned report is based on an estimated amount of waste generated per day of 0.86 kg per citizen, and 1.86 kg per tourist. These data were obtained from analysis of the Strategic Master Plan for Waste Management at national level, but are also based on the experience gained during the operation of the municipality landfills Lovanja and Livade, as stated in the report.;
- MONSTAT data is collected through an annual survey. This survey provides data on the public collection and separation of waste by municipalities, the source of collected waste, the treatment of waste collected and equipment and machinery. It is not clear whether any attempt has been made to estimate waste generated by those – mainly in rural areas - who are not served by a waste collection service, or to factor in waste that may have been dumped illegally. If the survey simply reports on what has been collected, then notwithstanding the fact that the reporting of this may not be perfect, the figures might underestimate total waste generation.

It is possible to conclude that currently in Montenegro there are weak waste management systems implemented at the level of the municipalities (absence in most of the cases of weighbridge facilities to allow the accurate determination of waste flows and a shortage of reliable composition data) and there are major difficulties associated with solid waste data collection and processing. These lead to generation of big

uncertainties in the input data for current waste generation. Estimation of the municipal solid waste is generally carried out assuming that waste is generated mainly by two sources:

- Household waste – waste generated in households by domestic activities;
- Non-Household municipal waste – waste of a similar composition of household waste but generated in:
  - Commercial activities – e.g. shops, offices, restaurants;
  - Industry – e.g. waste from factories (canteens, offices) – non-hazardous waste of comparable composition;
  - Institutional – similar waste from institutions such as educational establishments, healthcare facilities, governmental institutions etc.

The latest official data published by MONSTAT are shown in the Tables 4.1.3 and 4.1.4 [15, 16].

Table 4.2.3: Collected and generated quantities of municipal waste in Montenegro, 2011 – 2017 (tonnes)

Year	2011	2012	2013	2014	2015	2016	2017
Municipal waste collected by Public utility companies	285 061	268 669	275 864	268 083	277 781	280 988	282 282
Municipal waste collected by enterprises and natural persons	1 581	1 836	2 474	4 107	6 251	10 768	10 480
Total quantities of collected municipal waste	286 642	270 505	278 338	272 190	284 032	291 756	292 762
Quantities of waste from citizens who are not included in the public collection system of municipal waste	38 412	36 307	30 228	28 596	28 678	30 504	31 393
TOTAL	325 054	306 812	308 566	300 786	312 710	322 260	324 155

Table 4.2.4: Data on municipal waste

Year	2017	2018
Number of municipalities collecting the waste	23	23
The estimated population	622 373	622 227
Average number of days in year of collecting the waste	337	341
Total annual quantities of produced municipal waste, t	324 155	330 839
Total annual quantities of produced municipal waste, kg/per capita	520.8	531.7
Total annual quantities of collected municipal waste, t	292 762	303 107
Total annual quantities of collected municipal waste by Public utility enterprises, t	282 282	291 431
Total annual quantities of collected municipal waste by enterprises and natural persons, t	10 480	11 676
Total annual quantities of collected municipal waste, kg/per capita	470.4	487.1

According to the data presented in the Ministry reports on the implementation of the National Waste Management Plan for 2013 year, it is possible to determine the distribution of waste by municipalities (Table 4.1.4 [17]).

Table 4.2.5*: Data on municipal waste*

Municipalities	Quantities of waste generated (tonnes)	Share in total amount of waste (%)
Andrijevica	1 186	0,49
Bar	24 000	9,84
Berane (including Pljevlja)	9 928	4,07
Bijelo Polje	12 053	4,94
Budva	23 100	9,47
Cetinje	6 080	2,49
Danilovgrad	4 658	1,91
Herceg Novi	18 521	7,59
Kolašin	2 300	0,94
Kotor	12 500	5,12
Mojkovac	2 240	0,92
Nikšic	20 359	8,35
Plav (including Gusinje)	3 430	1,41
Pljevlja	8 532	3,50
Plužine	1 173	0,48
Podgorica	66 602	27,30
Rožaje	5 910	2,42
Šavnik	517	0,21
Tivat	8 100	3,32
Ulcinj	11 625	4,77
Žabljak	1 127	0,46
Total	243 941	100,00

Municipal waste compositions have been calculated for three major areas of the country, and for urban and rural settlements. It should be noted that the prognosis assumes that waste composition and generation rates are different in three "residential categories" – dense urban (dense, predominantly apartments and other dwellings without garden areas), urban (medium density, detached and semi-detached houses with gardens), rural (low density, detached, large gardens). The Table 4.1.6 indicates a range of waste compositions for municipal waste across the country [14].

Table 4.2.6*: Municipal Waste Composition in Montenegro (%)*

Type of waste	Centre			North		Coast	
	Densely Populated Urban	Urban	Rural	Urban	Rural	Urban	Rural
Organic	35.11	35.59	33.67	30.37	22.49	31.89	33.69
Paper and paperboard	12.34	16.18	10.33	10.44	15.18	14.23	9.02
Glass	10.91	4.18	4.74	10.44	9.02	6.41	6.17
Heavy metals	1.19	0.95	0.71	0.47	0.47	1.78	0.47
Non-ferrous metals	1.28	1.90	0.95	2.37	0.76	2.33	2.85
Wood	2.61	1.80	3.84	1.42	2.47	2.45	4.27
Composition packing	4.51	6.17	8.54	2.66	3.32	1.59	1.42
PET	4.74	6.17	8.54	2.66	3.32	1.59	1.42
Plastic	10.07	12.00	10.50	15.47	19.37	9.85	12.34
Textile	2.61	1.66	3.13	0.95	1.80	3.75	6.64
Inert waste (shot, etc.)	2.73	2.73	2.37	1.78	1.42	2.26	1.81
Hazardous waste	0.59	0.56	0.59	0.56	0.72	0.59	0.56
Green waste	0.87	1.04	1.21	1.66	1.92	0.69	0.77
Other	6.07	7.26	10.83	11.39	11.39	11.39	9.49

In National Waste Management Plan 2014-2020, based on the made assumptions, the forecast of municipal solid waste has been shown (Figure 4.2.1 [17]). Projections of municipal waste into the future have been made in the National Waste Management Plan. The main factor used appears to have been assumed changes in

population, based on projections of the Statistical Office of Montenegro. Other factors appear to have been used to estimate the waste arisings over time in the different regions, with the projection indicating an increase of waste from 256kt in 2016 to 359kt in 2036, an average compound rate of growth of 1.7% per annum [13].

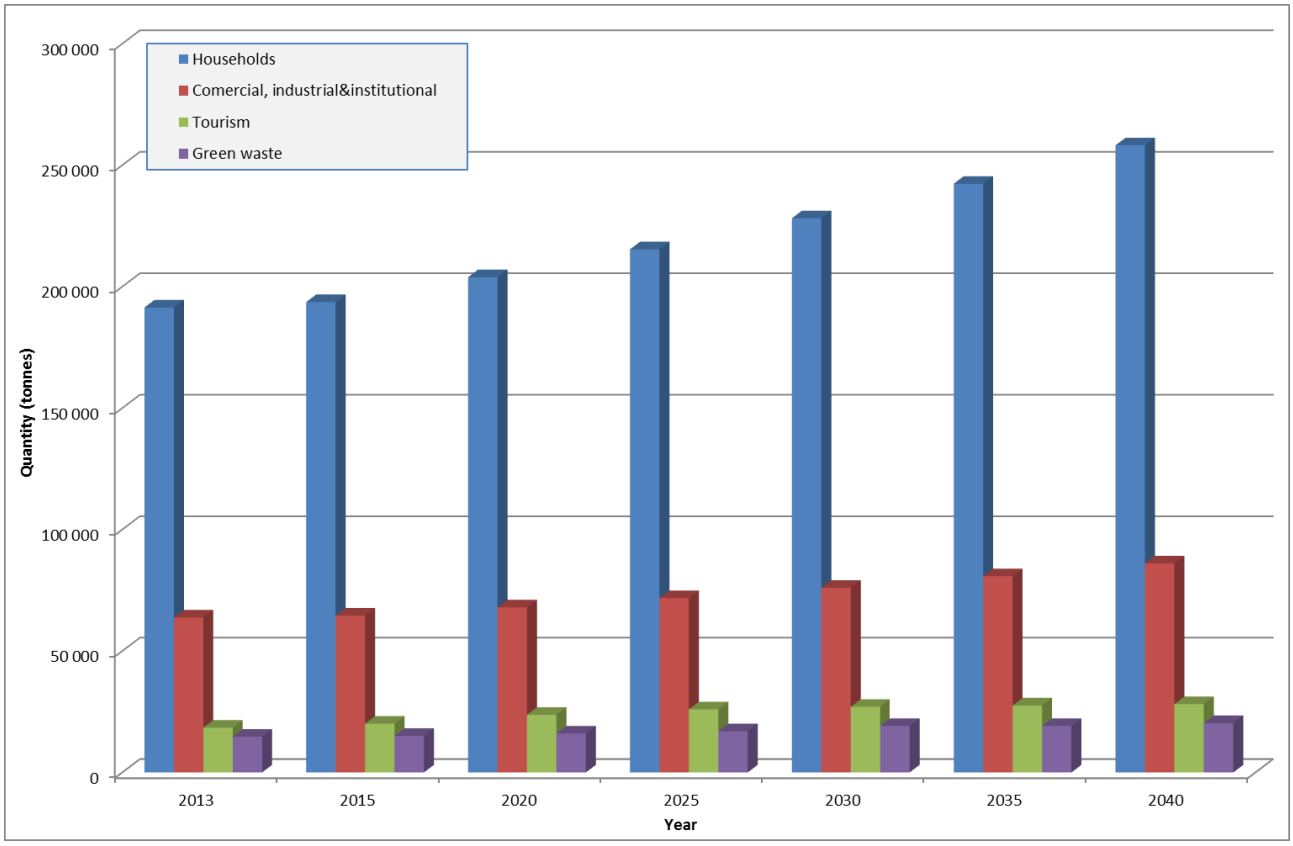


Figure 4.2.1: Montenegro's MSW generation

4.3 Current waste treatment and unused potentials estimates

The Waste Management Law requires the establishment of systems for separate collection of primarily separated waste components, such as paper, cardboard, metal, plastic, glass, and biodegradable waste. Collection of municipal solid waste is the obligation of local governments. In all municipalities in Montenegro, this activity has been entrusted to public utility companies registered for waste management activities and owned by the municipalities, but operated as separate legal entities. Every public utility company has a certain number of containers and bins needed to complete the collection, followed by the transport and disposal [18].

The data indicate that the public utility companies in the municipalities of Montenegro are equipped rather well, but there is some unevenness between municipalities in terms of number of equipment which is noticeable. In the following years it is necessary to equalize the status of equipment by municipalities.

The total amount of waste collected on the territory of Montenegro during the year is 89% (Table 4.3.1 [19]). According to data provided by the Ministry of Sustainable Development and Tourism, national targets of waste collection for 2017 are between 65 to 95% depending on the municipalities. According to the Report on implementation of State Waste management plan for 2017, around 20% of waste is disposed on temporary landfills while most of waste (61%) is disposed on sanitary landfills in Bar and in Podgorica [20].

This project received funding from the BBI JU under the EU Horizon 2020 research and innovation programme under grant agreement No.838087

Table 4.3.2 shows the quantities of waste collected by public utility enterprises in Montenegro broken down by the 4-digit chapter codes of the List of Waste [13].

There are 155 small unregulated landfills/dumpsites (under 100 m³) 68 medium unregulated dump sites (under 100-1000 m³) and 50 bigger than 1000 m³ across the country. Approximately 60% of total waste collected in the country end up in those unregulated landfills.

Table 4.3.1*: Quantity of Collected by Public Utility Enterprises*

Municipalities	Quantities of waste collected (tonnes)	Share in total collected waste (%)	Primary separated waste (tonnes)	Secondary selected waste (tonnes)	Total selected waste (tonnes)
Andrijevica	700*	60			
Bar	21 891	91	526.0		2.50
Berane (including Pljevlja)	7 942*	80	13.0		0.16
Bijelo Polje	12 053*	80			
Budva	22 492	95	419.0		1.90
Cetinje	4 864*	80			
Danilovgrad	2 950	63			
Herceg Novi	16 838	91	651.7		3.90
Kolašin	2 150*	93			
Kotor	11 820	95		397.0	3.40
Mojkovac	1 442*	64			
Nikšic	18 000*	88			
Plav (including Gusinje)	1 715*	50			
Pljevlja	7 000*	82			
Plužine	625	53			
Podgorica	64 125	96	1 178.4	2 170.0	5.30
Rožaje	2 955*	50			
Šavnik	500*	96			
Tivat	7 993	96	251.0	203.0	5.68
Ulcinj	9 328*	80			
Žabljak	850	75			
Total	218 233	89	3 039.1	2 570.0	22.84

Table 4.3.2*: Municipal Waste Collected by Public Utility Enterprises (tonnes)*

Waste Stream	2013	2014	2015
Packaging (15 01)	919	654	858
Separately collected fractions (20 01)	23 628	21 173	20 831
Waste from gardens and parks (20 02)	33 640	41 987	37 358
Other municipal waste (20 03)	226 178	223 072	234 825
Total annual quantities of collected waste by Public utility enterprises	284 365	286 886	293 842

The waste management infrastructure in Montenegro is still under developed. Its development is part of the new National Solid Waste Management Plan. There are currently 9 recycling yards (6 in Podgorica, 1 in Herceg Novi and 1 in Kotor), 4 material sorting facilities (in Podgorica, Žabjlak, Kotor and Herceg Novi), and 2 sanitary landfills (in Podgorica (Livade) and Ulcinj Municipality (Mozura) [20].

According to the last Strategic Master Plan for Waste Management it was planned to construct regional landfills in Kotor, Nikšić, Berane, Bijelo Polje, Pljevlja Herceg Novi (approximately 70 million euros) [20]. The government has announced its new plan in May 2018: it will consists of operating 4 waste management centers (Podgorica, Nikšić, Bijelo Polje and Bar) giving them the choice of having a Recycling Center (MRF Plant) and/or a waste treatment plant for separate and controlled disposal of construction waste, and/or a

waste heat treatment plant and/or a sanitary landfill. The choice is being left to each waste management center to select the most appropriate solution depending on their needs and their budget. State waste management plan is also proposing two containers system that includes "dry" and "wet" containers.

Currently less than 2-3 % of Montenegro's waste is recycled [20]. The goal set in the National Solid Waste Management Plan for 2017 was 25% and for 2020 is 50 %. The current objective is to increase recycling in all municipalities as much as possible, regardless of the set goal. Municipalities have set their target for 2017 between 0.8 % and 8 % of waste recycled/waste produced, with more than half with only 0.8 %. According to EuroStat, only 1% of municipal waste was recycled and 0% was composted in 2013 in Montenegro [13]. According to the more recent Report on the implementation of State Waste management plan of Montenegro the total amount of the collected recyclable waste is 10% of total collected waste throughout the 23 municipalities [20]. Additional investments are needed to increase the recyling rate

4.4 Summary and conclusions in relation to SWOT elements

Main challenges in municipal waste management in Montenegro are:

- the topography of Montenegro (mountainous country)
- the sparse and poor rural population
- the lack of current adequate waste management infrastructure
- the low budget of municipalities allocated to waste management
- the lack of channels to sell recyclables
- the lack of awareness regarding the impact of unregulated waste land-filling
- the local practices of outdoor waste incineration
- the lack of (human and financial) resources at national level.

The other problems related to municipal waste management are [22]:

- Dependence on foreign donors for investment in infrastructure
- Low level of cooperation among municipalities
- Lack of public involvement in waste separation
- Weak domestic market for recyclables, so most secondary raw materials need to be exported, decreasing the profits from their sale
- Lack of political will and low levels of coordination
- Failure to enforce legislation
- Lack of active engagement by stakeholders in taking up their tasks and responsibilities.

Although Montenegro has undergone significant changes in recent years, and the infrastructure for municipal solid waste (MSW) has been improved, the waste management system continues to lack financial resources as well as data delivery.

Initiatives taken to improve municipal waste management encompass:

- 2008 pilot project 'Separate waste collection'
- IPA 2009 Procurement of equipment and vehicles for public utility companies
- 2013 programme 'Every can counts'
- 2012 Regional landfill for Bar and Ulcinj
- 2014 Montenegro industrial waste management and clean-up project

The possible future trends will include the following [22]:

- Achieving the highest level of selective collection of waste and organizing non-sanitary landfills
- When it comes to municipal waste, the focus should be on primary selection, bringing it closer to the population, to raise the awareness of the public about the necessity of taking such action and all the benefits that it brings.

Table 4.4.1 summarizes SWOT elements of waste sector in Montenegro.

Table 4.4.1: SWOT analysis in relation to waste sector in Montenegro

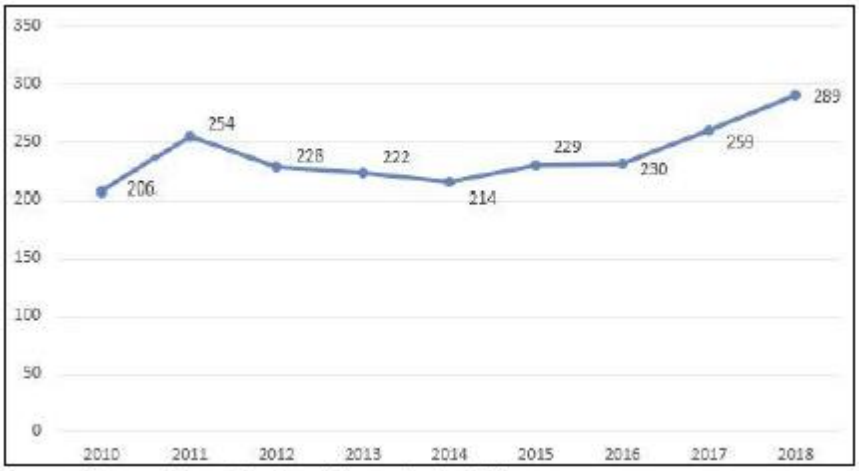
Strengths	Weaknesses
• Landscape (coast, mountains) • Tourist centers (e.g. The Bay of Kotor, Ulcinj) • Preventive and improved environmental protection • Recycling • Increasing awareness of environmental protection • Existence of national waste management strategy; • Adopted key laws on waste management harmonized with EU Directives; • Existing of recycling yards and sanitary landfills; • Unused potential for waste recycling	• Lack of sufficient infrastructure for treatment and disposal of waste • Absence of facilities for treatment of hazardous waste • Ununiform waste collection • Degraded areas due to inadequate waste disposal • Absence of organized collection and disposal of waste in rural areas • Lack of accurate data on quantity of waste
Opportunities	**Threats**
• Introduction of the EU waste management standards • Integration process and use of the EU and other funds • Reduction of industrial waste generation • Expansion of network infrastructure • Contribution to employment and opening of new jobs • Charging by quantity of generated municipal waste	• Lack of investment for development of waste management infrastructure • Capacity Planning • Insufficiently developed public awareness of necessity to treat waste properly • Environment as a public good, is in constant conflict with growth • Inability of citizens to pay the real, economic price for municipal services

5 Bio-based industries, products and markets

The beginning of the 21st century was characterized by three phases of reforms in the industry [50]:

- the first phase consists of privatization, internal pricing liberalization policy and external economic liberalization, macroeconomic stabilization;
- the second phase included imposing of its own legal system, the creating and strengthening of new institutions necessary for the regulation of the market, improving of the business environment and the adoption of international standards, as well as the co-ordination of economic policies;
- the third or the "current" phase assumes the total reintegration into international economic relations, which will be ended in the process of EU accession.

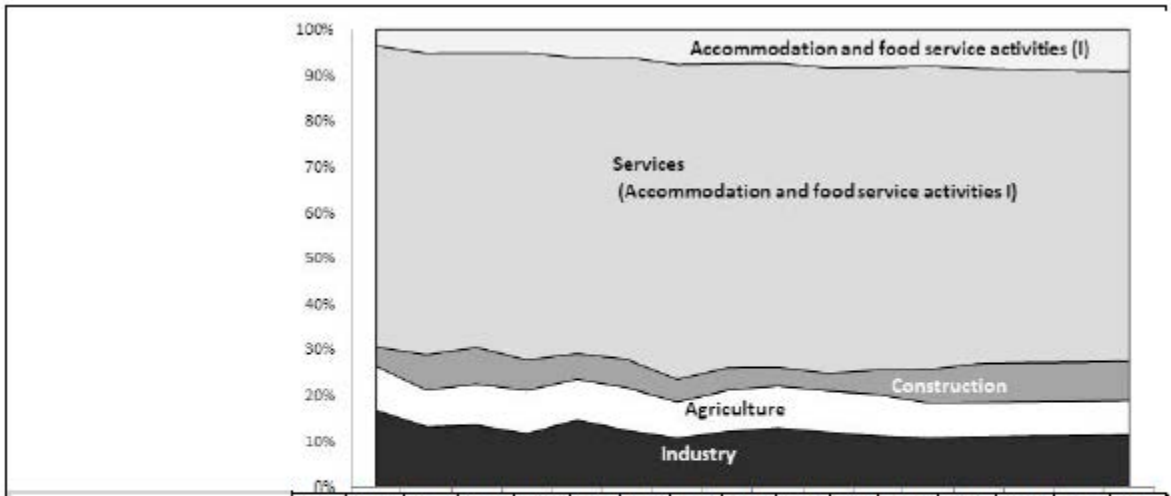
Industrial production, observed in absolute amounts, has in recent years recorded uniform values, with certain smaller oscillations, caused by movements within the industrial structure itself. Growth in the share of industrial production in the GDP for the year 2018 is the result of higher production activity especially in the Manufacturing Sector and in the Electricity Supply Sector (Figure 5.1).



Source: Monstat, The national statistics authority of Montenegro

Figure 5.1: Industrial production of Montenegro

Figure 5.2 points to the gradual changing of the structure of the Economy of Montenegro, from the „over industrialized" and "rigid" economy (economic structure) in the Yugoslav market to the gradual building of open, service oriented economy, with EURO as the official currency which is significantly dependent on external demand with the development model based on the growth of foreign direct investments (FDI) and strengthening of the service sector (which has the highest employment rate growth). This trend is also confirmed when the period after the renewal of independence is monitored.



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019*	2020*	2021*
Agriculture, forestry and fishing (A)	10%	8%	9%	10%	10%	10%	9%	10%	10%	10%	10%	8%	8,2%	8,2%	8,2%	8,2%
Industrial production (B, C, D, E)	17%	14%	14%	12%	15%	13%	12%	13%	14%	13%	12%	11,6%	12,4%	12,2%	12,3%	12,5%
Construction (F)	4%	8%	8%	7%	6%	7%	5%	5%	5%	4%	6%	8%	9%	9%	9%	9%
Services (excluding sector I)	68%	70%	68%	71%	69%	70%	75%	72%	72%	73%	72%	72%	70,5%	70,0%	69,6%	69,3%
Accommodation and food services activities (I)	4%	5%	5%	5%	7%	6%	8%	8%	8%	9%	9%	9%	9,3%	9,6%	9,9%	10,0%

Source: Monstat, The national statistics authority of Montenegro, 2019, PER 2019-2021

Figure 5.2: Structure of industrial production of Montenegro

The participation of sectors B, C, D and E (industrial production in the narrow sense of meaning) continues to record a decreasing trend in gross value added (GVA), from 17% in the year 2006, which "stops" at 12.4% in the year 2018 (the manufacturing industry is reduced from 9% to 5% within that structure). The projections of the Ministry of Finance in the Economic Reform Programme in the medium-term period indicate a 12.5% share of industrial production, in the structure of GVA by 2021. The service sector is constantly increasing until 2018, while the sectors of providing accommodation services and food services contained within show continuous growth in the medium term (up to 10% in GVA). Agriculture is consolidated at 8.2% of GVA share by the year 2021.

Diversification of industry presents a very important segment of further development, in which direction plans and projections of development should be moving towards the production of ecologic food and beverages, construction, financial services, and production of products with a higher degree of processing. The potential lies in investments to renewable energy sources, construction of energy efficient buildings, sustainable organic agriculture, which implies necessary support for ecologic innovations, improvement of energy efficiency and efficiency in using resources in SMEs and development of innovative entrepreneurial ventures in the field of information technologies and creative industries.

Wood and furniture industry

There are currently about 150 companies active in the wood industry of Montenegro (including companies and entrepreneurs engaged in furniture production), which have a share in the total industrial production of only 1.6 % and in the GDP of Montenegro of 0.16 %. By far the most companies or entrepreneurs are engaged in wood processing in sawmills. This is followed by plants for the production of mostly panel furniture. In the structure of companies engaged in wood processing, the representation of small companies is dominant.

Agriculture and tourism

The agriculture and tourism sectors offer a lot of opportunities for inclusive economic growth in Montenegro. Strengthening the linkages between tourism and agriculture in Montenegro is one of the most significant

income diversification strategies that promotes sustainable management of natural resources and viable economic development of rural areas. Linking the two sectors is a "hot topic" in Montenegro at present with many past and current roundtables, initiatives and projects focusing on this relationship, yet concrete impacts are elusive.

In December 2013, the Law on Organic Production came into force. This Law regulates the issues related to the general objectives and principles of organic production, production rules, on-farm production, labelling, control systems, inspection and penalty provisions. Despite the relevance of this certification in Montenegro, this label is not frequently used. According to the national certification body Monteorganica, the total number of organic registered producers is 172, of which 26 have received a certificate [55]. This limited number of registered and certified organic producers can be interpreted that many producers are not yet convinced or aware of the market benefits, as most producers are already using relatively minor amounts of pesticides and some agroecological methods.

There are several initiatives in place to improve the competitiveness of agricultural products in Montenegro and increase marketability, with the capability to enhance the linkage between agriculture and tourism [36]:

Slow Food BJELASICA&KOMOVI I PROKLETIJE	The Slow Food Network with their internationally recognized red snail logo is present in the northern region with a convivium of about 30 members with varied production (honey, medicinal herbs, dairy, meat, flours, fruits and vegetables).
Klaster PROBAJ DOMAĆE	Try Domestic is a formally registered cluster at Ministry of economy, which is based in Podgorica with members throughout Montenegro. The cluster was formed 10 years ago and currently has about 20 members, with some of the more successful members of the Slow Food convivium on the roster.
delicious MONTENEGRO	Delicious Montenegro is an interesting branding initiative and B2C platform that seeks to link producers to consumers interested in local foods. Originally formed with the support of UNIDO/UNDP, it is now based at the University Donja Gorica, with funding received from Horizon 2020 and through activities at fairs.
seljak.me	A young entrepreneur has developed the "Seljak" IT platform in 2018 with 20 000 members. Seljak is the first Montenegrin digital village that provides a simple market entry for all agricultural entities, either in the category of buying or selling business to business (B2B) and business to consumers (B2C), as well as links to technical assistance and services.

5.1 Current bio-based industries

Olive oil

Organic production of olives and olive oil in Montenegro is in its infancy, although there is a possibility for its intensive development in certain wider areas (e.g. Lustica and Valdanos) as well as in individual narrower localities. Currently, only one producer of organic olive oil and olives is registered, while three more are in transition.

In order to improve organic production, it is necessary to focus on the following issues: raising awareness and awareness of the benefits of organic production among olive growers, additional measures to encourage organic production (e.g. incentives per liter or kg produced), research and development of biological protection methods; research and use of biological insecticides, continuous monitoring of diseases and pests, education of local experts, development of the range of organic olive products, connection with the tourism industry, etc.

Olive growing

The number of modern oil mills with continuous olive processing lines is insufficient, while the use of traditional oil mills with hydraulic presses is still present, which negatively affects the quality of the final product. Olive processing in Montenegro has not been sufficiently modernized in accordance with international standards for the production of olives and olive oil, which also affects the quality of the final product. The olive fruit is processed into oil or canned for home use. Most of the yield is used to obtain oil. Olives for consumption are not grown to the required extent due to the collapse of existing production facilities ("Agroulcinj" from Ulcinj and "Primorka" from Bar). Olives obtained from trees that were planted for that purpose in the previous period, are today used for oil production, which means that their genetic potential has not been properly valorized. In addition, in Montenegro, no business entity is engaged in the cultivation of olives on plantations where all the necessary agro-technical measures are applied. Montenegro had a developed processing industry despite the fact that during the socialist era, production and the number of trees decreased. Olive processing facilities were mostly in the social sector, and the main representatives of that sector were oil factories in Bar and Ulcinj, i.e. in the centers where the largest purchase of olives took place, which greatly facilitated the purchase and transport on which the rational exploitation of olives depends. The capacity of these oil mills was as follows: Oil mill in Bar - oil extraction 2 t/h and Oil mill in Ulcinj - oil extraction 1 t/h

The premises in which the oil mills are located require further improvement in terms of sanitary and hygienic conditions, especially in terms of ventilation, temperature, maintenance of work surfaces, etc.

Storage capacities for olives before grinding are often inadequate, which adversely affects the quality of the final product. Storage capacity for olive oil after processing is also a limiting quality factor.

Representation of HACCP and other ISO standards in the sector of production, processing and storage of olive oil, table olives and other products is insufficient.

Harvest time and duration are also critical production points. Due to the insufficient number of available modern oil mills, it is common to "wait in line" and unnecessarily delay the harvest. In these conditions, the harvest often lasts for several months (even until March), so the quality of the oil is worse.

Insufficient share of extra virgin olive oil in the total amount of olive oil produced (about 11 %) clearly warns of the unsatisfactory situation in the sector.

Testing and determining product quality are segments that requires significant improvement.

The protection of geographical origin is a particular problem in terms of the future development of the sector.

It is necessary to improve the production of planting material, especially in order to form parent plantations in order to provide a sufficient amount of indigenous varieties and healthy seedlings.

Montenegro pointed out that in 2011, a yield of 1 600 tonnes of olives was recorded from 436 000 olive trees. Production is characterized by a low yield of 4.1 kg of olives per tree and 0.8 liters of olive oil per tree. Over 90 % of harvested olives are processed into olive oil. Olives are processed in 23 oil production plants.
Montenegro pointed out that, in the period 2007-2012, it implemented support measures for the reconstruction and revitalization of existing olive groves.

In Montenegro, on an area of 2850 hectares, 108 wineries annually produce about 17 million liters of wine, of which they export 5.7 million liters.
Large increase in new registered wineries is present, from four wineries in 2007 to 108 wineries in 2019. There is also a significant increase in the volume of wine production in smaller wineries, which is not visible in the global statistical presentation of the sector due to the dominance of Plantations.
Projects that have strengthened the position of Montenegro in the wine world are "Regionalization of wine-growing geographical production areas of Montenegro" and "Project of genetic identification of indigenous Montenegrin grape varieties".

5.2 Summary and conclusions in relation to SWOT elements

The main SWOT analysis findings considering the bio-based industries, products and markets are summarized in table 5.4.1.

Table 5.2.1: SWOT analysis of bio-based industries, products and markets in Montenegro.

Strengths • Landscape (coast for olives and fruits, mountains for grass and wood) • Availability of natural energy sources, especially renewable (hydro, solar and biomass) • High quality, preservation and soil fertility • Favorable climate for many types of production • Opportunities to build-up forest based BBE further	**Weaknesses** • Non-sustainable and material and energy non-efficient production • Much of the production is not competitively priced • Unfavorable age and social structure in rural areas • Administrative implementation
Opportunities • Expanding the capacity for processing agricultural products • Organic farming • Development of agriculture through tourism, additional food consumption	**Threats** • Low productivity, agricultural production, lack of modern technology and knowledge • Lack of planning and land use regulation • Lack of network infrastructure

6 Infrastructure, logistics and energy sector

6.1 Introduction

Apart from land borders entrances with neighboring countries, international access to and from Montenegro is possible from the port of Bar (with ferry services from Italy) and the international airports of Podgorica and Tivat (Figure 6.1.1 [23]). Effective and efficient transportation is obviously critical for the economic and social prosperity of the country. However, accumulated problems of the past, lack of funding for adequate infrastructure maintenance, transport limitations, traffic accidents, a non-competitive railway system, and insufficient usage of sustainable means of transport, as well as related deficiencies / restrictions, all contribute to a negative impact on Montenegro's socio-economic development. Montenegro is currently planning major overhauls of its road, rail networks, possible expansions of its air transportation system, and further valorization of its maritime system.

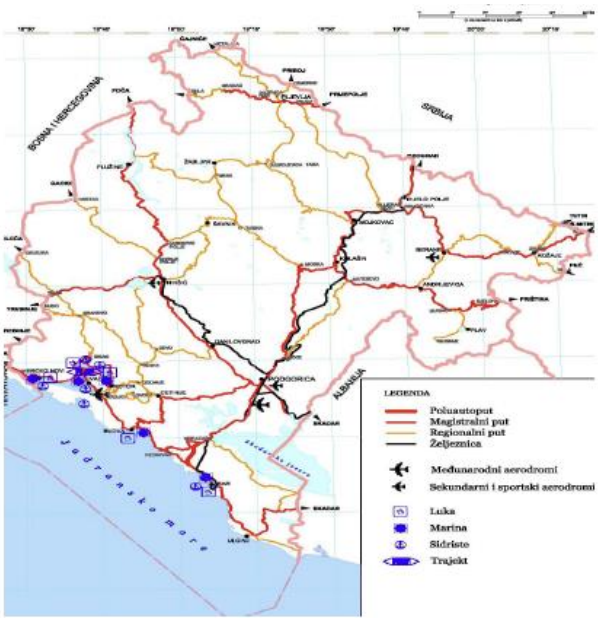


Figure 6.1.1: Transport map of Montenegro

A steady progress in market liberalization of the transport sector has been evident, with a pronounced initiative to be included in the EU Rail Freight Corridor, as well as in market opening on the Orient/East Med TEN-T Corridor.

The Memorandum of Understanding for the Development of the Basic Regional Transport Network in South East Europe (SEETO1 Memorandum) was signed in Luxembourg on June 11, 2004, by the governments of Montenegro, Croatia, Bosnia and Herzegovina, Macedonia, Albania, Serbia and Kosovo, as well as by the European Commission. Accordingly, Montenegro was a participant of this format and a full member, and in this way, it actively participated in regional cooperation, which is the cornerstone of the European Union's policy of action towards the Western Balkan countries in the field of transport. Further positioning of the Memorandum has been made possible through the application of Protocol IV on land transport within the framework of the Stabilization and Association Agreement between the European Communities and their Member States, on the one hand, and Montenegro on the other. The mission of the Memorandum was the cooperation on the development of the main and auxiliary infrastructure on the multimodal basic regional transport network in South East Europe and the improvement of policies in this area in order to achieve faster progress in development. The successor to this Memorandum will be the Treaty establishing the Transport Community (in the Western Balkans region), signed by the Prime Minister of the Western Balkans six in Trieste in 2017 [23].

The agreement on the establishment of a transport community (signatory parties from South-East Europe: Albania, Bosnia and Herzegovina, FYR Macedonia, Kosovo*, Montenegro and Serbia) shall serve the following purposes:

- Better and faster integration of transport markets;
- Better treatment of transport operators in a non-discriminatory manner in terms of their access to transport infrastructures;
- The desire of each individual South-East European (SEE) partner country to comply with its transport laws and related issues with EU law, including the future development of the Union's acquis;
- To provide significant technical support, including better addressing the challenges and needs of environmental protection and the fight against climate change;
- To enable the development of the transport sector in a sustainable manner;
- To ensure a more adequate view of the social dimension of the transport community and the establishment of a social dialogue structure among the JIE Contracting Parties;
- To support the resolve of candidate countries and potential candidates to come closer to the European Union and enforce its legal framework, especially in the field of transport.

6.2 Existing industrial hubs and harbors

The coastal zone of Montenegro is one of the most valuable national resources. The area has a high development potential which is of vital importance for the development of Montenegrin society. However, it is also characterized by complex relations between human activities and natural environment that often result in pronounced pressures on natural resources. The Law on spatial planning and construction of objects, coastal zone of Montenegro is defined as the area within administrative boundaries of Herceg Novi, Kotor, Tivat, Budva, Bar and Ulcinj municipalities [24].

Ports are divided according to purpose and type of maritime traffic:

- commercial ports - Port of Bar (renamed into Port of Adria) and Commercial Port of Kotor
- nautical tourism ports - marinas Luka Budva, Luka Tivat-Porto Montenegro and Nautical tourism port - marina Bar
- shipyard ports - Port of Bijela and shipyard port Bonići – Tivat.

In relation to the type of traffic, the ports are divided in two groups:

- the ports for international maritime traffic - Bar, Budva, Kotor, Tivat (Gat I and Gat II) and Zelenika,
- the ports for internal maritime traffic - Bar, Budva, Kotor, Tivat (Gat I and Gat II), Bonići - Tivat and Zelenika.

Pursuant to the Decision of the Government of Montenegro on the designation of ports by importance, for ports of national importance are determined [25]:

- Bar Commercial Port (port of Adria)
- Nautical tourism port - Marina Bar
- Commercial port of Kotor
- Shipyard port Bijela.

The fishing port of Njivice is no longer a port of national importance.

In the area of maritime transport (short-sea shipping, including ro-ro), services are provided by two big national companies – Barska plovidba ad and Crnogorska plovidba ad Kotor – and around a hundred of small companies that provide local transport services. Transport of goods and passengers on overseas lines has been on the decrease over the last years. In 2012, around 109 000 t of cargo and around 53 000 passengers were transported [24]. Maritime fleet was enlarged with two new ships (with the capacity of 35 000 DWT each) in 2012, but it still has a modest capacity.

The most important port is Bar (Port of Adria) with around 3 500 m of operating coast, and capacity of around 5 million tonnes of freight, while other ports have substantially lower capacity. The port of Bar is a transit Centre of regional importance. The ports of Zelenika and Kotor have for years represented important maritime centres

in the Boka Kotorska Bay. Recently built berth for mega yachts Porto Montenegro has become a new tourist symbol of the country. Shipyard Bijela is equipped for reparation and reconstruction of all kinds of vessels with the capacity up to 120 000 DWT. The shipyard is also equipped for construction of smaller navigation objects such as different-purpose barges, pontoons, work platforms and similar. Ports do not have equipment for reception and treatment of oily water and solid waste from ships. Due to insufficient equipment and inadequate environmental management procedures, ports and Bijela shipyard generate significant pressures on the coastal sea and sediments.

Port of Adria is a member of Global Ports Holding (GPH), a unique port group and operator of cruise and commercial ports (Figure 6.2.1 [26]). Positioned in the South East Adriatic Sea, Port of Adria has primacy to easily serve and be the first and main gateway for Montenegro, Serbia, Kosovo, Bosnia and Herzegovina to the international market. Port of Adria represents an important link in the intermodal transport chain in the region due to its integration with Bar-Belgrade railways and road transport network and an opportunity for establishing distribution centres for a range of product groups. Complete area of Port of Adria is under Free Zone regime and provides benefits in terms of exemption from customs duties, taxes and other duties.

Figure 6.2.1: Port of Adria

Port of Adria has an operating area of 518 790 m^2 and an operational quay of 1 440 m long [26]. The main parts of the Port of Adria are: Container Terminal, General Cargo Terminal, Timber Terminal, Ro-RO Terminal and Closed Open Storage Facilities. The main characteristics of the Port of Adria are shown in Table 6.2.1 [26].

Table 6.2.1: Main characteristics of the ports in Montenegro

Part of the Port of Adria	Characteristics
Container Terminal and Services	Terminal is equipped for unloading, handling and loading containers, stuffing and stripping of containers. All the activities are carried out both on open storages and in warehouses, depending on the goods and required handling methods. Key features: – Operational quay length of 1,5 km – 2 STSG container cranes – Maximum permissible draft 11,5 m – 270 Reefer plugs – Railway tracks reach every berth and warehouse.
General Cargo Terminal and Services	General Cargo Terminal is equipped for handling and dispatch of all types of general cargoes (palletized goods, food products, various metal products, coils, slabs, strips, pipes, bundles, other standard types of cargo). Key features: – Operational wharf 1 km – 7 berths – Storage capacity (warehouses) 76 732 m^2 – 2 Storage capacity (open area) 51 250 m^2.
Timber Terminal and Services	Key features: – Total Terminal area 5.800 m^2 – Railway tracks 4 x 120 m = 480 m – Storage capacity (open area) 45.000 m^2 – Storage capacity (covered area) 21.213 m^2 – Estimated annual capacity 100.000 m^3.
Warehousing Facilities and Services	12 closed warehouses with the total capacity of 76 732 m^2 and open storage with capacity of 163 389 m^2
RO-RO Terminal	Key features: – Total storage space: 49 120 m^2 – New-built Ro-Ro ramp for stern-ramp vessels, with 120t load capacity – Secondary Ro-Ro ramp on container terminal – Berths for Ro-Ro vessels 330m length – Complete area covered by CCTV, protective fences and security guards
Bar Cruise Port	Key features: – Possibilities of accepting cruises over 300 m – Significant capacity for further development of the port – Bus parking area is 4 000 m^2. Parking lots for 80 large buses – Project: 1.000 m^2 Terminal Facility

The port of Kotor is located next to the Adriatic Highway and it is connected with places along the coast, as well as with cities in the interior. The length of the operational shore at the disposal of the Port of Kotor in the port is 665 m [27]. Port of Kotor specializes in cruising tourism since 2006, enjoying the reputation of one of the busiest destinations in the Mediterranean. Located in Bay of Kotor, attractiveness of the site exhibits dynamics for developing a sustainable business trend. For a number of years, operator of the Port of Kotor has been Port

of Kotor JSC whose majority of capital is ownership of the municipality of Kotor, and its main activity is passenger traffic from ships for cruise travels via cruisers ships. At the end of 2009 Crnogorska plovidba JSC Kotor contracted the construction of two bulk cargo ships from Shanghai Shipyard Co., Ltd China via company POLY from China [23]. These ships are "handy" bulk carriers with the capacity of 35 000 tonnes , 179.90 m long, 28.40 m wide, with 5 warehouses, four cargo devices/cranes 30 tonnes each. Usage of the first ship Kotor started in January 2012, while the usage of the ship Dvadesetprvi Maj started in August 2012.

Montenegro has limited inland waterways transport, which is currently regulated under the same provisions as maritime transport [28]. An exception is Pivsko Lake, on which there are two ships used for the transport of persons from one shore to the other for the needs of the hydro-electric power plant Piva. Boats are registered in the registries of Harbor Master Offices in Bar and Kotor Montenegro has limited inland waterways transport, which is currently regulated under the same provisions as maritime transport. Lake Skadar and the connecting rivers (e.g. Bojana River) will have to be reclassified as inland waterway, the relevant EU legislation will have to be transposed, and a new body responsible for inland waterways will have to be established.

The business zones in Montenegro are defined as a unique entity in the area of local self-government, partly or fully equipped with infrastructure, which, in addition to the common space and infrastructure, provides potential investors with additional tax and administrative facilities from the state and local levels. Business zones are opened in 8 municipalities (Figure 6.2.2 [28]). Detailed overview of business zones is presented in Table 6.2.2 [28].

Figure 6.2.2: Business zones in Montenegro

Table 6.2.2: Main characteristics of business zones in Montenegro

Business zone	Characteristics
Berane	Business Zone Rudeš is situated along the Berane-Rožaje regional road. There is an access road and a good network of local roads. The municipalities of Plav, Andrijevica, Bijelo Polje, Rožaje and Berane set up the Regional Business Center and Business Incubator in Berane for the purpose of administrative and technical support to the existing and start-up companies.
Bijelo Polje	Nedakusi Business Zone is situated along the Belgrade-Bar regional road. The railroad runs through the Zone. The railroad cargo transfer center, town by-pass and bus station are all situated within the Zone. Some 74 000 m² of land is available for development and is equipped with roads. The Vocational Training Center is situated at 6 km away. The Business Zone includes retail business centers, banks, technology-production park of meat and baking industries, as well as concrete and textile factories.
Cetinje	First business zone was created in cooperation with the world-wide recognized artist Marina Abramovic. Business zone has 133,00 m² with great infrastructure and over 50.000m2 halls available to the investors. Business zone called "Cetinje II" is located next to the highway between Cetinje and Budva. It is spread on the 300.000 m² with very good transport links to the central and south part of the state, international airports in Tivat and Podgorica, Port Bar and Rail transport in Podgorica.
Kolašin	The Business Zone Bakovici site is unoccupied, relatively undeveloped and without infrastructure in place. It is situated in Kolašin industrial zone, 4 km away from the town center, along the Belgrade-Bar regional road. The local railway station is 5 km away. Several small-sized wood-processing companies are already operating in the industrial zone and a pellet factory will be opened soon. Major business activities are spring water bottling and wood processing. Major resources are: water (hydropower, bottling), forests, ornamental and construction stone.
Mojkovac	The Business Zone Babica Polje is partially equipped by infrastructure. It is located 2,1 km away from the town center. The business zone has excellent connectivity with other countries in the region: Serbia, Bosnia and Herzegovina, Croatia and Albania. Natural resources: arable land, the hydropower potential of the Tara River; biomass for pellets; forest reserves; lead and zinc mines.
Nikšić	The central location and good connectivity with the rest of the centers in Montenegro and the neighboring countries are some of the key factors for the development of this Business Zone. The E-762 international road is the transport lifeline of the Nikšić region. The Zone enables access to the regular railway and industrial siding; there is adequate infrastructure and a green buffer zone, as well as potential for expansion further to the west. "Technopolis", an innovation / entrepreneurship center, is to be built in order to foster the development of science and entrepreneurship. It is intended to function as a science and technology park, business zone and business incubator. The Municipal Strategic Development Plan identifies the following key drivers of development: metal processing, engineering industry, minerals, agriculture, wood processing and food industry.
Podgorica	The 280ha plot for the first Business Zone in Podgorica is situated at 10km from the city center, in the vicinity of Golubovci Airport and the Bar-Podgorica-Bijelo Polje main road, 1000m from Podgorica Airport, along the Belgrade-Bar railroad. The proximity of the Port of Bar (situated at some 50km from the site) is also a key advantage. The Business Zone comprises the existing facilities of the Podgorica Aluminum Plant (KAP), producer of non-ferrous metals with 600 employees.
Ulcinj	It is planned to develop the following zones: Industry zone (with an area of 36.74 ha), storage zone (9 ha) and service zone (2 ha).

Additionally, four additional municipalities expressed interest in establishing and registering the business zones [29]:

- Andrijevica - business zone "Most Bandovića" in within which it is planned to perform production and service activities. The zone is located along the main road Andrijevica-Berane.
- Plevlja – a spatial-urban plan is under development and the areas of the business zones will be precisely defined.
- Rožaje – municipality defined the business zone area few decades ago. In the meantime, in that area several factories were built and many of them are out of order. The infrastructure is good and there is the potential for new facilities.
- Danilovgrad – municipality has defined the following zones: agro-industrial zone (area on which large agro-production and agro-processing plants-farms, mills, plants for fodder production already exist) and additional 4 zones which will be developed in future.

The distribution logistics center and the headquarters of the Montenomaks is located in Danilovgrad on an area of 20 000 m². The company has 10 500 m² of a storage area – 7 000 m² in Podgorica and 3 500 m² in Danilovgrad [30]. Capacities are 10 000 pallet positions in modern high-pallet systems (PAL RACK) and 1 500 square meters of blocks for unpalletized goods. The warehouses are equipped with state-of-the-art warehouse equipment and WMS Gold technology including voice picking technology via voice commands - Pick by Voice - implemented in Podgorica. Due to the constant need of customers to adapt their products to consumer habits, Value Added Services - VAS has been established for the refinement and customization of a wide range of consumer goods, food, pharmaceuticals and technical products. This implies pasting of declarations and stamps, repackaging, marking, forming of commercial packages, making promotional and action sets. Depending on the client's needs, the goods can be stored for a day, week or month, after which they are transported to Montenomaks facilities by regular daily lines and then distributed to the end-user as soon as possible.

Logistic center VOLI - The area of the open logistics distribution center is 16 000 square meters [31]. The facility has 21 000 pallet places, 16 000 in ambient and 5 000 in cooling mode. It contains 13 cooling chambers in the mode from -25 to +4 °C, chambers for meat, fruits and vegetables, as well as banana ripening rooms. The most modern equipment is installed, which meets all world standards and quality, whether it is 38 loading and unloading ramps, the highest quality HTC floors, shelving, forklifts or WMS, or software for managing the flow of goods in the warehouse. The project was realized through a partnership between the European Bank for Reconstruction and Development (EBRD) and Voli, in which the EBRD has a 15.7 % share in the name of convertible ownership, which is the first corporate capital investment of this bank in our country. The goal is to avoid imports, to promote domestic products.

NTC LOGISTICS d.o.o. is a recently established company in Nikšić. The goal of the company is to provide customers with a complete logistics service to the end customer with the help of many years of experience in the field of import, customs clearance, warehousing and distribution of goods, as well as our storage capacity and rolling stock, thus enabling them to redirect all their energy and focus to sales and communication with customers [32].

6.3 Existing railways

The country's railway network consists of three (mostly) electrified, standard gauge railway corridors with a total length of 300 km; these connect the port of Bar with Podgorica and Serbia (Belgrade-Bar railway), the cities of Podgorica and Nikšić (Podgorica – Nikšić railway) and Podgorica with Albania (Podgorica-Shkodër railway) – Figure 6.3.1 [23]. The railway line to Albania offers exclusively freight service. Railways are operated by companies, which independently handle railway infrastructure, passenger transport, cargo transport and maintenance of the rolling stock.

Figure 6.3.1: Business zones in Montenegro

In total, Montenegro has 18.4 m of railway lines per km^2 and 0.40 km per 1 000 inhabitants [23].

The rail sector has exhibited considerable progress in the past decade. The railway line between Podgorica and Niksic has been fully overhauled and electrified since 2012, while about 48% of the Bar – Podgorica – Bijelo Polije railway line was been rehabilitated and/or upgraded. It is the highest railway viaduct in Europe (the Mala Rijeka viaduct) and the 6.2 km long Sozina tunnel. About one-third of the Montenegrin part of line is in a tunnel or on a viaduct. The Nikšić-Podgorica line (56.6 km long) was thoroughly reconstructed and electrified during 2006-2012 period, with passenger service reintroduced. Operating speeds on the Nikšić-Podgorica line range between 75 km/h and 100 km/h. The rail line Vrnbica-Bar, part of the core rail network is TEN-T compliant but needs further upgrade and maintenance. The line from Podgorica to Tuzi and the state borders with Albania is currently non-compliant. The project has been included in the SPP list for completion after 2025 at an estimated cost of €35 mil., primarily for line electrification [23]. The overview of recent (major) developments in railway sector is shown in Figure 6.3.2 [23].

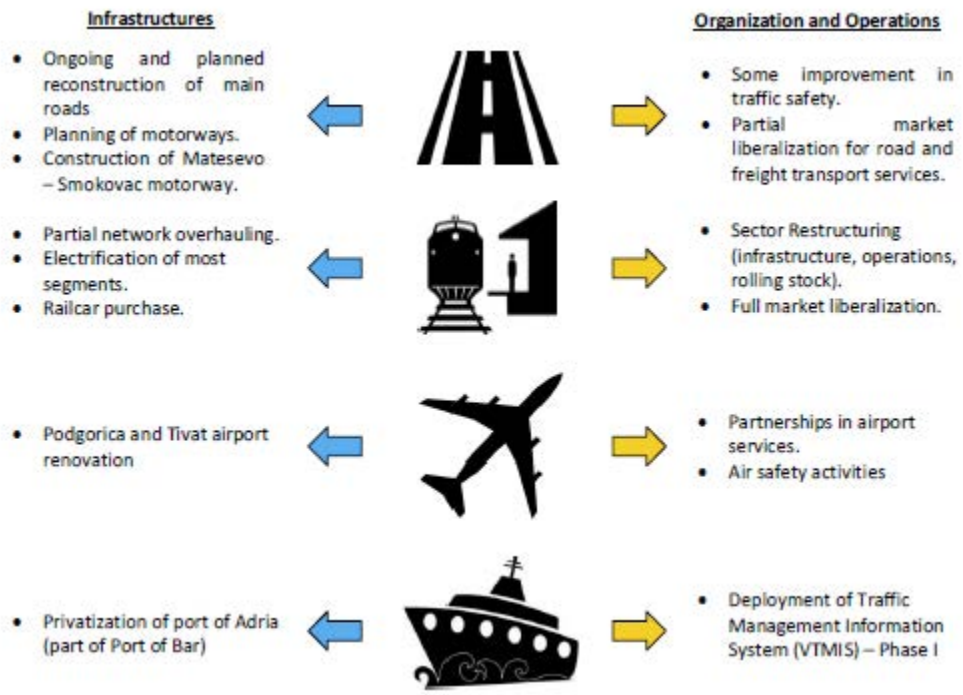


Figure 6.3.2: Recent developments in transport sector in Montenegro

Also, railcars have been either purchased or refurbished in the recent years. From an organizational side, the sector was restructured by separating infrastructure management from operations; four new joint stock companies were established: railway infrastructure management, rolling stock maintenance, rail passenger transport and freight transport. Furthermore, the market was opened to the competition, albeit no new players have entered so far.

The realized and forecasted railway ridership and freight volumes are shown in Table 6.3.1 [23]. The future cases consider rail passenger operations between Podgorica and Tuzi (Albanian border) and Podgorica – Nikšić railway line extension to Bileća and Trebinje. A considerable increase in both the passenger and freight traffic is anticipated for Montenegro in the future years. This is attributed both to external (macroeconomic) factors such as economic growth of both Montenegro and neighboring countries, as well as the improvement and upgrade of the rail infrastructure, which will allow for better services in terms of travel times, capacity and reliability of service. Indeed, an estimated 15% improvement in ridership along the Bar – Bijelo Polje corridor is attributed to a 30 min of travel time [23, 33].

Table 6.3.1: Main characteristics of business zones in Montenegro

Year	Rail passenger traffic			Rail freight traffic	
	Trips*	Passenger – km	Passenger – hr	Freight volumes*	Tonne - km
2015	11 725	204 680	2 558	2 705	387 351
2025	16 778	297 580	3 710	3 788	542 943
2035	22 863	405 758	5 059	5 063	665 948

*include trips with at least one trip end in Montenegro

The country's only intermodal station between rail and maritime transport is established in the Port of Bar. However, railway connecting segments between the port piers and the railway network are insufficient. Furthermore, infrastructure dedicated to intermodality between rail and road transport is missing. This implies that capacity of railway lines is not fully exploited, and road transport undertakes the majority of containerized freight flows.

6.4 Existing road infrastructure

Total length of Montenegro's roads is approximately 7 800 km, of which around 1 850 km consists of main and regional roads, while the remaining length consists of local roads [23]. Currently, there are no highways in Montenegro (but are under planning) and main roads connecting major urban centres have single carriageways, with one lane per direction (and occasionally a third overtaking lane). Remaining road network includes regional and local roads of lower design standards (Figure 6.4.1 [23]).

Figure 6.4.1: Main and regional roads of Montenegro (in blue and yellow respectively – red depicts the Smokovac- Mateševo highway section, currently under construction)

Main roads (labelled "M") connect the country's most important cities, economic centres and border crossings. They have single carriageways per direction (of a width of at least 3m per lane and a narrow shoulder in most cases) and a third overtaking lane on sections with steep gradients. Only a few segments around urban areas have two-lanes per direction, with or without a median. Alignment of main roads allows a maximum speed of 80 km/h. Regional roads (labelled "R") connect regional centres, feed the main network and offer access to border crossings. Their alignment allows lower speeds compared to main roads (50 km/h).

In addition, connection between the capital (Podgorica) and the coast was improved by upgrading roads to Budva, Bar and Cetinje and by completing the Sozina tunnel (between Podgorica and Bar); the tunnel alone reduced the journey between the two cities by 30 minutes.

In recent past, several reconstruction and rehabilitation projects have been planned and/or implemented in the road sector, of a total length of approximately 110 km and at a cost of 110 million € [23]. These projects improved the quality of the country's state roads and enhanced their level of service and road safety. When it comes to the highway between Bar and Boljare and Adriatic-Ionian expressway coastal variant, these projects have only been in a planning stage, except for the Smokovac–Uvac–Mateševo section of the Bar-Boljare highway, which is currently under construction. The overview of recent (major) developments in road sector is shown in Figure 6.3.2 [23].

Current and planned reconstruction projects have partly been financed by state budget as well as from loans obtained from EIB and EBRD. In the case of financing via loans, state contribution was around 15%-20% of costs. For the Bar – Boljare highway project, 85% of funding was secured through a credit arrangement with EXIM Bank, from China, based on a separate agreement. The reconstruction of 16 main and regional roads

with a total length of 120 km and a budget of about 110 million euros and 14 roads of a total length of 223 km and a budget of approximately 120 million euros are carried out in last few years.

The Bar-Boljare highway (Figure 6.4.2 [23]) will be constructed in four phases: i. Smokovac-Mateševo, ii: Mateševo-Andrijevica and bypass Smokovac - Tološi – Farmaci, iii: Andrijevica – Boljare, and iv: Podgorica – Đurmani. Currently, the construction of the Smokovac-Uvać-Mateševo section (41 km) is underway and preparatory activities for other sections of Bar-Boljare highway are being undertaken. The coastal variant of the Adriatic-Ionian expressway (Route 1) goes along the Montenegrin coast, and aims to improve connectivity within the region as well as the region with the EU. This is a strategic project for the region of Southeast Europe and the Balkans. Its completion will provide a high capacity corridor of high quality that connects central Europe and northern Italy with the Ionian peninsula through Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, Albania and Greece. Part of the Adriatic-Ionian corridor that passes through Montenegro, from the border with Croatia to the border with Albania, is about 108 km. It consists of the bypass system around the coastal towns of Bar and Budva, Tivat, Herceg Novi and the major construction feature, a high bridge crossing over the Boka Kotorska Bay– Verige bridge.

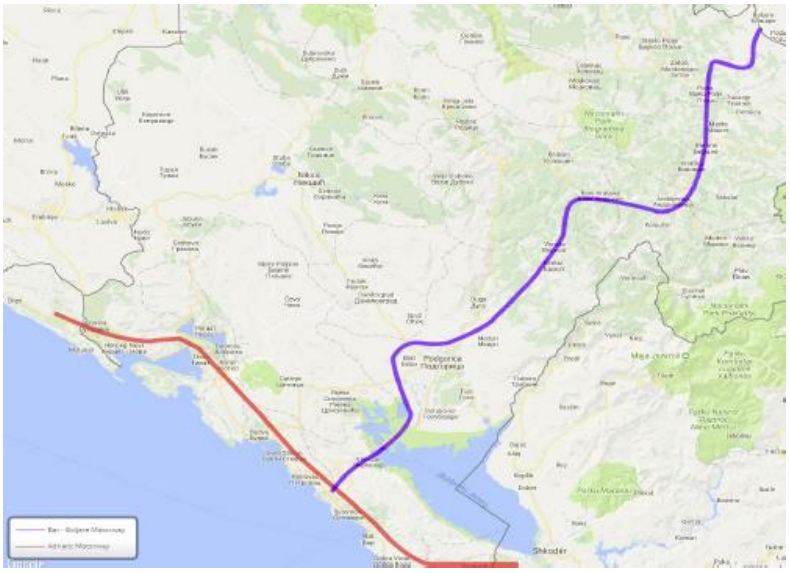


Figure 6.4.2: The Bar – Boljare highway and Adriatic-Ionian expressway coastal variant (in purple and red)

Road transport is expected to grow by at least 45 % up until 2025 and another 25 % up until 2035 (Table 6.4.1 [23, 33]). Planned highways are expected to undertake relatively high average daily traffic volumes (of about 22 000 vehicles per day in 2025 and 27 000 in 2035 for worst network segments), which however will not severely affect their performance. Also, future road traffic will increase for some road sections of the existing main road network (for example, the main roads between Podgorica and Budva and between Podgorica and Nikšić). Total travel distance (measured in vehicle-kilometers, veh-km) increases in the future, since total route lengths are not radically reduced (new highways run in parallel to the existing network) while traffic volumes increase. On the other hand, the introduction of highways reduces travel times and therefore total veh-hours are reduced compared to the base network, at least for 2025 and almost identical for year 2035 (given the fact that traffic will increase considerably by 2035).

Table 6.4.1: Main characteristics of business zones in Montenegro

Year	Road passenger traffic			Road freight traffic		
	Trips*	Veh - km	Veh - h	Trips*	Veh - km	Veh - h
2015	40 924	3 921 870	101 360	3 430	355 462	5 299
2025	59 752	5 020 369	75 742	4 397	399 972	4 321
2035	74 763	6 527 882	109 961	5 027	462 751	4 977

*includes trips with at least one trip end in Montenegro

6.5 Energy sector

The table below summarizes data on the Montenegrin energy sector in 2017 [34, 35, 36].

Table 6.5.1: Montenegrin energy sector in 2017

Category	Montenegro	EU average	Unit
Primary energy consumption	1.60	3.22	toe/capita (2012)
Energy dependence	30.9(34.7 in 2016)*	55.4	%
Renewable energy share	38.8	17.9	%
GHG emissions	4.08	9.47	tonne CO_2-eq/capita
Bioenergy in RE	52	69	%
Bioenergy in total energy	21.2	10.6	%
Biofuels prod. Capacity	-	0.051	ton/capita

*depending of the hydrology conditions

Total consumption of final energy in Montenegro in 2017 was 768 ktoe, with consumption divided by sectors and energy products presented in Figures 6.4.1 and 6.4.2 [34]. The energy system of Montenegro is small, with only 285 000 customers and an electricity demand of around 3,400 gigawatt hours (GWh) annually [37, 38]. In the conditions of reduced activities of industry, transport and households are becoming dominant sectors in relation to other sectors and similar trend is expected in the final energy consumption in the future. The Government of Montenegro recognized the following vision: "*Montenegro recognized as a regional energy hub and a leader in production and use of energy from renewable energy sources*" [42].

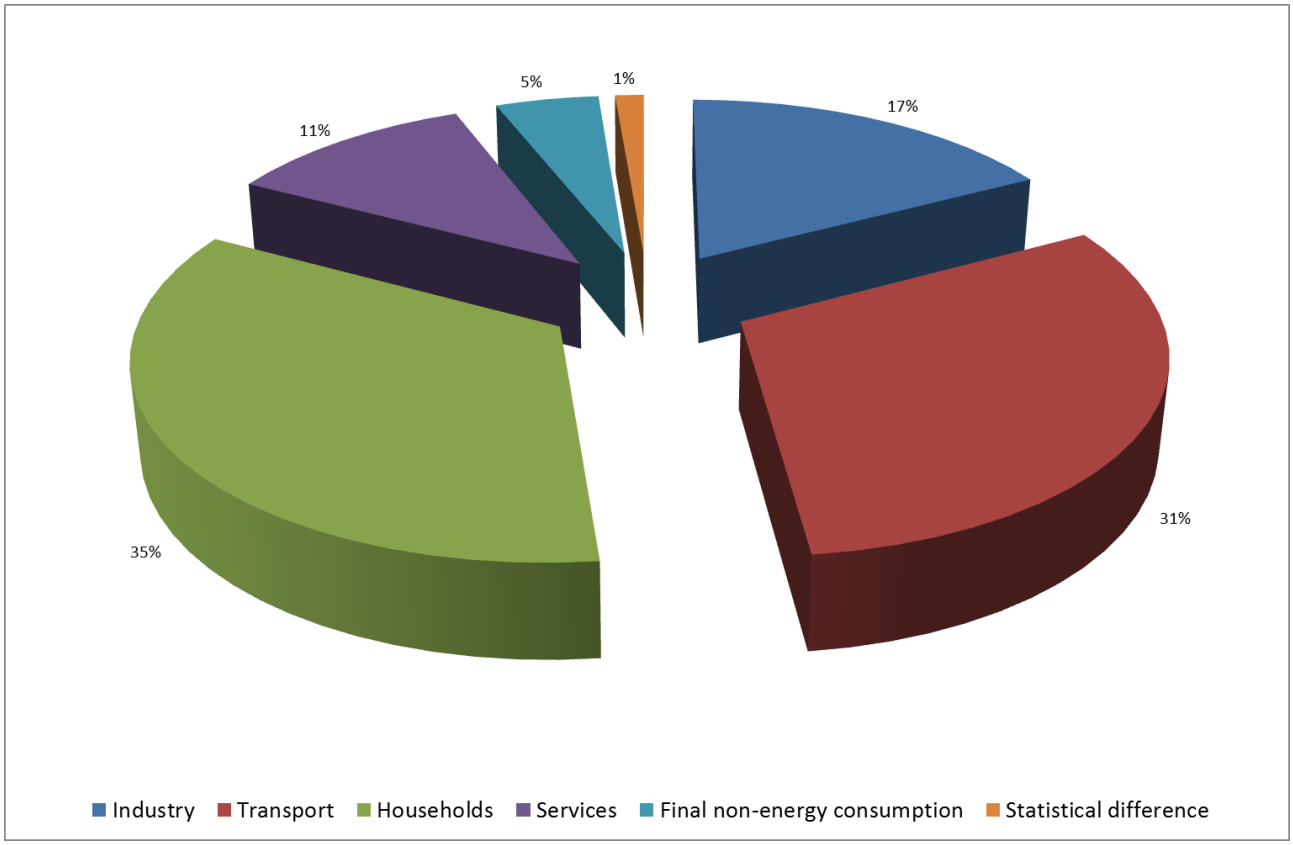


Figure 6.5.1: Structure of final energy consumption in 2017 by sectors

In the energy available for final consumption, petroleum products, electricity and biomass are dominant. District heating in Montenegro exists to a very limited extent, is not developed nor is it sufficiently investigated, despite the fact that climatic conditions and the availability of suitable energy sources for use for these purposes – biomass. District heating is a current topic in Montenegro and according to the experiences of countries with similar climatic conditions it can be profitable in the northern part of the country, where there are sufficient amounts of biomass for such plants. Of course, the conditions biomass procurement and the existence and location of the required heat consumption can significantly affect project economy [39, 40].

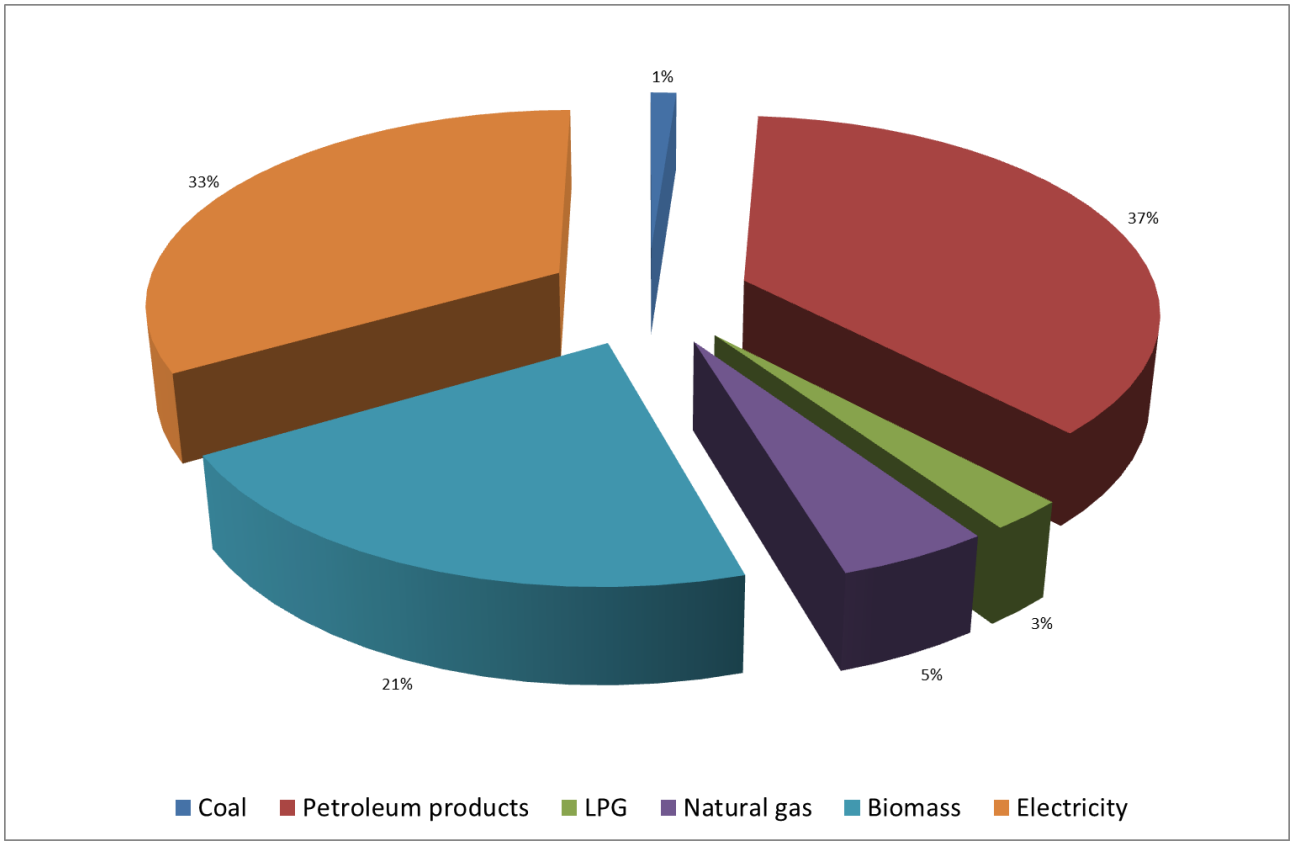


Figure 6.5.2: Structure of energy available for final consumptions in 2017

Figure 6.5.3 presents the electricity production in Montenegro from various energy sources. In the last two years, Montenegro produced more than 50 % of electricity from renewable energy sources, which is the result of a good investment environment and the inherited production infrastructure. From the structure of production, realized during 2019, it is clear that hydropower plants dominantly have the largest share with over 50%, the share of thermal power plants is about 41 %, wind farms participate with 8.69 % while the share of solar power plants is negligible. The majority of electricity in Montenegro is produced at the Pljevlja coal-fired Thermal Power Plant, the Perucica, and the Piva hydro power plants [39]. Electricity is also produced from two wind farms – Krnovo and Možura, small hydro power plants and solar plant [39].

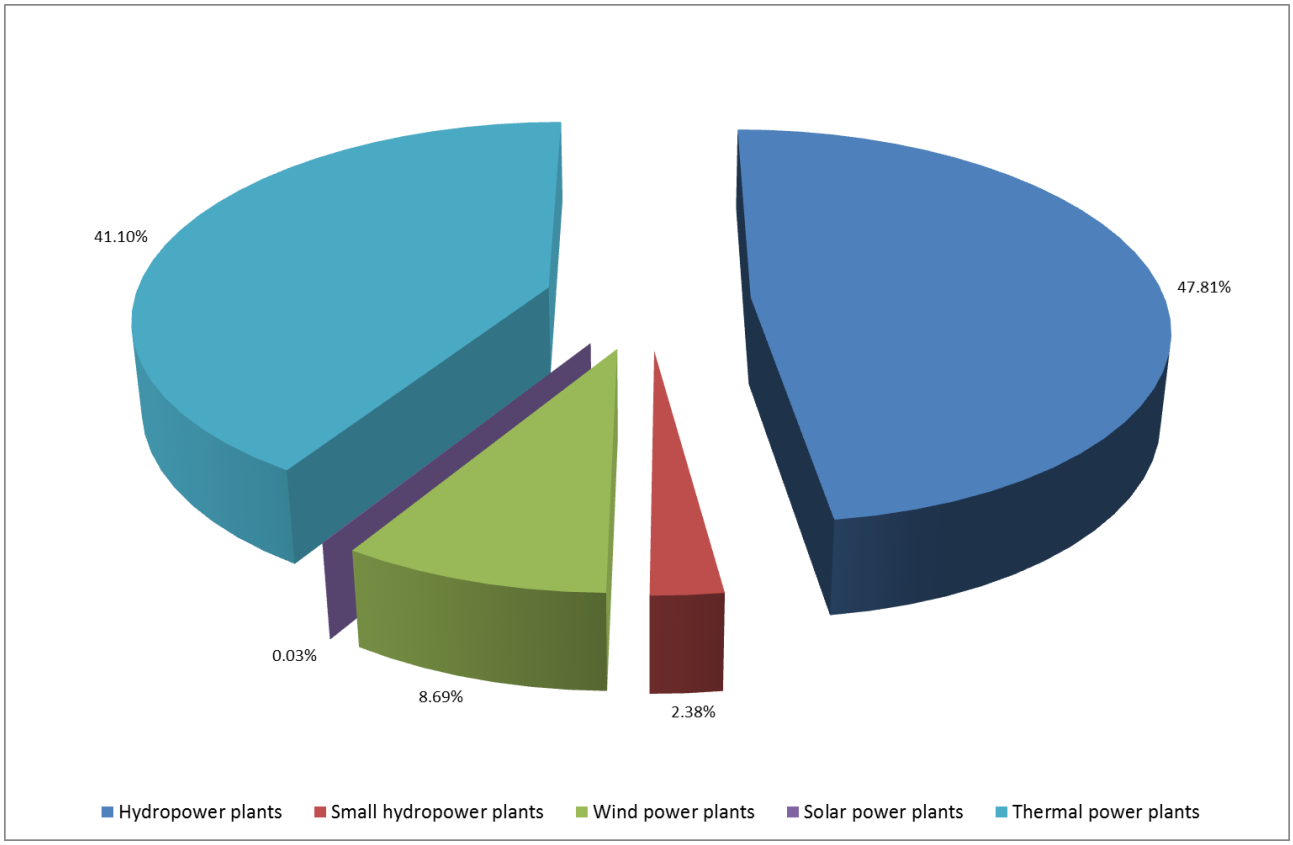


Figure 6.5.3: Structure of final energy consumptions in 2019 by energy products

Hydro potential and coal are the most important energy source in Montenegro. Rich hydro-energy potential is with a noteworthy index of cost-effectiveness of investments and favorable conditions for integration into the ecological and social environment. Montenegro only uses around 20 percent of its hydro potential and consumes more energy than it produces; there are ample opportunities to develop new energy sources. To fully develop this sector, Montenegro will need a developed/upgraded transmission and distribution network. Coal reserves in Montenegro are located in Pljevlja area and Berane basin.

According to official data, Montenegro does not have oil and natural gas reserves. Previous research on oil and gas in the Montenegrin submarine indicates the prospects of this product. In late 2013, Montenegro invited international oil and gas companies to bid on licenses to explore its offshore coast, based on the seismic data which showed favorable conditions for hydrocarbon deposits off Montenegro's deep-water coast. The Government of Montenegro has signed concession agreements with two consortia: the Italian-Russian consortium Eni/Novatek for four blocks and the Greek-British consortium Energean oil/Mediterranean oil & gas for one block. It is expected that the exploration will start in 2019, and several more licensing rounds are foreseen by 2020 for additional exploration blocks [37].

In the last decade Montenegro has used renewable energy source in the form of hydropower for electricity generation and biomass in the form of firewood (Figure 6.5.4 [40]). Use of hydropower in unpredictable due to hydrological conditions and shows significant oscillations and indicates clear consequences (positive or negative) on the electricity system and security of supply. In addition to the use of RES in final consumption (firewood, pellets and briquettes, solar collectors, heat pumps as well as RES in transport - biofuels and electricity from RES), the strategy envisages intensive use of RES in electricity and heating sector (especially in district heating).

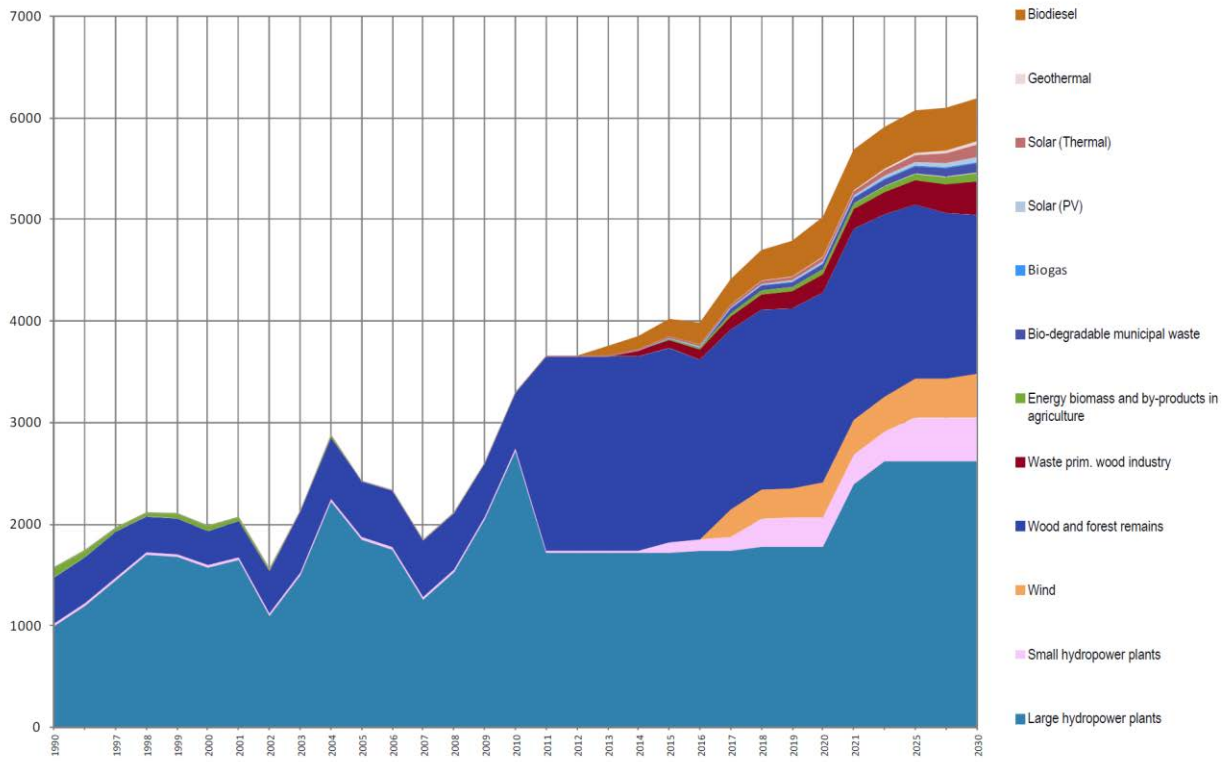


Figure 6.5.4: Total use of RES in the past (1990-2010) and envisaged by the Strategy until 2030 (GWh)

The goals in sector of renewable energy in 2022 are [42]:

- Increasing production from renewable energy sources to 42% when it comes to final consumption.
- Reducing overall energy deficit through the increase in use of renewable energy sources and stimulating end users to be producers of electric energy.
- Promoting research and innovation for creating technologies to reduce the level of environmental pollution.
- Raising the level of energy efficiency and using renewable energy sources in public buildings, enterprises and residential buildings.
- Use of eco-funds for adaptation of tourist and residential buildings.
- Transport electrification, with a focus on public transport.
- Application of the concept of smart networks.
- Preparation and start of implementation of strategies for environmentally favourable use of coal in various energy resources.

Focal areas and technologies that have the great potential are identified:

- Hydro energy.
- Wind energy.
- Solar energy for the production of electrical energy and heating.
- Hybrid energy systems (conventional + alternative energy sources).
- Energy production from biomass and waste.
- Production of improved stoves (energy efficient).
- Energy efficiency, energy balance improvement, reduction of consumption and CO_2 emissions (building renovation, LED technology, eco-active / passive buildings).
- Development of a system for storing energy.
- Smart facilities (houses, buildings, hotels, roads, intersections, etc.).
- Construction of electric vehicle charging stations (solar and hybrid).
- Encouraging distributed production and consumption response.
- Strategic positioning in European energy corridors for transit of energy and energy generating products.

Montenegro has a great potential for renewable energy sources and although hydro energy already provides for two-thirds of the total energy production in the country, only 17 % of the theoretical hydro energy potential has been exploited so far. Until recently, hydro energy has been the only renewable energy source that significantly contributes to energy production in Montenegro.

The potential of large hydropower plants on the main rivers in Montenegro is 9 846 GWh, while on smaller rivers it amounts to 800-1 000 GWh per year. Technically and economically justified useful potential on the main rivers in Montenegro is between 3.7 and 4.6 TWh/year. For comparison, the real useful potential for small hydropower plants is estimated at 400 GWh per year. Based on currently granted concessions, 20 small hydro power plants have been implemented, with a total installed power of about 33 MW. Overall, the theoretical potential for hydro energy in Montenegro is slightly less than 11 TWh/year, of which 5.7 TWh/year can be used in an economically quality manner.

Montenegro has a wind potential of 100 MW for high-speed zones, i.e. areas with wind speeds above 7 m/s. The potential increases to 400 MW if medium potential zones are considered as well. Energy produced from wind can reach up to 25 % (925 GWh) of annual energy consumption in the country. The latest projects, such as the Krnovo wind farm (72 MW) and Možura (46 MW, under construction), point to the direction of the future development of the wind potential.

The average annual number of sunny hours in Montenegro is more than 2 000 hours, while the coastal regions have more than 2 500 hours of sunshine per year. Construction of the first large solar power plant is planned as well, while the solar energy has so far mainly been used for solar thermal heating and cooling.

Montenegro has great potential to use the biomass energy potential, which primarily relates to the forestry sector. The annual increase in the amount of wood, as the most important energy source of this type, is estimated at 2.6 m^3/ha per year, while the current level of wood consumption is estimated at about 1.03 m^3/ha per year. The estimated tree increment is between 850 thousand m^3/year and 1 060 thousand m^3/year. In Montenegro, the wood waste energy potential amounts to 400 MW.

New underwater electrical energy cable between Montenegro and Italy is put in operation in January 2020, which enables Montenegro to take the position of a regional energy exchange hub. From the standpoint of the construction of wind farms, Montenegro has positioned itself as a testing environment for the application of technologies in extreme conditions, because the wind farm at Krnovo is located at the highest altitude in Europe so far.

The indicators for development of renewable energy sector and energy sector in Montenegro are shown in Table 6.5.2 [42].

Table 6.5.2: Main characteristics of business zones in Montenegro

Indicator	2018	2022
Share of energy in GDP (%)	6	8
Increase in production from renewable energy sources in relation to final production (%)	33 (2017)	42
CO2 emissions (Gg)	3 178	2 800
EEER – Indicator of energy efficiency in residential and public buildings (kWh/m^2)	240	200
Level of energy dependence (%)	34.7 (2016)	32

The Government of Montenegro intends to develop the country's mostly untapped hydroelectric power potential through Public Private Partnerships. As a priority, the government wants to develop Moraca River's potential through a series of four hydroelectric power plants for a total installed capacity of 238 MW and an annual production of 694 GWh [38]. For Komarnica River, the investment is needed in two power generators of 168 MW, with a combined annual production of 232 GWh. Additionally, 34 concession contracts have been signed for the construction of 53 small hydro power plants.

Areas with highest solar radiation are located in south of Montenegro (aria around cities Bar and Ulcinj) and area around capital city Podgorica. There is also a growing interest for renting of state-owned ground for construction of on ground installed solar power plants. The Ministry of Economy has so far issued 19 energy permits for installation of rooftop PV plants with installed power of up to 1 MW. Their total installed power is around 10.5 MW, while the planned annual production is around 13.8 GWh [38]. In 2016 the local authority of the capital city of Podgorica issued planning documents for construction of a ground mounted solar power plant at Velje Brdo, with installed power of at least 50 MW. In October 2018, a consortium between Fortum, Montenegrin energy company EPCG and Sterling & Wilson International Solar FZCO has won the public call to build a solar power plant in the Ulcinj solar site in Montenegro. The consortium has proposed to build 250 MW of solar power in Ulcinj.

Plantaže AD and regional ESCO company GGE , have signed a contract for the installation of a new biomass steam boiler to use wine cuts as new biomass fuel. GGE's team of engineers has proposed to Plantaže to start utilizing vine cuts since it is locally available, free-of-charge in addition to its low moisture content and high calorific value. GGE, the company that has succeeded in positioning itself region wide with its innovative energy solutions, has proposed to its client to improve energy efficiency as well as its environmental footprint by installing new biomass steam boiler of 2MW capacity, 3t/h, with a partially new steam line and an entirely new condensate return system. This investment will provide Plantaže with EUR 200,000 savings each year during the five-year contract with GGE, after which it will benefit from even higher savings [41].

The Government has decided to start gradually reducing feed-in tariffs for renewable energy sources as of January 1, 2020 and has announced that it will continue to promote the realization of wind farms, solar power plants, and large hydropower plants, without guaranteed incentive prices. Furthermore, the Government has decided not to issue energy licenses nor award concessions for the construction of small hydropower plants in the upcoming period.

The overview of projects planned for energy generation is shown in Table 6.5.3 [36].

Table 6.5.3: Future projects in energy sector in Montenegro

No.	Project	Timeframe	EU ETS	Budget (million EUR)	Potential for GHG reduction/ CO_2 sink increase
1	Eco upgrade of TPP Block 1	2018-2021	Yes	64.5	Not quantified
2	Revitalization of existing large HPPs	2018-2020	No	106.7	23.6 $ktCO_2$/yr
3	Revitalization of exiting small HPPs	2018-2020	No	20.25	6.68 $ktCO_2$/yr
4	Construction of new HPPs	2019-2025	No	671	337.2 $ktCO_2$/yr
5	Construction of small HPPs	2018-2020	No	106.7	130 $ktCO_2$/yr
6	Construction of wind power plants	2019-2021	No	165	50 $ktCO_2$/yr (additional potential in the case of constructing a 75 MW WPP)
7	Construction of photovoltaic power plants	2019-2022	No	Not quantified	8 $ktCO_2$/yr (additional potential in the case of constructing power plants in excess of 200 MW and 50 MW)
8	Construction of power plants using landfill biogas	2019	No	1.2	0.35 $ktCO_2$/yr
9	Construction of biomass-fueled cogeneration plants	2021-2030	No	67	55.5 $ktCO_2$/yr
10	District heating for Pljevlja	2019-2023	No	23	Not quantified

In the transport sector, with a steady trend of increasing energy consumption, some studies have been done on the prospects for the production and use of biodiesel, the potential for introducing other alternative fuels in transport sector, potentials for energy efficiency in transport and the Action Plan for sustainable use of energy in transport. Apart from increasing the use of biodiesel, it envisages an increase in the overall share of alternative fuels (liquefied petroleum gas – LPG and compressed natural gas – CNG) and electrical power in transport, including development of the relevant infrastructure (Table 6.5.4 [36]).

Table 6.5.4: Actions already taken and planned for transport in Montenegro

No.	Project	Timeframe	EU ETS	Budget (million EUR)	Potential for GHG reduction/ CO2 sink increase
1	Use of renewable energy in transport (biodiesel and alternative fuels)	2018-2020	No	Not quantified	10 $ktCO_2$ by 2020
2	Introduction of low-carbon vehicles	2018-2030	No	Not quantified	9 $ktCO_2$
3	Sustainable Urban Mobility Plan	2021-2030	No	Not quantified	Not quantified
4	Increased use of railway transport for passengers and freight	2018-2030	No	Not quantified	Not quantified

6.6 Summary and conclusions in relation to SWOT elements

Table 6.6.1: SWOT analysis of Infrastructure, logistics and energy sector of Montenegro

Strengths	Weaknesses
Railway, road, water and intermodal • geographical location and level of development of the transport network; • infrastructure resources; • a defined framework (which respects European and regional transport policy) and global objectives; • existence of professional and competent resources; • appraisal of the importance of marine and coastal habitats and species and ecosystem services of marine and coastal environment at the highest level • established institutional functions and capacity • coherence with the international legislation framework (EU Directives, International Conventions) • enhanced attractiveness of the coastal zone *Energy sector* • geographical position of Montenegro and implemented capital energy projects make Montenegro the energy hub of the Balkans • small but very flexible and efficient energy system • EES has been decentralized in Montenegro - newly-formed energy entities (production,	*Railway, road, water and intermodal* • strict protection measures and limitations on use of resources • lack of involvement of local government and stakeholders • the transport infrastructure on the corridors is not fully constructed and is not equipped with modern technical and technological systems; • the need for significant investments in infrastructure reconstruction and construction of a new one; • many economic discontinuities in the previous period; • modes of the transport system are not integrated; • lack of stable funding sources; • unfavorable qualification structure and number of employees *Energy sector* • bureaucratic problems in business operations of enterprises • lack of local energy plans, despite the legal obligation imposed on local governments to pass them. • unavailability of adequate and sufficiently educated staff.

transmission, distribution and market, as well as the regulatory agency) are successfully following European directives and frameworks • distinct diversity of production capacities: hydro, solar, wind and thermal • long-term policy in the field of energy.	
Opportunities *Railway, road, water and intermodal* • coordination and integration of national policies, plans and implementation programs for biodiversity protection • integrated management of Marine National Parks with the existing system of terrestrial National Parks and ecological network • assignment of dedicated financial provisions for management of Marine National Parks • creation of trans-boundary Marine Parks with neighboring countries • the interests of countries in the region in the development of the Core Regional Transport Network; • new investment models in the field of transport (concession, PPP, use of European funds); • development of a multimodal transport system; • conservation of ecological content; • increase of export potential; *Energy sector* • unused potential in renewable energy sources. • wind power plant in Krnovo – Gvozd should be used as a testing energy environment due to the high altitude on which it is located, which is a comparative advantage • development of smart transport of energy and information can be a subsector within the sector. Similarly, an analysis of the state of the electrical energy market can be a subsector, and so can the scanning of the electrical energy sector. • construction of electric vehicle charging stations is planned, which will contribute to a better tourist offer • investments/tests are in progress in smart facilities (houses, buildings, hotels, roads, intersections, etc.), as well as in smart energy networks • transmission and transit of energy (cable, electrical energy transmission network and gas pipeline). • hybrid energy systems are being developed (most often it is a combination of solar-diesel systems, but there are also plans for wind-solar systems, wind-diesel systems, etc.), especially in areas where there is no grid connection.	**Threats** *Railway, road, water and intermodal* • duplication of management structures • weak coordination with other competent institutions both at the national and local levels • possibilities for a multiple use of resources are limited and can prevent acceptance of the protected area from the local communities • a large number of border crossings on major routes; *Energy sector* • a problem of cyber security as a potential challenge in business operations and energy systems management (trade in energy, production capacity management, generator engagement, etc.) • potential problems of physical security of energy facilities due to natural disasters • competition at the regional and global level.

7 Skills, education, research and innovation potential

7.1 Research infrastructure

Innovative organizations that perform innovative activities in Montenegro are: scientific research (SR) institutions, centers of excellence (CE), higher education (HE) institutions, technology transfer centers (TTC), science and technology parks (S&TP), innovation and entrepreneurship centers, business incubators and companies, or parts of companies.

SR institutions, CE and HE institutions, are innovative organizations if they perform R&D by implementing development research based on the results of applied research, which relate to the creation and application of new or improvement of existing technologies, procedures, products, services and processes, in accordance with market needs.

In Montenegro, scientific research and innovation activities are performed by 58 licensed SR institutions, which are registered in the Register of the Ministry of Science. The structure of licensed SR institutions consists of: 33 faculties, which are organizational units of three Montenegrin universities, 8 institutes (2 of which are part of universities), 5 independent private faculties, 1 independent state faculty, 3 companies, 3 non-governmental organizations, 3 centers, 2 agencies, 1 office and 1 museum (Figure 7.1.1). Although a large number of these institutions conduct research in several fields of science, if classified by dominant field, 50 % of licensed institutions are in the field of social sciences and humanities, 22.41 % in the field of technical and technological, 13.79 % in the field of natural and mathematical, 8.62 % in the field of medicine and 5.17 % in the field of agricultural sciences (Figure 7.1.2).

Montenegro, for now, has one CE, which started operating on June 1, 2014. Namely, the Ministry of Science granted the status of the first CE in Montenegro, UCG - Faculty of Electrical Engineering in Podgorica, for the implementation of the SR project "Center of Excellence in Bioinformatics - BIO-ICT" 21.

TTC can be established by the university, CE and S&TP, to perform the transfer of new technologies to companies, to apply new or improve existing technologies, processes, products, services and processes; encouraging the realization and commercialization of technology transfers, consulting services and providing assistance in the protection and use of intellectual property rights. There is no such center in Montenegro for now, but its establishment is planned in the coming period at UCG.

S&TP is an innovative organization, which provides specialized infrastructure and services, information system, professional and consulting services in several fields of science, SR institutions, HE institutions and other research organizations (RO) and companies, with the aim of connecting them, and for the needs of economic development of several regions or countries.

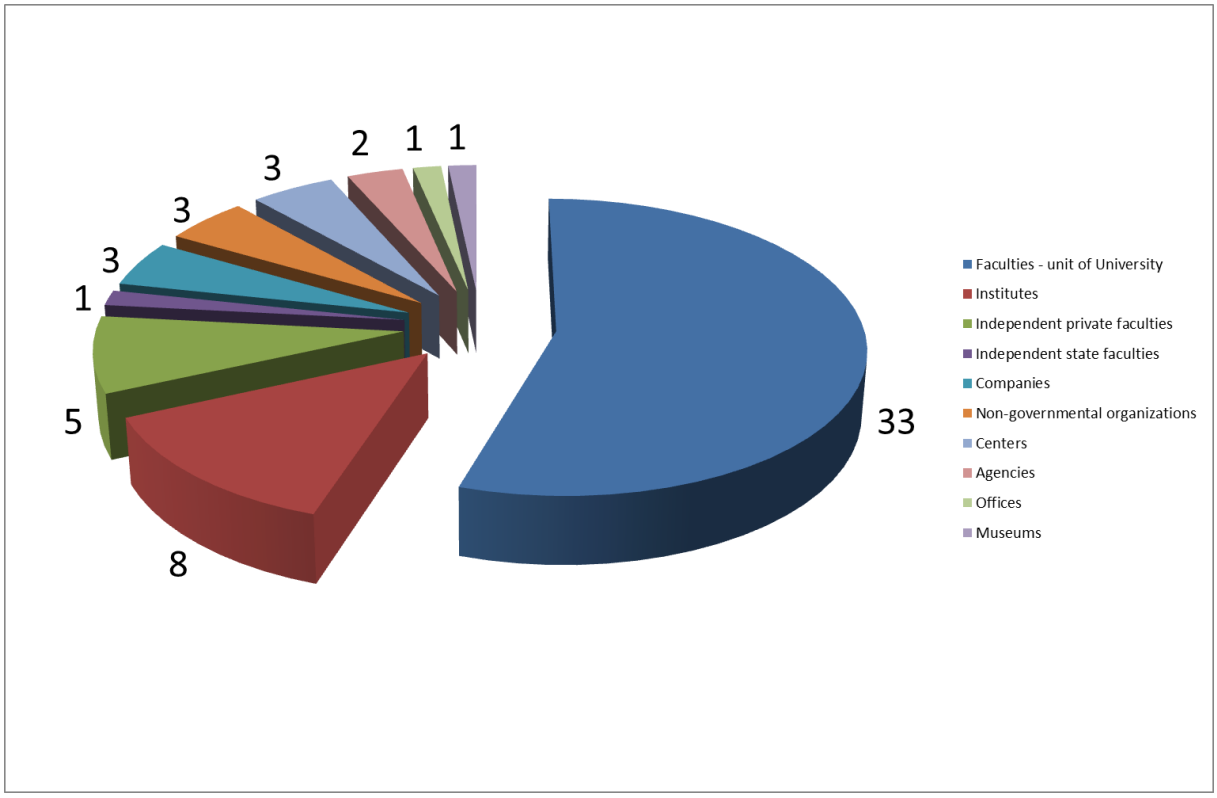


Figure 7.1.1: Structure of licensed SR institutions

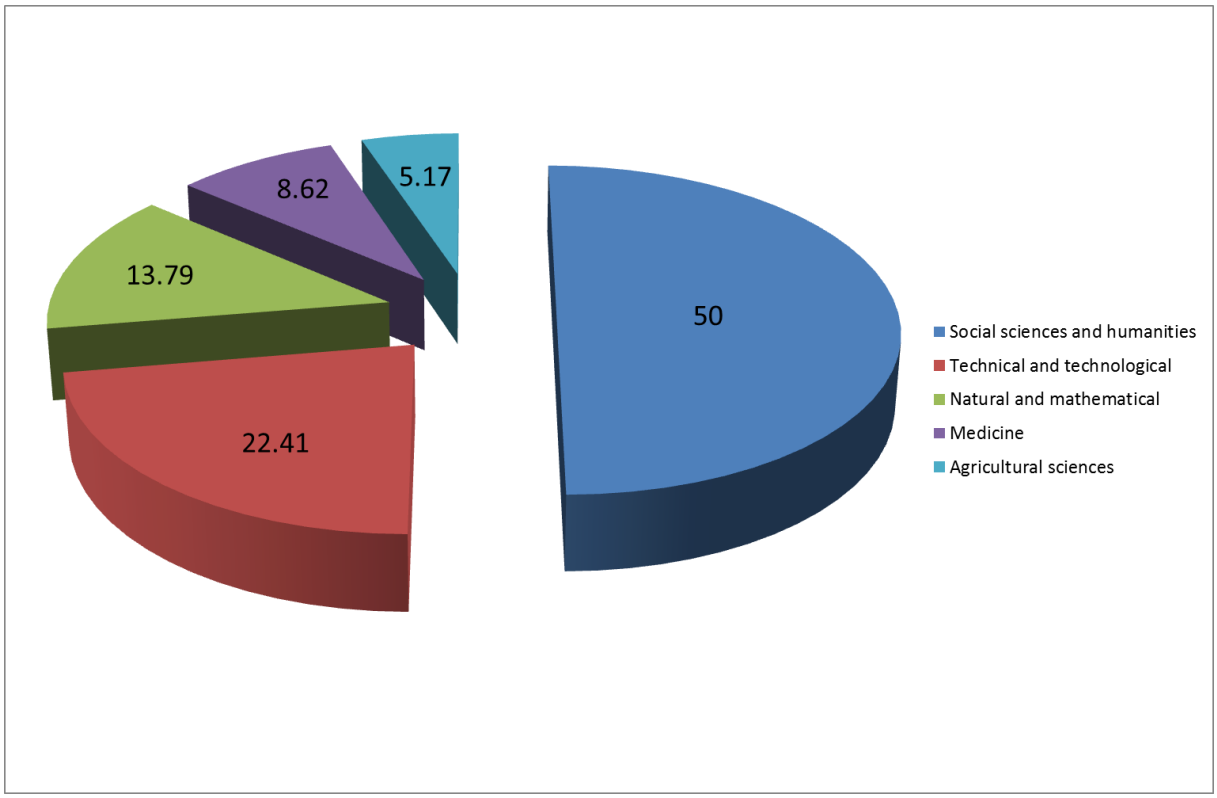


Figure 7.1.2: Licensed SR institutions distributed per science field

7.2 Education infrastructure

47 licensed HE institutions and 178 accredited study programs are registered in the Register of the Ministry of Education. The structure of licensed HE institutions consists of: 35 faculties, which are organizational units of three Montenegrin universities, 2 institutes (within the university), 9 independent private faculties and 1 independent state faculty. Although a large number of these institutions conduct research in several fields of science, if classified by dominant field, 70.21 % of licensed institutions are in the field of social sciences and humanities, 19.15 % in the field of technical and technological, 4.25 % in the field of natural sciences. mathematical, 4.25 % in the field of agriculture and 2.13 % in the field of medical sciences
An overview of universities and academies where study programs related to the topic of this study are studied are shown in Table 7.2.1.

Table 7.2.1: Accredited universities and academies in Montenegro

State Universities	
University of Montenegro	https://www.ucg.ac.me/
• Biotechnical Faculty	https://www.ucg.ac.me/btf
• Faculty for Sport and Physical Education	https://www.ucg.ac.me/sport
• Faculty of Architecture	https://www.ucg.ac.me/af
• Faculty of Civil Engineering	https://www.ucg.ac.me/gf
• Faculty of Dramatic Arts	https://www.ucg.ac.me/fdu
• Faculty of Economics	https://www.ucg.ac.me/ef
• Faculty of Electrical Engineering	https://www.ucg.ac.me/etf
• Faculty of Fine Arts	https://www.ucg.ac.me/flu
• Faculty of Law	https://www.ucg.ac.me/pf
• Faculty of Maritime Studies	https://www.ucg.ac.me/pfkotor
• Faculty of Mechanical Engineering	https://www.ucg.ac.me/mf
• Faculty of Medicine	https://www.ucg.ac.me/med
• Faculty of Metallurgy and Technology	https://www.ucg.ac.me/mtf
• Faculty of Philology	https://www.ucg.ac.me/fil
• Faculty of Philosophy	https://www.ucg.ac.me/ff
• Faculty of Political Science	https://www.ucg.ac.me/fpn
• Faculty of Science and Mathematics	https://www.ucg.ac.me/pmf
• Faculty of Tourism and Hospitality	https://www.ucg.ac.me/fth
• Historical Institute	https://www.ucg.ac.me/ii
• Institute-Center of Excellence for Research and Innovation	https://www.ucg.ac.me/ciii
• Institute of Marine Biology	https://www.ucg.ac.me/ibm
• Music Academy	https://www.ucg.ac.me/ma
Private Universities	
University Mediteran	http://unimediteran.net/index.php/mne/
• Montenegro Tourism School	http://ftht.unimediteran.net/
• School of economy and Business	http://fps.unimediteran.net/index.php/mne/
• School of Information Technologies	http://fit.unimediteran.net/
• School of Visual Arts	http://fvu.unimediteran.net/index.php/mne/
• Law School	http://pf.unimediteran.net/index.php/mne/
• School of Foreign Languages	http://fsj.unimediteran.net/index.php/mne/
University Donja Gorica	https://www.udg.edu.me/
• Faculty of International Economics, Finance and Business	https://fmefb.udg.edu.me/
• Faculty for Culture and Tourism	https://fkt.udg.edu.me/
• Faculty for Information Systems and Technologies	https://fist.udg.edu.me/
• Faculty of Polytechnics	https://politehnika.udg.edu.me/

• Faculty of Law	https://fpn.udg.edu.me/
• Humanistic studies	https://hs.udg.edu.me/
• Faculty of Arts	https://fu.udg.edu.me/
• Faculty for Food Technology, Food Safety and Ecology	https://fptbhe.udg.edu.me/
• Faculty of Sports Management	https://fsm.udg.edu.me/
• Faculty of Design and Multimedia	https://fdm.udg.edu.me/
• Faculty of Philology	https://ff.udg.edu.me/
• Faculty of Applied Sciences	https://fprn.udg.edu.me/
• Center for Foreign Languages	https://www.udg.edu.me/cfl/
Adriatic University Bar	http://www.univerzitetadriatik.com/
• Maritime Faculty Bar	http://www.pfbar.me/
• Faculty of Business Economy and Law Bar	http://fpebar.me/
• Faculty of Business and Tourism Budva	http://www.fbt-budva.com/index.php?lang=me
• Faculty of Mediterranean Business Studies Tivat	http://www.fms-tivat.me/index.htm
• Faculty of Management Herceg Novi	https://www.fm-hn.com/
• Faculty of Transport, Communications and Logistics Budva	https://www.fskl-cg.me/me
• HEC Faculty of International Management in Tourism and Hospitality	No web site

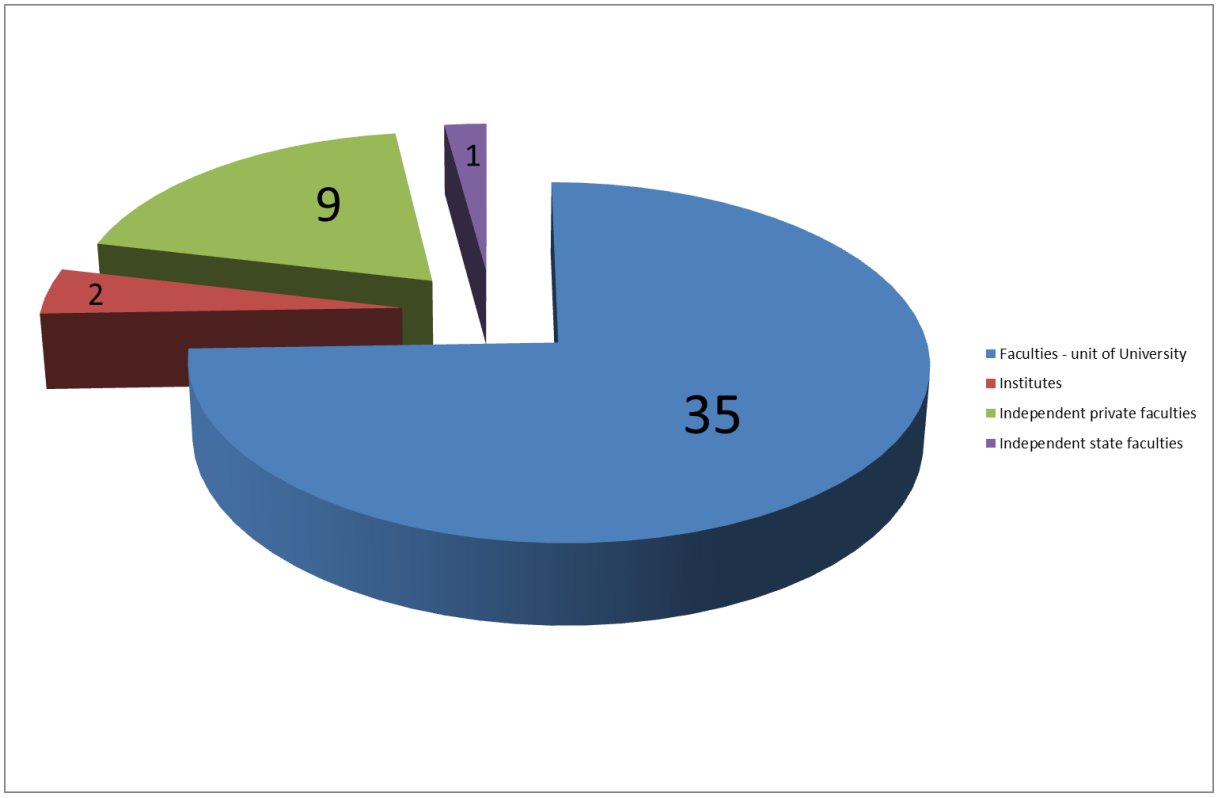


Figure 7.1.3: Structure of licensed HE institutions

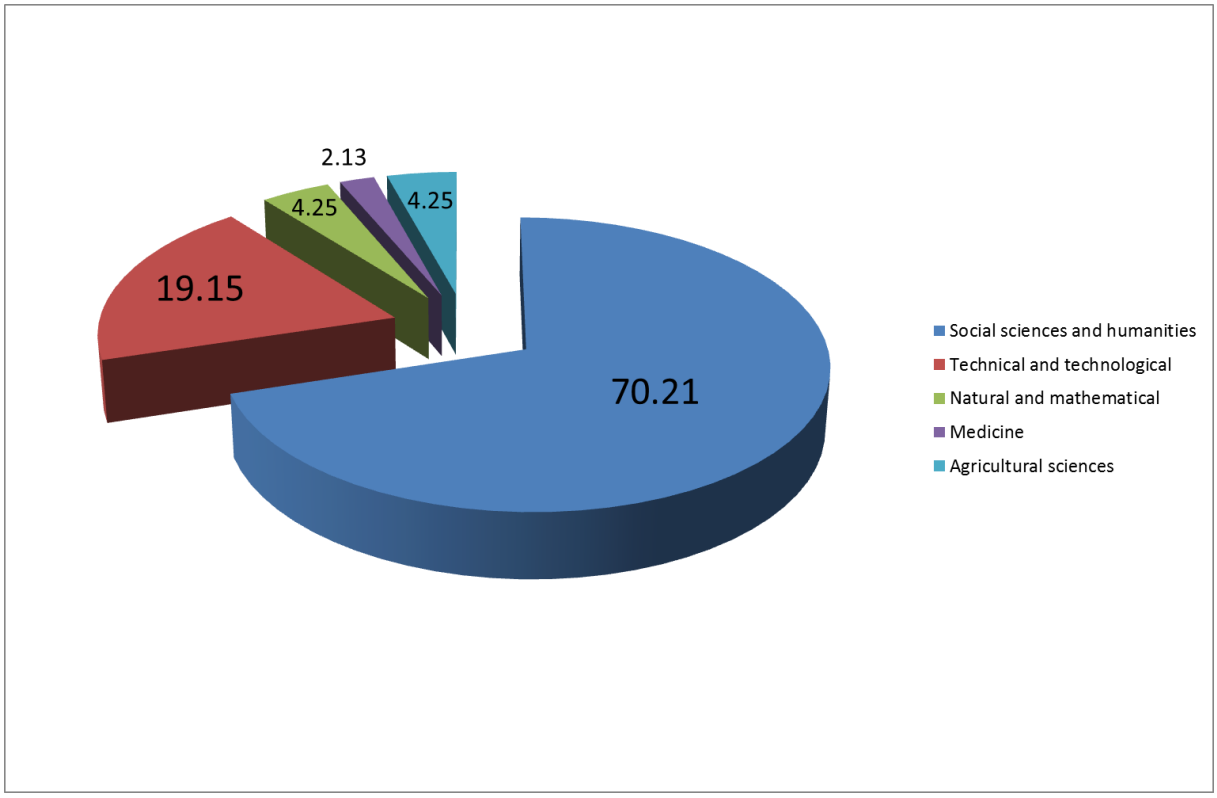


Figure 7.1.4: Licensed HE institutions distributed per science field

7.3 Environment for start-ups

Innovation and Entrepreneurship Center is an innovative organization, which provides specialized infrastructure and services, information infrastructure, professional and consulting services, support for cooperation with potential partners for participation in national and international programs, projects and funds from certain fields of science, users of scientific research services. institutions, higher education institutions and other innovative organizations and companies, and for the needs of economic development at the local or regional level.

CPI "Tehnopolis" in Niksic is, for now, the only CPI in Montenegro, which began operating with the entry in the Central Register of Business Entities in September 2014.

Business Incubator is an innovative organization, which provides administrative, technical, consulting and other services to customers of start-up and spin-off companies, in the first years of business, with the aim of supporting their development. Montenegro currently has three business incubators.

Business Incubator "Inventivnost" from Podgorica started operating in 2008. The founders are the Capital Podgorica and the Government of Montenegro - Directorate for SME Development. The incubator supports young and talented people in the field of ICT and services in starting a private business, by enabling them to use business premises on favorable terms, equipment, legal and consulting assistance, as well as attending various courses and other types of training led by renowned experts. from the country and abroad. In addition, the incubator provides services of constant mentoring of companies and networking with the private sector, both in our country and in the environment.

The BSC Bar Incubator began operations in 2010, with a core mission to support entrepreneurship promotion through comprehensive and integrated MSC support. BSC Bar is a general incubator, which conducts

activities with special emphasis on SME development through business skills training, consulting services, mentoring, financing through the competition of the best business plans, and the provision of business space in the business incubator on favorable terms. It operates 40 companies.

"Regionalni biznis centar" Berane d.o.o was established by the municipalities of Andrijevica, Berane, Plav, Rožaje, Bijelo Polje and the Regional Development Agency for Bjelasica, Komovi and Prokletije. In the business zone "Rudeš", a facility for the needs of the Regional Business Center and business incubator was reconstructed and equipped. The facility of 1000 m^2 is intended for beginners in business and is a production and service type. The project also implements training for incubator employees in order to create preconditions for business beginners to realize their business ideas. The center was opened in February 2016.

7.4 Public private partnerships

Gathering reliable data on existing PPP projects in Montenegro is challenging as there is no systematic recording of PPPs at the central level. The Commission for Concessions runs a Registry of Concession Contracts which contains data on several PPP projects but the distinction between PPPs and other types of concessions is not always clear [Montenegro PPP Units and Related Institutional Framework].

PPPs in Montenegro can be authority-pay and user-pay contracts (concessions). The procedure for awarding authority-pay contracts is not clearly regulated as there is no legal framework for this type of PPPs. The procedure for awarding user-pay contracts is defined by the Law on Concessions.

The Law on Concessions defines several types of concession contracts although only public works and public services concessions can be considered PPPs.

To date, the PPP market in Montenegro has been relatively narrow and fragmented. Apart from a bundle of several small DBOT projects under the management of the Ministry of the Economy, there has never been any attempt to set up a PPP programme. A few central or local authorities have however implemented isolated PPP projects.

According to the information provided by the Prime Minister's Office and the Commission for Concessions, several PPP projects have been implemented at the national and sub-national levels and a number of others are in preparation.

Montenegro didn't have the Law on public-private partnership until recently. It was promulgated by the Decree of the President of Montenegro on December 25, 2019, and entered in force on January 4, 2020. Based on data from PPP Knowledge Lab only two PPP projects were developed in Montenegro, both in the sector of Electricity, Krnovo Wind Farm in 2015 with investment of 154.60 million USD, and Montenegro Mozura Wind Farm in 2018 with investment of 99.75 million USD [https://pppknowledgelab.org/countries/montenegro].

7.5 Summary and conclusions in relation to SWOT elements

Table 7.5.1: SWOT analysis of Skills, education, research and innovation potential of Montenegro

Strengths • Highly-skilled engineering professionals are educated, which are very flexible or adaptable	**Weaknesses** • Little medium TRL (3–6) research/development infrastructure, slowing down development.
Opportunities • Setting up pilots in order to speed up development.	**Threats** • The loss of engineers due to brain drain migration or competitiveness due to PPP pilots lacking

8 Policy framework: Regulations, legislation, rule of law & taxes and tariffs

8.1 Introduction

Montenegro does not have the integral strategy that would encourage the development of the bioeconomy. Although there is no such strategy, there are a number of other, sectoral, strategies that to some extent cover individual sectors of the bioeconomy. Strategies and regulations are being developed and harmonized within the process of association and accession to the European Union. The chronology of Montenegro and the EU relations and opening of the most important chapters for bioeconomy development, as well as the activities on which will be the focus in the coming years are given in Table 8.1.1 [44, 45].

Table 8.1.1: Overview of the most important chapters in the process of negotiation between EU and Montenegro

Date	Chapter	Comment and activities in future
Dec. 2012	Chapter 25: Science and research - official launch and provisional closing	Although harmonization is not necessary, Montenegro has its own national legislative and strategic framework in this area and it is regulated by: – Law on Scientific Research Activity – Law on Innovation Activity – Strategy of Innovation Activity 2016-2020 with the Action Plan – Strategy of Scientific Research Activity 2017-2021 with an Action Plan. Montenegro has created a new strategic framework with the Smart Specialization Strategy - S3 (2019-2024) which is based on the available resources and potential of Montenegro for their use, identification of competitive advantages and technological specialization as the basis for future innovative activities. The EU "Policy Support Facility" project for creating a stimulating innovative environment for startups and other key actors in the innovation system was implemented, financed from the Horizon 2020 program, and the Innovative Startup Encouragement Program (2019-2021) with the Action Plan (2018) was adopted. The first Innovation and Entrepreneurship Center "Technopolis" was established in Nikšić (2016), and the Science and Technology Park of Montenegro in Podgorica (2019) was established, whose founders are the Government of Montenegro and the University of Montenegro. In the coming year, Montenegro should in increase participation in Horizon 2020 and intensify investment in research.
Dec. 2013	Chapter 20: Enterprise and industrial policy	Montenegro has defined a strategic framework for increasing gross value added, employment, exports, addressing regional development issues and structural adjustment of the economy. To that end, the Government adopted the document Industrial Policy of Montenegro until 2020, which defines the priorities of industrial development with an emphasis on creating conditions for its modernization and increasing the competitiveness of the Montenegrin economy. In the coming year, Montenegro should in particular: – continue to improve the implementation of industrial policy, in cooperation with stakeholders; – adopt a revised industrial policy and action plan after finalizing a mid-term review.
Dec. 2014	Chapter 33: Financial and budgetary provisions	The focus of activities in the coming period will be on the implementation of the Action Plan for the establishment of the EU's own funds system in Montenegro, which was adopted in April 2019.
March 2015	Chapter 16 – Taxation	By the time of accession to the European Union, Montenegro must establish a system of exchange of VAT information between the competent authorities, which allows the exchange of VAT data between the Member States through a common information network, i.e. that such data may be obtained by any

		member of the Union, its tax administration, as well as taxpayers. It is also necessary to provide for the supervision of the movement of excise goods, or its electronic monitoring, especially in situations where the payment of excise tax and the exchange of information between the competent authorities of the Member States is postponed. Therefore, in the coming year, Montenegro should in particular: – further align legal framework and rules of administration for the own resources system and VAT with the EU acquis; and respect commitments made in the framework of the technical assistance and own resources monitoring programme; – update and fully implement the own resources system action plan; – ensure adequate capacity at the Directorate for Coordination and Management of EU resources and at all institutions involved in the own resources system.
Dec. 2015	Chapter 14 - Transport policy	Montenegro will ensure increasing road safety as well as better protection of passengers in all types of traffic. When it comes to road traffic, there is greater road safety, the safety of transporting dangerous goods, and the introduction of smart tachographs. In rail, one of the benefits is fair access to the market as well as simplification of licensing procedures. Air traffic is also improving the regulation in the field of air navigation services and airspace management. In the coming year, Montenegro should in particular: ensure the operational independence and appropriate staffing of the railway regulatory body and the railway safety authority; – lay down the strategic framework for implementing intelligent transport systems (ITS) on its core road, rail and maritime network and to align with the EU ITS Directive; – achieve full membership of the Paris Memorandum of Understanding (MoU) on Port State Control.
Dec. 2015	Chapter 15 – Energy	In the forthcoming period, efforts will be focused on intensifying activities to meet the final benchmarks, as well as to achieve the goals of the European Union's energy policy related to security of energy supply, sustainability and competitiveness. In addition to addressing the shortcomings set out below, in the coming year Montenegro should, in particular: – create or join a functioning day-ahead market and couple with neighboring markets, including Italy; – move to market-based support schemes for renewable energy production and streamline the permitting and connection procedures; – adopt the Law on security of supply of oil products and set up the stockholding body for the mandatory oil stocks.
Dec. 2016	Chapter 11 - Agriculture and rural development	In the coming period, Montenegro should in particular: – implement the measures entrusted to it under the IPARD II programme and seek to be entrusted with budget implementation tasks for other measures of the programme; – implement the action plan for EU acquis alignment on agriculture and rural development, in particular by further developing the Integrated Administration and Control System (IACS).
June 2017	Chapter 22 - Regional policy and coordination of structural instruments	In the coming year, Montenegro should in particular: – make further efforts to enhance the implementation of EU pre-accession funding under indirect management, in particular by developing a management information system; – continue implementing the action plan for meeting requirements deriving from EU cohesion policy; – take measures to put a far greater emphasis on cross-sector strategic planning and preparation.

The Government of Montenegro and the Chamber of Commerce of Montenegro, with the support of the UNDP, began the process of creating guidelines for the development of the Roadmap of Montenegro to the circular economy [46].

8.1.1 STRATEGY FOR THE DEVELOPMENT OF AGRICULTURE AND RURAL AREAS 2015-2020

The aim of the strategy is to establish a framework and path for the development of agriculture and rural areas in the context of the general Montenegro's priority to pursue an EU accession policy [47]. Montenegro does not have the capacity to be competitive in the market of the EU's main agricultural products, but therefore has the potential to develop the production of high quality agricultural and food products in an innovative and traditional way.

The main objectives in the areas of Agriculture and Rural Development are as follows [48]:

1. The long-term management of agricultural resources in a sustainable way, along with the preservation of the environment,
2. Ensuring a stable supply of safe food that is affordable both in terms of quality and price;
3. Improving both the standard of living of the rural population and the standard of rural development in general, whilst preserving traditional values; and
4. Strengthening the competitiveness of food producers.

Two of the main priorities for Montenegrin agriculture are to produce high quality food and to increase the number of producers who operate in accordance with the rules of organic production. Montenegro has committed to such improvements primarily because of its natural characteristics that do not allow for mass production. Results can only be achieved by integrating the various quality assurance standards regarding food safety, quality schemes (designations of origin, geographical indications and designations of guaranteed traditional specialty) and organic production, into agricultural production. The allocation of support for the introduction of quality standards, education and the promotion of products will continue.

In the long-term, Montenegro aims to increase its number of producers involved in quality schemes and in organic production as well as increasing the scope of production in all areas of agriculture in Montenegro. Recognizable brands will be created and will hopefully find a niche on the demanding EU market. Tourism, as a driver of the Montenegrin economy, presents a significant market for local products. Traditional products of high quality will be attractive to tourists while also linking agriculture and tourism in terms of developing rural tourism. Rural tourism has significant potential in the Northern Region of Montenegro and represents an extra income for agricultural holdings.

For IPARD accreditation purposes, Montenegro will work on strengthening its administrative capacity, both in Ministry and in advisory services, with the aim of fully implementing IPARD measures and also maximizing the use of funds by producers. Montenegro had a positive experience when implementing the World Bank project, MIDAS, which was aimed at the preparation of agricultural producers and their administration for IPARD. In the long-term, the main objective regarding administrative capacity is the accreditation of a Paying Agency for the implementation of CAP; this implies the establishment and full operational capacity of IASC.

8.1.2 National forest strategy (2014-2023)

The forests of Montenegro with their quality, functions and products are recognizable symbol of an ecological state. Forestry, wood and non-wood products are an integral part of rural economy and rural development. In addition to agriculture and rural tourism, they are one of the main opportunities for socio-economic improvement of rural areas.

The strategy has two general objectives relating to forests as an ecosystem and as natural resource and on economic sector of forestry and wood industry [49]:

- improvement of forests and sustainability of management by increasing forest stock in forests available for use from 104 to 115 million m^3 of gross wood mass;
- increase the general income deriving from forestry sector, timber industry and other dependent activities performed on the territory of Montenegro.

IPARD funds will be used for development breakthroughs in the following areas: afforestation, filling and care of young and degraded stands; fire protection; rural infrastructure, including rural and forest roads; diversification of the rural economy related to forests; investments in small enterprises of forestry, wood industry and tourism in rural areas.

In addition, forestry is actively involved in the implementation of EU Natura protected areas 2000.Potential of services and products, including timber, non-finished products, recreation and tourism and ecosystem services have been valorized to support investment in forestry transporters and forest care, which increased the share of forestry and wood industry.

8.1.3 Waste management strategy until 2030

Waste Management Strategy of Montenegro until 2030, implies a wide range of achieved goals in terms of creating conditions that as the result should contribute to improving the quality of life of the population. Based on the National strategy of sustainable development of Montenegro, as its basic document, but also a constitutional determination Montenegro is developing as an ecological country, and the Strategy defines its goals as needed ensuring synergy of state development and preservation of the environment in terms of the impact of waste on quality basic parameters.

The Waste Management Strategy defines the following goals [41]:

- accelerated and intensive development of public awareness related to waste management, as well as equally important and binding participation of population, industry and state institutions in the functioning and respecting of the established waste management systems;
- introduction of the principles of circular economy in the production and trade system in Montenegro with a clear goal of improving the reuse of materials and products;
- achieving a satisfactory level of development and intensive application in the practice of the system primary and secondary selection of waste, all with the aim of collecting recyclable, primarily packaging, materials for reuse and / or recycling, i.e. their economic
- valorization, i.e. processing into other products of similar or lower quality, which certainly have a place in the market;
- increasing the degree of separation and utilization of biodegradable waste;
- increasing the level of separation and adequate recycling and disposal of construction waste and demolition waste;
- providing treatment of sewage sludge;
- reducing the amount of waste that needs to be permanently disposed of in one of the landfills;
- preparation of the waste management system for future utilization of energy from waste and / or thermal treatment of waste.

8.1.4 Industrial Policy of Montenegro for the period 2019-2023

Industrial policy of Montenegro 2019-2023 is a strategic document for the development of the competitiveness of the economy of Montenegro with a focus on the industrial sector. Industrial policy 2023 recognizes that the real drivers of change and development are legal entities that need to maximize their potential for growth, development and competitiveness with adequate support. The Industrial policy of Montenegro links with strategic national documents, as well as documents from the EU and the region (Figure 8.1.1 [50]).

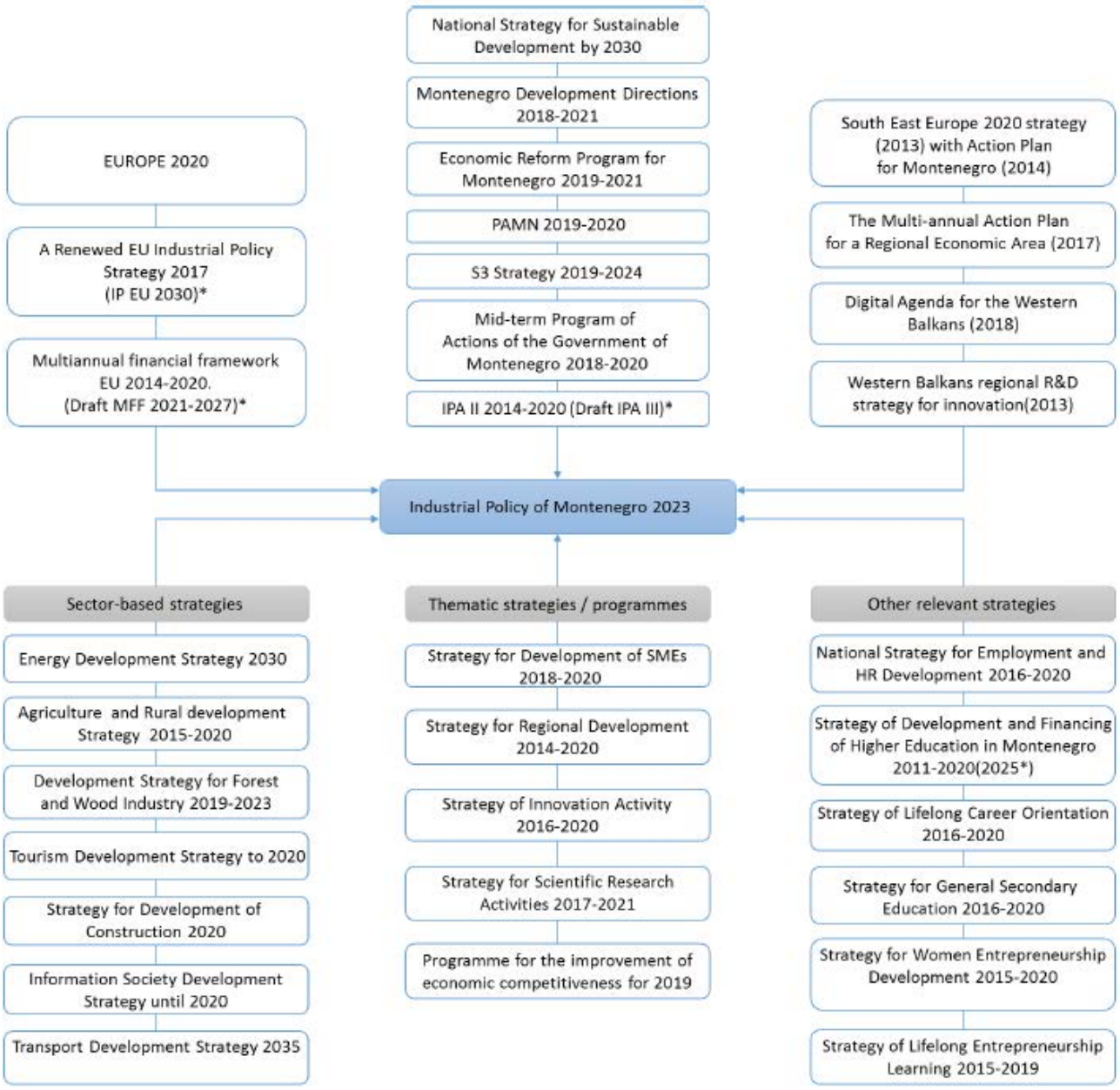


Figure 8.1.1: Overview of the linkages between strategic documents

The main objective of Industrial policy is to improve infrastructure and business environment for efficient industrial development, increase in investments for modernization of industry, stimulating innovation, technology transfer and development of entrepreneurship, as well as improving access to the market. The basic priorities are:

- Establishing preconditions for further improvement of physical infrastructure for development as well as more efficient use of available resources in order to reduce the cost of input components;
- Enhancing the growth and development of companies, based on efficiency, productivity and innovation.

The strategic goals of the Industrial Policy 2019-2023 were formulated as follows [50]:

- SG1: IMPROVING INFRASTRUCTURE AND BUSINESS ENVIRONMENT FOR EFFICIENT INDUSTRIAL DEVELOPMENT: further development of the energy and transport sectors (improved physical capital), strengthening of ICT infrastructure, enhancing sustainable resource management, development of human capital and improving the regulatory framework and business environment.

- SG2: IMPROVING INVESTMENTS AND FINANCES FOR MODERNIZATION OF THE INDUSTRY: Improved investment and regulatory framework for industry modernization through better approach, availability and accessibility to financing, improving access to financing for competitive and innovative enterprises with the growth of investments in the manufacturing sector.
- SG3: STIMULATING INNOVATION, TECHNOLOGY TRANSFER AND ENTREPRENEURSHIP DEVELOPMENT: enhanced infrastructure for innovation and co-operation between scientific and research institutions and companies, strengthened capacities for accessing the EU funds, development of institutional infrastructure and supporting services for entrepreneurship development; development of the green economy, supporting diversification of the industrial offer in the regional context, and dynamic digitalization of society and economy;

SG4: IMPROVING ACCESS TO THE MARKET: simplified trade procedures and reduced technical barriers to trade, improved clustering and linking to international value chains, and strengthening the export performance of companies.

8.1.5 Taxes and tariffs in Agriculture sector

The Agriculture and Rural Development Program of Montenegro under IPARD II 2014-2020 (IPARD II Program) is one of the preconditions for using European pre-accession funds through IPA II - the field of agriculture and rural development policy. A total of EUR 51 816 473 in grants will be made available to Montenegrin farmers through the implementation of the IPARD II program, of which EU funds amount to EUR 39 000 000 and national co-financing amounts to EUR 12,816,473 with user input [51],
The implementation of the IPARD II program will invest around 86 million euros in Montenegrin agriculture.

The objective of the IPARD II program is to restructure and modernize the agricultural and processing sectors, with the aim of creating competitive farms and processing sectors, ready to enter the EU and use EU funds.
The IPARD II program includes seven support measures:

Measure 1	Investments in physical capital of agricultural manufactures
Measure 3	Investments in physical capital related to the processing and marketing of agricultural and fishery products
Measure 7	Diversification of manufacturing and business development
Measure 9	Technical assistance
Measure 4	Agro- environmental-climate and organic production measures
Measure 5	Implementation of local development strategies - leader approach
Measure 6	Investments in public rural infrastructure

Montenegro has so far accredited the management structure and obtained from the European Commission's authority the approval to implement measures 1 and 3.

8.1.6 Investment and Development Fund

Investment and Development Fund of Montenegro (IDF MN) was established by the Law on Investment and Development Fund of Montenegro JSC ("Official Gazette of Montenegro" No. 88, dated December 31 2009). The Fund is established with the purpose of supporting and facilitating economic development of Montenegro through: completing privatization process by sale of capital generated in the process of ownership transformation, supporting micro, small and middle companies and entrepreneurs, supporting infrastructure project, water supply projects, waste waters treatment and environmental protection, as well as financing project of local, regional and state-level importance.

Investment and Development Fund is the organization which provides a success measure for development institutions effectively and efficiently rendering services to beneficiaries and supporting sustainable development of the community. The main areas of work are [52]:

- Growth and development of micro, small and middle companies
  - Supporting start ups
  - Enabling entrepreneurs to launch new investment cycle
  - Strengthening entrepreneurship capacities
  - Improving company liquidity
- Encouraging balanced regional development
- Encouraging development of priority sectors (tourism, agriculture, wood processing, production, services)
- Promoting competitiveness of local companies
- Supporting new work capacities
- Supporting new products and technologies development
- Encouraging export
- Financing environmental production and infrastructure projects.

An overview of the supporting measures is given in Table 8.1.2 [53].

Table 8.1.2: Overview of financial support program in 2020

Program	Measure
Entrepreneurship Development Support Program	Direct credit line: – Maximum amount up to € 50 000; – The interest rate is 2.50% per annum with proportional – method of interest calculation; – Repayment period up to 12 years (including grace period); – Grace period up to 4 years. Special credit conditions: – For entities that implement projects in the municipalities of the northern region and in municipalities that are below the average value of the index development rate in Montenegro, the interest rate is 2.00 % on annually with a proportional method of interest calculation.
Start-up program	Credit line: – Maximum amount up to € 50 000 (for entrepreneurs up to € 30 000); – The interest rate is 3.00 % per annum with – proportional method of interest calculation; – Repayment period up to 12 years (including grace period); – Grace period up to 4 years. Special credit conditions: – For entities that implement projects in the municipalities of the north regions and in municipalities that are below average – of the development index in Montenegro, the interest rate is 2.50 % on annually with a proportional method of interest calculation.
Program youth in business program	Credit line: – Maximum amount up to € 50 000 (for entrepreneurs up to € 30 000); – The interest rate is 2.50 % per annum with – proportional method of interest calculation; – Repayment period up to 12 years (including

	grace period); – Grace period up to 4 years. Special credit conditions: – For entities that implement projects in the municipalities of the north regions and in municipalities that are below average development index in Montenegro interest rate is 2.00% on an annual basis with a proportional interest calculation system.
Development of micro, small and middle companies and entrepreneurs	Loans approved under this credit line will be financed 50% from funds of EBRD. – Maximum amount up to € 100 000 (for start - up companies up to – € 50 000, while with the guarantee of a creditworthy legal entity it is possible – approve over € 50 000; for entrepreneurs up to € 30,000.00); – The interest rate is 3.50 % per annum with – proportional method of interest calculation; – Repayment period up to 8 years (including grace period); – Grace period up to 1 year. Special credit conditions: – For entities that implement projects in the municipalities of the northern region and in municipalities that are below the average value of the development index in Montenegro, the interest rate is 3.00% per annum with proportional method of calculating interest.
Program for permanent financing of micro, small and middle companies and entrepreneurs	Loans approved under this credit line will be financed 50 % from funds of EBRD. – Maximum amount up to € 100 000; – The interest rate is 4 % per annum with proportional – method of interest calculation; – Repayment period up to 6 years (including grace period); – Grace period up to 1 year. Special credit conditions: – For entities registered in the municipalities of the northern region and in municipalities that are below the average value of the development index in Montenegro the interest rate is 3.50% per annum with proportional method of calculating interest.

8.2 Summary and conclusions in relation to SWOT elements

Table 8.2.1: SWOT analysis of Bioeconomy Policy Framework of Montenegro

Strengths	**Weaknesses**
• Implementation of the EU Stabilization and Association Agreement and significant experience in the process of accession to the EU • Favorable investment climate (incentives and tax allowances for investors) • Implementation of the Free Trade Agreement (EFTA, Turkey, Ukraine, and others), economic co-operation as well as mutual encouragement and protection of investments with other countries	• use of energy-intensive and often outdated technology and equipment • low productivity rate in industry • Insufficient connectivity between the industrial sector and scientific research institutions • insufficient investment in research and development • discrepancy of the labor market and the education market • weak industrial relations with other sectors in the economy • small number of SMEs which develop development on innovation
Opportunities	**Threats**
• ensuring resource efficiency through sustainable management and use of resources and preserving the quality of the environment • developing products and services with higher added value • modernization of production processes through the introduction of new technologies and innovations • compliance with the requirements of international business standards and acceptance of EU standards • reducing barriers to business development and access to the market • greater connection of companies and scientific and research institutions • digitalization of the economy and society • development of the financial market and the possibility of access to funds for medium technology and high technology areas • integration into EU industrial development programs and projects (IPA II, Horizon 2020, COSME, EASI, etc.) • efficient use of public-private partnerships	• lack of capital for the development of the industrial sector • administrative obstacles to investment and business development • insufficient investment in education and training of employees • strong foreign competition is present in the local market

9 Financing

9.1 Introduction

Due to a fact that Montenegro has substantial potential for new projects in the area of renewable energy, energy sector is one of most prospect sectors of industry in Montenegro (wind farms, small hydro plants, solar energy, biomass, oil and gas, etc.).

Notwithstanding the relatively small size of Montenegro's energy market of around only 385 000 customers (electricity production in Montenegro in 2018 was approximately 3,787 GWh), Montenegro has ambition to become an energy hub of the Balkans. With the impending completion of the Montenegro – Italy project of construction of electricity transmission system of underwater energy cable, Montenegro will be able to export electricity to Italy, from its own sources and also from the countries of the region.

Montenegro adopted three packages of EU directives and regulations. Montenegrin Regulatory Agency for Energy (RAE) has an observer status at the Agency for the Cooperation of Energy Regulators (ACER), being the first non-EU regulator to obtain this status. This is another signal that investors in Montenegro are guaranteed the status and rights as in any EU country.

Electricity market in Montenegro has been liberalized as of 1 January 2009 for all consumers, except households, which obtained the right to choose their own supplier in 2015. Montenegro's operator of the distribution system CEDIS (www.cedis.me) was established in 2016, ensuring a non- discriminatory access to the distribution network.

Apart from the state-owned power utility EPCG (www.epcg.com), five more electricity suppliers operate in the Montenegrin electricity market: Montenegro Bonus LLC (majority State owned) (www.montenegrobonus.me/en/ , Energia gas and power Podgorica (private, Slovenian), Uniprom Nikšić (private, Montenegrin), Energia gas and power (private, Slovakia) i Petrol Crna Gora (private, Slovenian).

Procedures for projects in the field of renewable energy sources

According to the Law on Concessions, concessions imply designing, constructing, maintaining and using of the energy-related and other structures for generation, transmission, and distribution of electrical energy, thermal energy, and gas or the reconstruction, modernization, maintenance, and usage thereof. Concessions shall be awarded pursuant to an annual plan adopted by the Government and published on the web site of the Government of Montenegro: www.gov.me, www.mek.gov.me.

The energy permit is issued in accordance with the Energy Law and the Rulebook on the contents of the request for issuing an energy permit and the content of the energy permit register, based on the annual plan adopted by the Government of Montenegro. On the basis of concluded concession contracts, concessionaire pays the concession fee.

The Government has not envisaged issuing energy permits in its Plan for 2019.

Pursuant to the Law on State Property, investors are obliged to pay the rent for the state-owned land which is the object of a land tenure agreement concluded with the Government of Montenegro.

The Institutional Development and Strengthening of Agriculture of Montenegro (MIDAS) project is funded by the World Bank and implemented by the Ministry of Agriculture and Rural Development (MAFRD). It is conceived as such to prepare a part of Montenegrin institutions in the field of agriculture and agricultural producers for pre-accession and accession period to the European Union (EU). This preparation refers to several aspects, from the establishment and construction of new institutions, through the strengthening and modernization of existing ones, to the preparation of agricultural producers themselves to the conditions that await us in the EU market competition. The main weaknesses of the agricultural sector in Montenegro are related to unfavorable structures of agricultural holdings (farms), especially in the livestock sector. There are a large number of farms with small livestock (cattle, sheep, goats), as well as a large number of semi-natural companies. The overall situation in the agricultural sector is characterized by a high share of small farms, a

high level of fragmentation of arable agricultural land, a low level of modernization of agricultural holdings and a lack of investment capital. There is currently a general shortage of large quantities of raw materials of adequate quality, especially meat, to cover domestic needs.

Although trade opportunities are substantial, producers and agricultural processors will, if not become more productive, face difficulties in competing with low-priced and high-quality imports in both domestic and foreign markets. Also, one of the very important causes of insufficient competitiveness of Montenegrin agriculture is the low productivity of working capital, which results from insufficient technical and technological equipment of farms. Agricultural farms, due to the unfavorable economic and social situation, are not able to provide enough funds for the modernization of production. Production is less efficient and human resources are less used. With better equipment and modern mechanization, it is possible to better meet the requirements of maintaining natural resources, protection and welfare of animals and food safety.

The MIDAS grant scheme is conceived as a simulation of the IPARD grant program, which awaits us in the coming period. From call to call, the MIDAS grant scheme approaches the IPARD program with its procedures, enabling beneficiaries (farms and agricultural companies) to adapt to the rules that await them in the IPARD program through the so-called soft landing, and later through other forms of support for the EU's Common Agricultural Policy. In this process, Montenegrin institutions (IPARD Paying Agency, Sector for Rural Development - Managing Authority, etc.) are also adjusted, built, trained, accredited and become reference bodies that will enable the use of EU programs and funds intended for agriculture.

The amount of eligible investment is 10 000-70 000 € for measures Investments in agricultural holdings, and support is provided in the amount of 50 % of eligible investments, for all investment sectors. While for measures (I) Agri-environmental investments in mountain farms, the amount of eligible investment is € 3 000-50 000, with a grant of up to 60 % of the value of the investment; and in measure (II) Manure management and erosion prevention, the amount of eligible investment ranges from 5 000 to € 70 000 with a grant of up to 60 % of the investment value

Montenegro is committed to the application of the principles of a multiparty system, pluralism and a market economy in accordance with the conditions set out in Article 1 of the Agreement Establishing the European Bank for Reconstruction and Development ("EBRD"). In the period since the adoption of the previous strategy, Montenegro's efforts to move closer to the European Union (EU) have remained a major external anchor for comprehensive reforms, and it is currently the most advanced country in the Western Balkans region in its EU integration.

Economic growth remained stable in 2016 and is expected to increase further in the short term, with the help of continued strong foreign direct investment (FDI), growth in an important tourism sector and the impact of large infrastructure projects under way, but the economy faces a number of structural constraints and shortcomings. Montenegro's business environment has improved over the years, but it is still hampered by problems with access to electricity and property registration, and problems in areas dealing with building permits.

Access to finance for many firms and SMEs is difficult and the legacy of outstanding loans continues to hamper credit growth. Agriculture is one of the most important sectors of the economy, but productivity in the sector remains relatively low, due to fragmented land ownership, so further connections with other sectors are underdeveloped. Montenegro's ability to take advantage of its comparative advantages as a tourist destination remains limited by underdeveloped transport and utility infrastructure.

Montenegro has significant potential for growth and the Bank's strategy is ambitious in its support of the country's development program, as stated in the Montenegrin Development Directions (MDD) and in the Draft Economic Reform Program of Montenegro 2017-2018 (ERP). These domestic incentives to accelerate reforms, combined with progress in Montenegro's accession to the European Union (and related EU funding available), have been established to provide additional support to the Bank to deepen and expand its engagement in the new strategic period.

The EBRD will focus on the following three strategic priorities:

• Priority 1: Increase the competitiveness of the private sector, also through the development of agricultural retail chains and tourism feedback. As Montenegro aspires to EU membership, it needs to develop a more resilient, innovative private sector that will help accelerate the country's productivity approach to those already in the EU in terms of productivity. The Bank will thus seek to support local companies in fostering innovation and adopting best operational skills and management practices, including aligning Montenegro's comparative advantages through, inter alia, developing agricultural retail chains and promoting linkages with the dominant tourism sector through a combination of investment and advisory services. small business. Improving access to finance for SMEs and underserved segments will remain a priority, as will the Women in Business (VIB) program. To this end, the Bank will continue to provide long-term financing directly and through partner financial institutions (banks, as well as leasing and factoring companies) to privately owned domestic companies, as well as on a risk-sharing basis.

• Priority 2: Improve connections and regional integration through the expansion of cross-border transport and energy links. The lack of a road network and outdated railway infrastructure, their inadequacy exacerbated by Montenegro's mountain topography, prevent cross-border integration, making the regional goal of improving connections in the Western Balkans particularly important for Montenegro. The Bank, in cooperation with the European Investment Bank (EIB), will support key projects in the road infrastructure sector, especially those that serve to improve the country's connectivity with the rest of the region, including the improvement of major internal roads connecting to cross-border connections. To increase energy connectivity, the Bank will continue to promote the creation of a regional energy market, by coordinating ongoing initiatives, including the work of the Coordinated Auction Office (CAO) in South East Europe, established by regional transmission system operators with the support of the European Commission. (EC) and the EBRD. In addition, the Bank will continue to support the development of a new high-voltage underwater electric cable, connecting Italy and Montenegro, as part of the wider Trans-Balkan Corridor, through investments in high-voltage transmission infrastructure to various connection points.

• Priority 3: Continue to encourage the transition to a green economy, including sustainable tourism. As Montenegro marks 25 years since declaring itself an "environmental" country, the Bank will support the move towards a more environmentally friendly and sustainable economy through selected investments in industrial waste disposal, water resources management and sustainable energy. Montenegro's energy intensity remains high and there is a need to make progress in implementing the legal framework to support sustainable energy projects, as well as reducing network losses and depending on political will, developing efficient production capacities and renewable energy sources and promoting smart grids. In addition, support for sustainable tourism, which minimizes negative social and environmental impacts and generates more inclusive economic benefits for local people, is also crucial in the context of Montenegro, whose tourism industry generates its main export product and, as such, is the most reliable driver. economic growth. Modernization of existing hotels through privatization, resolving seasonal issues through promoting the development of congress tourism and health tourism facilities, and modernization of supporting infrastructure, are areas of potential involvement of the Bank.

The new strategy envisages the continuity of the Bank's existing engagement, and the new strategic directions do not represent a material deviation from the priorities of the previous Strategy. It would be more to say that they imply a deepening of engagement and a sharpening of focus based on lessons learned. Investments and policy dialogue activities related to the three strategic priorities can be further adjusted in the context of: i) the progress of EU-related reforms that provide a better context for a proportional increase in the Bank's investment; ii) the extent of sovereign fiscal space that could hamper EBRD public sector investment; III) drivers of demand in the corporate sector, in particular progress on privatization and NPL initiatives that could create additional opportunities for investment within the private sector. Continued cooperation with the EU, international financial institutions and bilateral donors, in particular within the Western Balkans Investment Framework (WBIF), will be essential.

Energy sector

Despite initial delays in transposing the third EU energy package, Montenegro adopted a new Energy Law in December 2015 and a Law on Cross-Border Electricity and Gas Exchange in June 2016, thus fulfilling its transposition obligations. The new Energy Law promotes market integration and contains requirements regarding the unbundling of electricity system operators and a number of other measures to improve the national energy framework. The Law on Cross-Border Exchange of Electricity and Natural Gas defines the conditions for access to the system of electricity transmission and gas transport and transparency of the electricity and natural gas markets. This includes the procedure for system operator certification, international cooperation, interconnector capacity allocation and transparency requirements. Following the adoption of new energy laws, Montenegro should give priority to the drafting and adoption of relevant bylaws and the adequate implementation of the existing legal framework.

The Montenegrin electricity market was opened in 2009 to all eligible customers, with the exception of the household market, which was opened in 2015. The country is compliant with EU rules on security of electricity supply and infrastructure investment. The country also has the necessary framework for the structure of the gas market. The Energy Regulatory Agency of Montenegro (RAE) is a non-profit organization, legally and functionally independent from state bodies and energy entities. The RAE budget is adopted by the Assembly, but is funded by license fees, annual license fees and other costs set by RAE.

Priority 3: Continue to encourage the transition to a green economy, including sustainable tourism

Energy efficiency

While the regulatory framework of Montenegro on energy efficiency (EE) is already quite well developed by the Law on Energy Efficiency, the adoption of the new Law on Energy Efficiency will further improve the EE framework in the country. Namely, the latter introduced clearer procedures for measuring and verifying energy savings, established a new register of large consumers, energy performance certification procedures, defined energy-related products and obligations for market participants, set clearer inspection procedures, etc.

The new Law on Energy Efficiency has also allowed for the further development of bylaws in the field of EE. In accordance with the provisions of the Law on Energy Efficiency, in December 2015 the Ministry of Economy prepared new and updated existing regulations on energy efficiency, such as the Rulebook on methodology for determining annual primary energy consumption, the content of the energy efficiency improvement plan and the report on implementing a plan for large consumers; Rulebook on minimum energy efficiency conditions in buildings; Rulebook on certification of energy performance of buildings; Ordinance on performing energy audits of buildings and others.

As regards labeling, while the Law on Energy Efficiency has transposed the key requirements of Directive 2010/30 / EC, the Ordinance on the labeling of energy-related products has yet to be adopted.

Adoption of the remaining bylaws is a priority. Models for public-private partnerships in the field of EE, including the j + framework that enables the services of energy companies, need to be further developed. The institutional set-up must be strengthened, either by increasing capacity within the Ministry of Economy and local government or by establishing a special Energy Efficiency Agency.

The authorities should focus on the implementation of the third energy package in practice, which requires the adoption of comprehensive bylaws. The implementation of existing provisions, such as the implementation of unbundling and the adequate implementation of support measures for renewable energy, is also critical. RAE needs to further strengthen its institutional capacity to perform the functions provided for in the new energy law efficiently. The issue of renewable energy in the transport sector needs to be addressed. In addition, the regulatory and institutional framework for promoting EE in public buildings through enterprise energy services and other forms of public-private partnerships needs to be strengthened.

9.2 Summary and conclusions in relation to SWOT elements

Table 9.2.1: SWOT analysis of Bioeconomy Financing of Montenegro

Strengths	**Weaknesses**
• Natural resource wealth – potential for FDI attraction • Low customs duty rates • Low tax rates • Potential for the development of tourism, • energy industry, and agriculture • EU candidate status – access to funds	• Unused credit potential of banks • Inconsistent regional development • Underdeveloped infrastructure • Rigid labor market and unemployment • High FDI dependency, low levels of greenfield • investments, and investments in production • Low and not diversified exports • Dependency on imports and unfavorable • imports structure • High level of public debt • Shadow Economy • Tax evasion
Opportunities	**Threats**
• Agricultural production potentials – strengthening of processing sector in agriculture • Wood-processing industry and production of finished wood products • Potential for the development of low carbon tourism • Planned development projects, especially in • the sectors of tourism and energy • Actualization of major infrastructure projects • Tax debt collection • Attraction of FDI in production industries	• Further public debt growth • Threats of issued state guarantees being called upon • High level of fiscal deficit • Lower FDI inflow, low level of reinvestment and potential foreign capital outflow

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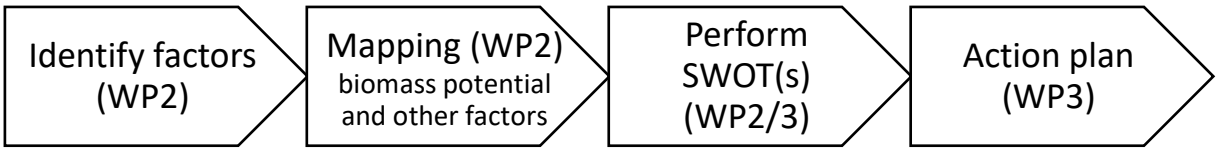
Annex 1 Approach guiding the structure and contents of this report

Identification of factors that are important for establishing bio-based production chains in a country

One of the objectives of the CELEBio project is to map opportunities in the target countries for setting up bio-based business activities. This includes the mapping of the biomass feedstock potentials, and other key success factors for establishing bio-based production chains, e.g. business activities, what bio-based products can be generated, and what is the market demand of these products.

The BBI is focused on the next bio-based products and markets: Chemicals, Plastics (polymers, materials, packaging), Specialties (surfactants, lubricants, pharmaceuticals, nutraceuticals, cosmetics), Textiles, Food ingredients and feed, Advanced biofuels.

To be able to perform SWOT(s) and generate action plans, the first step is to identify which factors are important. These factors should be determined based on the perspective of both entrepreneurs/business developers and governments. The identified factors should be mapped and will be the basis for performing a SWOT (Strength, Weakness, Opportunity and Threat) analysis for development of biobased production chains.



Based on input from industry and business developers a logical set of factors was identified that guide the choice of investing in the bio-based economy and location of conversion plants (Van Dam et al., 2014). This set is expanded/updated (amongst others based on the BBI project BIOFOREVER (bioforever.org)). Via an interview sheet, different stakeholders (15) from different countries (the Netherlands, Croatia, Czech Republic, Hungary, and Slovenia) were asked to comment on the factors and rank them.

Highest ranked factors:

- Feedstock supply: price, security of supply, quality
- Product market: price, off-take security
- Regulations, legislation, and rule of law

Medium raked factors:

- Financing: investors, subsidies, guarantees, risk minimization options
- Taxes and Tariffs
- By-product valorization: heat, CO2, fodder, lignin

Lowest ranked factors:

- Infrastructure: what part of the chain is already available (harbor, industries)
- Logistics: cost, reliable
- Technology: TRL, robustness, yield, CAPEX, OPEX
- Sustainability: economical, environmental, and social aspects

Overall, the ranking of the factors only differed slightly. Most of the experts mentioned that all the identified factors are important and that a system approach is key in developing biobased initiatives. If one link in the chain is missing, the biobased initiative will not succeed.

According the experts the most important stakeholders for establishing biobased production chains are:

- Producers/suppliers of biomass
- Chemical industry
- Energy industry
- R&D organizations
- Regulatory authority
- Environmental organizations
- Public

Annex 2 Explanation of the S2BIOM approach to assessing lignocellulosic biomass potentials from agriculture, forestry and waste

In S2BIOM project the core biomass cost supply data was generated in WP1 for 37 European countries at regional level. Lignocellulosic biomass assessed by S2BIOM includes biomass originating from the following:

- Primary residues from agriculture
- Dedicated cropping of lignocellulos biomass on agricultural area
- Wood production and primary residues from forests
- Other land use
- Secondary residues from wood industry
- Secondary residues of industry utilising agricultural products
- Waste collection/ tertiary residues

Data have been assessed for 2012, 2020 and 2030. They are provided for several 'potentials' including: a technical potential; a base potential considering currently applied sustainability practises; and further potential levels that are determined considering changing sustainability restrictions, mobilisation measures and different constraints to account for competing use.

The technical potential represents the absolute maximum amount of lignocellulosic biomass potentially available for energy use assuming the absolute minimum of technical constraints and the absolute minimum constraints by competing uses. This potential is provided to illustrate the maximum that would be available without consideration of sustainability constraints.

The base potential can be defined as the technical potential considering agreed sustainability standards for agricultural forestry and land management. The base potential is thus considered as the sustainable technical potential, considering agreed sustainability standards in CAP (Common Agricultural Policy) for agricultural farming practices and land management and in agreed (national and regional) forestry management plans for forests (equivalent to current potentials described in EFSOS II). This also includes the consideration of legal restrictions such as restrictions from management plans in protected areas and sustainability restrictions from current legislation. Further restrictions resulting from RED (Renewable Energy Directive) and CAP are considered as restrictions in the base potential as well. CAP sustainable agricultural farming practices include applying conservation of Soil Organic Carbon (SOC) (e.g. Cross Compliance issues of 'maintaining agricultural land in good farming and management condition' and avoiding soil erosion).

The user-defined potentials vary in terms of type and number of considerations per biomass type. Following the general nomenclature of potentials the user defined potentials can also be considered as sustainable technical potentials but differ in the constraints considered vs the base potential and among each other. The user can choose the type of biomass and the considerations he would like to employ and calculate the respective potential accordingly. This flexibility is meant to help the user to understand the effect on the total biomass potential of one type of consideration against the other. These can include both increased potentials (e.g. because of enhanced biomass production) or more strongly constrained potentials (e.g. because of selection of stricter sustainability constraints).

Technical, base and one user defined (UD) potential has been assessed for all biomass groups. For forest biomass many more user defined potentials were quantified. See underneath:

Table A2.1: Overview of agricultural residual biomass potential types and considerations in S2BIOM.

	Area/ Basis	Yield, Growth	Technical & environmental constraints on the biomass retrieval (per area)	Consideration of competing use	Mobilisation
Technical (straw & stubbles)	Area in 2012, 2020, 2030 with cereals, rice, sunflower, rape, corn maize	Growth based on regional growing conditions & management. Yield according to regional averages including expected developments in yield towards 2020 and 2030	Maximum volume of straw and stubbles that could be harvested in 2012, 2020 and 2030	None	None
Technical (prunings permanent crops)	Area in 2012, 2020, 2030 with fruit trees, vineyards, olive & citrus	Growth based on regional growing conditions & management. Yield according to regional averages including expected developments in yield towards 2020 and 2030	Maximum volume of prunings and cuttings that could be harvested in 2012, 2020 and 2030	None	None
Technical (sugarbeet leaves & tops)	Area in 2012, 2020, 2030 with sugar beet	Growth based on regional growing conditions & management. Yield according to regional averages including expected developments in yield towards 2020 and 2030	Maximum volume of sugarbeet leaves and tops that could be harvested in 2012, 2020 and 2030	None	None
Base (straw & stubbles)	As for technical potential	As for technical potential	Only the biomass part can be removed that is not needed to keep the SOC stable. This is assessed according to carbon content that is removed with the residue and the SOC level in the soil that has to be maintained.	None	None
Base (prunings permanent crops)	As for technical potential	As for technical potential		None	None
Base (sugar beet leaves & tops)	As for technical potential	As for technical potential	Removal of leaves and tops from field is only allowed in Nitrate vulnerable zones where nitrogen surplus needs to be declined through removal of nitrogen rich biomass.	None	None
User potential (straw & stubbles)	As for technical potential	As for technical potential	As in base	In cereal straw a subtraction is applied according to demand for straw for animal bedding & feed . For rice straw, corn stover and sunflower and rape stubbles no competing uses are assumed.	None
User potential (prunings & cuttings)	As for technical potential	As for technical potential	All pruned material is available that is currently according to real practices NOT used to maintain the SOC and fertility of the soil. So the part that is now removed to the side of the field for energy uses or that is burned with & without energy recovery is seen as potential and can be removed. This follows the common treatment practices of prunings as assessed in the EUROpruning project.	None	The potential that is NOT used for SOC and fertility maintenance according to current practices needs to be mobilised gradually as it requires a change in management. It is therefore assumed; it becomes available from 50% in 2012 to 60% in 2020 and 70% in 2030.

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Table A2.2: Overview of woody biomass potential types used in S2BIOM.

	Area/ Basis	Yield, Growth	Technical & environmental constraints on the biomass retrieval (per area)	Consideration of competing use	Mobilisation
Technical	Forest area available for wood supply. This excludes protected and protective areas, where harvesting is not allowed according to protection purpose.	Growth based on regional to national growing conditions, including changes in biomass increment due to climate change. Yield according to regional management guidelines for age limits for thinnings and final fellings.	Maximum volume of stemwood that could be harvested annually during 50-year periods. Technical constraints on residue and stump extraction (recovery rate)	None	None
High	As for technical potential	As for technical potential	As for technical potential, but considering additional less stringent constraints (compared with base potential) for residue and stump extraction: Site productivity -Soil and water protection: ruggedness, soil depth, soil surface texture, soil compaction risk -Biodiversity (protected forest areas) -Soil bearing capacity.	None	None
Base	As for technical potential	As for technical potential	As for technical potential, but considering additional constraints for residue and stump extraction: -Site productivity -Soil and water protection: ruggedness, soil depth, soil surface texture, soil compaction risk -Biodiversity (protected forest areas) -Soil bearing capacity.	None	None
User potential - option 1	Reduction of FAWS by 5%	As for technical potential	Equivalent to increase of protected forest area by 5%.	None	None
User potential - option 2	Reduction of FAWS by 5%	As for technical potential	Increase of protected forest area by 5% and increase in retained trees by 5%.	None	Reduction in harvest by 5%
User potential - option 3	As for technical potential	As for technical potential	No stump extraction.	None	None
User potential - option 4	Reduction of FAWS by 5%	As for technical potential	Increase in protected forest by 5% plus increase in retained trees by 5% plus no stump extraction	None	Reduction in potentials by 5%
User potential - option 5	As for base potential	As for base potential	As for base potential	Roundwood production for material use (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Pulpwood, Round & Split + Other Industrial Roundwood) in period 2010-2014) subtracted from BP.	None
User potential - option 6	As for base potential	As for base potential	As for base potential	Roundwood production for material use excl. for pulp and paper and board industry (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Other Industrial Roundwood) in period 2010-2014) subtracted from UP4.	None
User potential - option 7	As for user potential - option 4	As for user potential - option 4	As for user potential - option 4	Roundwood production for material use (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Pulpwood, Round & Split + Other Industrial Roundwood) in period 2010-2014 subtracted from BP.	As for user potential - option 4

	Area/ Basis	Yield, Growth	Technical & environmental constraints on the biomass retrieval (per area)	Consideration of competing use	Mobilisation
User potential - option 8	As for user potential - option 4	As for user potential - option 4	As for user potential - option 4	Roundwood production for material use excl. for pulp and paper and board industry (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Other Industrial Roundwood in period 2010-2014) subtracted from UP4.	As for user potential - option 4

Table A2.3: Overview of potentials calculated for biowaste and wood waste.

Technical potential The Technical potential represents the amount of biomass assuming only technical constraints and a minimum of constraints by competing uses. In case of biowaste no constraints are considered in the technical potential. In case of post-consumer wood, the technical potential assumes that 5% of all wood waste cannot be recovered and used for energy application for technical reasons. Competing uses (current material application of the wood) are not taken into account.
Base potential This is the sustainable technical potential, considering currently agreed sustainability standards. In case of biowaste the base potential equals the technical potential. In case of post-consumer wood, the base potential takes into account the current material application of recovered wood, and assumes that this material application remains constant in 2020 and 2030
User defined potential The user-defined potentials vary in terms of type and number of considerations per biomass type. The user can choose the type of biomass and the considerations he would like to add and calculate the respective potential. This flexibility is meant to help the user to understand the effect on the total biomass potential of one type of consideration against the other. In case of biowaste no user-defined potentials have been developed. In case of post-consumer wood, one user-defined potential has been developed. This user defined potential on cascading use of post-consumer wood takes into account the current material application of post-consumer wood in 2012, and assumes that the material application of non-hazardous post-consumer wood will increase to 49.2% in 2020 and 61.5% in 2030, or remain stable if current (2012) material use is higher.

Primary agricultural residual biomass assessments

For the assessment in S2BIOM (like for Biomass Policies) land-use and livestock production levels are used based on the most recent CAPRI baseline run 2008-2050, providing intermediate results for 2010, 2020, 2030 and 2050.

The potential supply of agricultural residues was estimated for the period from 2012, 2020 and 2030. It uses as main input the cultivated land and main crop production and yield combinations made for these years by the CAPRI model. Residual biomass covered in S2BIOM from agriculture comes from primary residues from arable crops (straw and stubbles) and pruning, cutting and harvesting residues from permanent crops.

The assessment of residues from arable crops builds on methodologies and assessments already done in Biomass Policies and Bioboost. The assessment for vineyards, olive groves and fruit plantation residues bases builds on work done in EuroPruning project.

The aim of S2BIOM was to identify the part of the residues that can be removed from the field without adversely affecting the SOC content in the soil.

It is the carbon balance module in the MITERRA-Europe that has been further adapted in S2BIOM (and Biomass Policies) to take account of removal of straw (and also prunings, see next). This was done by

incorporating the RothC model (Coleman and Jenkinson, 1999) into MITERRA-Europe. RothC (version 26.3) is a model of the turnover of organic carbon in non-waterlogged soils that allows for the effects of soil type, temperature, moisture content and plant cover on the turnover process. It uses a monthly time step to calculate total organic carbon (ton C ha-1), microbial biomass carbon (ton C ha-1) and Δ14C (from which the radiocarbon age of the soil can be calculated) on a years to centuries timescale (Coleman and Jenkinson, 1999). For this study RothC was only used to calculate the current SOC balance based on the current carbon inputs to assess taking account of soil types (including Soil C levels) the sustainable crop residue removal rates at which the carbon C in the soil remains constant.

Primary forest biomass potential assessment

The potential supply of woody biomass was estimated for the period from 2012 to 2030 for stemwood; branches and harvest losses (further: 'logging residues'); and stumps and coarse roots (further: 'stumps') (Table 20). First, we estimated the theoretical potential of forest biomass supply in Europe based on detailed forest inventory data. This theoretical potential was defined as the overall, maximum amount of forest biomass that could be harvested annually within fundamental bio-physical limits (adapted from Vis and Dees 2011, Dees et al. 2012), taking into account increment, the age-structure and stocking level of the forests. Second, multiple environmental and technical constraints were defined and quantified that reduce the amount of biomass that can be extracted from forests for different biomass potential types. Third, the theoretical potentials from the first step were combined with the constraints for the biomass potential types.

This sequence of steps is based on the approach developed and applied within the EUwood and EFSOS II studies (Verkerk et al. 2011; UNECE et al. 2011; Verkerk 2015). The approach in S2BIOM differs from previous studies in several ways, with the main difference being that that woody biomass potentials have been estimated using a typology of potentials developed within S2BIOM. Other changes include (i) an updated of the forest inventory data used as a basis to estimate biomass potentials; (ii) extension of the geographical scope to include all 37 S2Biom countries; (iii) improvements to set the of constraints; and (iv) improve the potential estimates at regional level by spatially disaggregating estimated biomass potentials. All improvements are described below.

The large-scale European Forest Information SCENario model was applied (EFISCEN) (Sallnäs, 1990) to assess the theoretical potential of forest biomass at regional to national level. Versions 3.1.3 (Schelhaas et al. 2007) and 4.1 (Verkerk et al. 2016a) were used because the former version is included in a script to estimated biomass potentials Verkerk et al. (2011), while the latter version has the ability to directly store results in a database, which is used to run the EFISCEN disaggregation tool (Verkerk et al. 2016b). EFISCEN describes the state of the forest as an area distribution over age- and volume-classes in matrices, based on data on the forest area available for wood supply (FAWS), average growing stock and net annual increment collected from NFIs. Forest development is determined by different natural processes (e.g. increment) and is influenced by human actions (e.g. management). A detailed model description is given by Schelhaas et al. (2007; 2016). National forest inventory data on area, growing stock and net annual increment are used to initialize the EFISCEN model.

The amount of wood that can be felled in a time-step is controlled by a basic management regime that defines the period during which thinnings can take place and a minimum age for final harvest. Age-limits for thinnings and final fellings were based on conventional forest management according to handbooks at regional to national level (Nabuurs et al. 2007) and by consulting national correspondents (UNECE-FAO 2011). The amount of stemwood potential removed as logs was estimated by subtracting harvest losses from the stemwood felling potential. Harvest losses were estimated using the ratio between fellings and removals as reported by UNECE-FAO (2000) for coniferous and broadleaved species separately.

Branches together with harvest losses represent logging residues that can be potentially extracted as well. In addition, stumps could potentially be extracted, separately from logging residues. The volume of branches, stumps and coarse roots was estimated from stemwood volume (incl. harvest losses) using age-dependent, species-specific biomass distribution functions (Vilén et al., 2005; Romano et al., 2009; Mokany et al., 2006;

Anderl et al. 2009). We assumed no difference in basic wood density between stems and other tree compartments, due to lack of information.

Climate change is accounted using results from LPJmL (Sitch et al. 2003, Bondeau et al. 2007). Data are an average for several climate models for the A1b SRES scenario. Annual tree Net Primary Production (NPP) in gC/m2 for 3 individual years (2010, 2020, 2030) was calculated with LPJmL and used to scale the increment functions used in EFISCEN.

Secondary biomass potentials from agro-food industry

For an overview of the calculation methods and assumptions of secondary biomass sources from agro-food industries see the table below.

Table A2.4: Overview of assessment rules applied in S2BIOM to assess potentials for olive stones, rice husk, pressed grapes residues and cereal bran.

Biomass type	Area / Source	Residue factor	Technical & Environmental constraints
Olive-stones	CAPRI & national statistics: Area with all olive trees (table=oil olives) 2012, 2020, 2030	Olive pits make up between 10%-12.5% of the weight of olive according to Garcia et al. (2012) and Pattarra et al., (2010)	Base= pits from all oil olives + 30% of table olives
Rice husk	CAPRI & national statistics: Area with rice in Europe 2012, 2020, 2030	Rice husk is approximately 20% of the processed rice, with average moisture content of 10% ((Nikolaou, 2002)). It is assumed that all rice produced in the S2BIOM countries is locally processed	None
Pressed grapes residues (pressing residues & stalks)	CAPRI & national statistics: Area with vineyards in Europe 2012, 2020, 2030	Of the processed grapes 4.6% consists of dregs and 1.5% of stalks (FABbiogas (2015)- Italian country report)	None
Cereal bran	CAPRI total estimate of tons processed cereals per EU country	In wheat processing 20% to 25% wheat offals (Kent et al., 1994). Wheat bran represents roughly 50% of wheat offals and about 10 to 19% of the kernel, depending on the variety and milling process (WMC, 2008; Prikhodko et al., 2009; Hassan et al., 2008). . So the residue to yield factor used is 10% of cereals processed domestically.	None

For the calculation of the olive stones, rice husk and pressed grapes dregs we assumed that all domestic production would also be processed locally and that is no further processing of imported olives, rice and grapes. This implied that the residues would be available locally and that the regional distribution of the processing residues is a direct outcome of the cropping area distribution over regions in every country.

For cereal bran it is more logical to assume that the basis should be the total amount of cereals processed in every country. This implies that cereal bran needs to be calculated for a total net domestic cereal production and imports:

$$Domestic\ production_{cereals} - export_{cereals} + import_{cereals}$$

The data on total domestic production, exports and imports levels were available from CAPRI for 2010 (extrapolated to 2012), 2020 and 2030 for all S2BIOM countries except for Ukraine.

To come to a regional distribution of the cereal bran potentials in every S2BIOM country 2 assumptions were made:

1) The bran based on the net domestic production (=domestic production – exports) is distributed regionally according to cereal production area share.
2) The cereal bran based on processing of imported biomass is distributed over largest (port) cities per country as it is expected that processing industries are there where imports enter the country and

where population is concentrated. The residues were spatially distributed to regions with the large and medium sized cities (>100,000 inh.), every city was equally weighted.

Method used to estimate secondary forest biomass produced in the forest processing industry

The EU-Wood study (Mantau, 2010) projects the demand for material use without considering competition with other sectors in order to explore if the increasing demand for energy will lead to a strong competitive situation where the demand substantially exceeds the supply. The EU-Wood project (Mantau, 2010) has aligned the prediction of the future demand to the real GDP (Gross domestic product) and thus the prediction that utilises the IPCC B2 scenario assumptions shows a strong increase (see figure below).

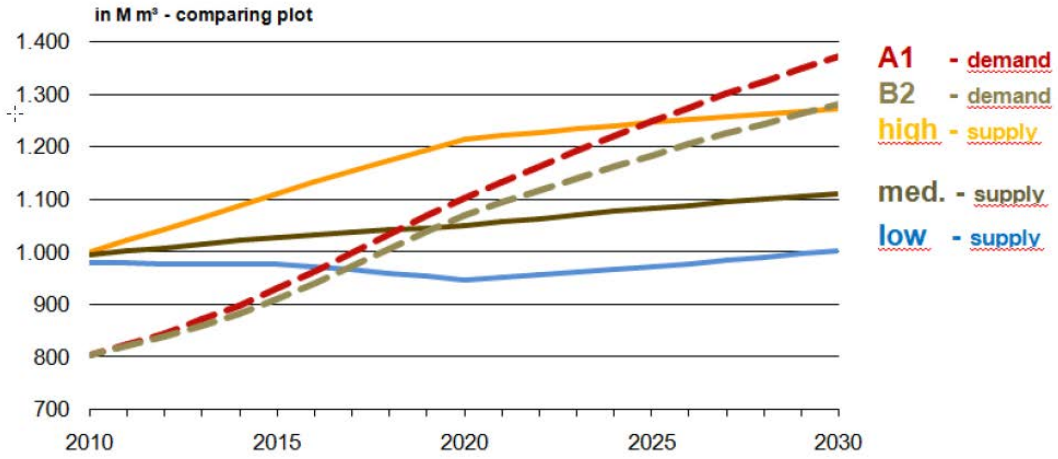

Figure 1-4: Development woody biomass potential demand and potential supply

Source: EUwood 2010

Figure A2.1: Future development of demand and supply as projected by the EU-Wood project for different scenarios (Mantau, 2010).

Thus, to constrain the potentials by such demand projection would constrain the potential with strong preference to material use. The recent trends of the forest products consumption index indicate that the production has changed its relation to the GDP (see figure below).

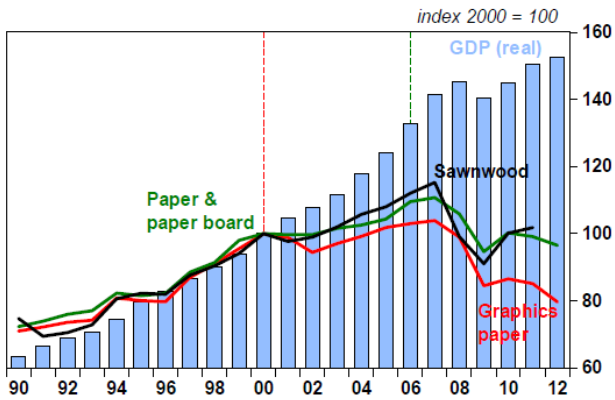

Figure 2.1.2. EU GDP (real) and forest products consumption index over the period 1990-2012 (2000 = 100). (Forest products data from FAO; GDP data from IMF, Gross domestic product based on purchasing-power-parity (PPP) valuation of country GDP).

Figure A2.2 EU GDP and forest products consumption index[3]

An alternative to use predict the future industry production results from modelling that considers economic competition. Such estimates are available from the EFSOS II study for 2010, 2020 and 2030. The trends of the EFSOS II study are utilised by S2BIOM. Figures 3 and 4 show for sawn wood and panels that the S2BIOM data for 2012 are close to EFSOS II reference scenario projections 2010.

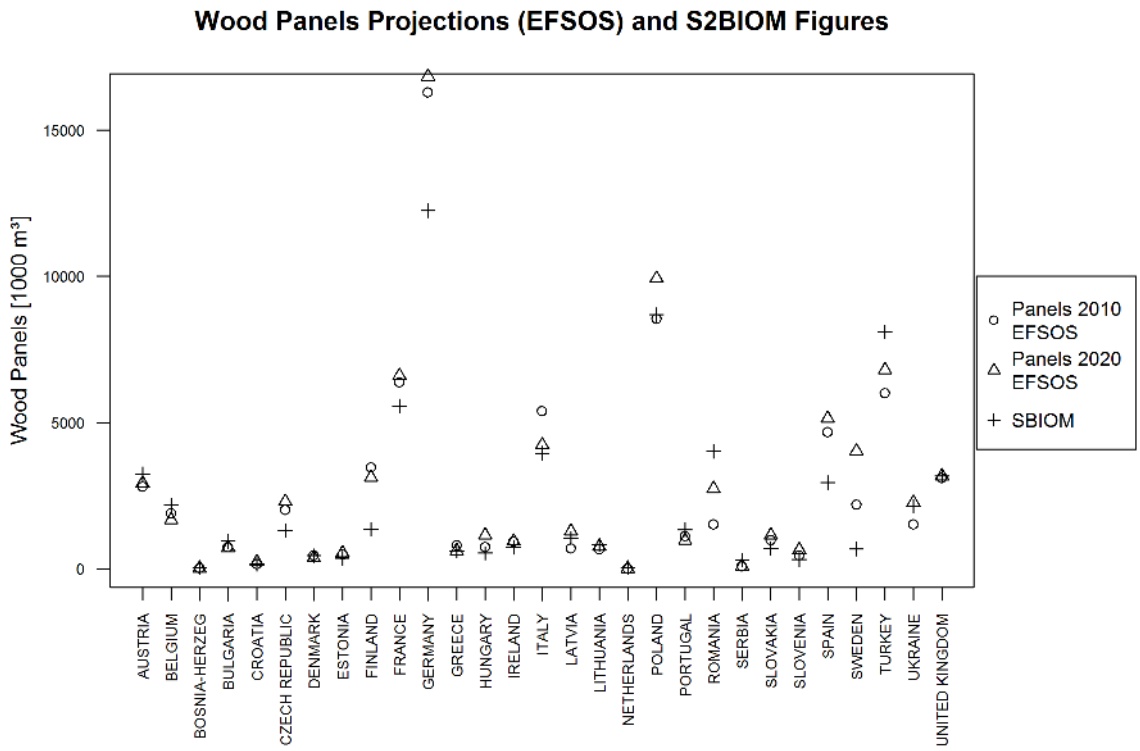

Figure A2.3 Wood panel production, EFSOS 2 reference scenario projections, and S2BIOM 2012 estimates

[3] Source: Birger Solberg, Lauri Hetemäki, A. Maarit I. Kallio, Alexander Moiseyev and Hanne K. Sjølie (2015) Impacts of forest bioenergy and policies on the forest sector markets in Europe – what do we know?

The S2BIOM residue and production figures of the timber industry were thus projected to the years 2020 and 2030 using the growth rates of the reference scenario of the UNECE European Forest Sector Outlook Study II (EFSOS II) for sawnwood and wood based panel production.

For the pulp and paper sector there was a huge difference between S2BIOM 2012 quantities and the EFOS reference scenario projections.

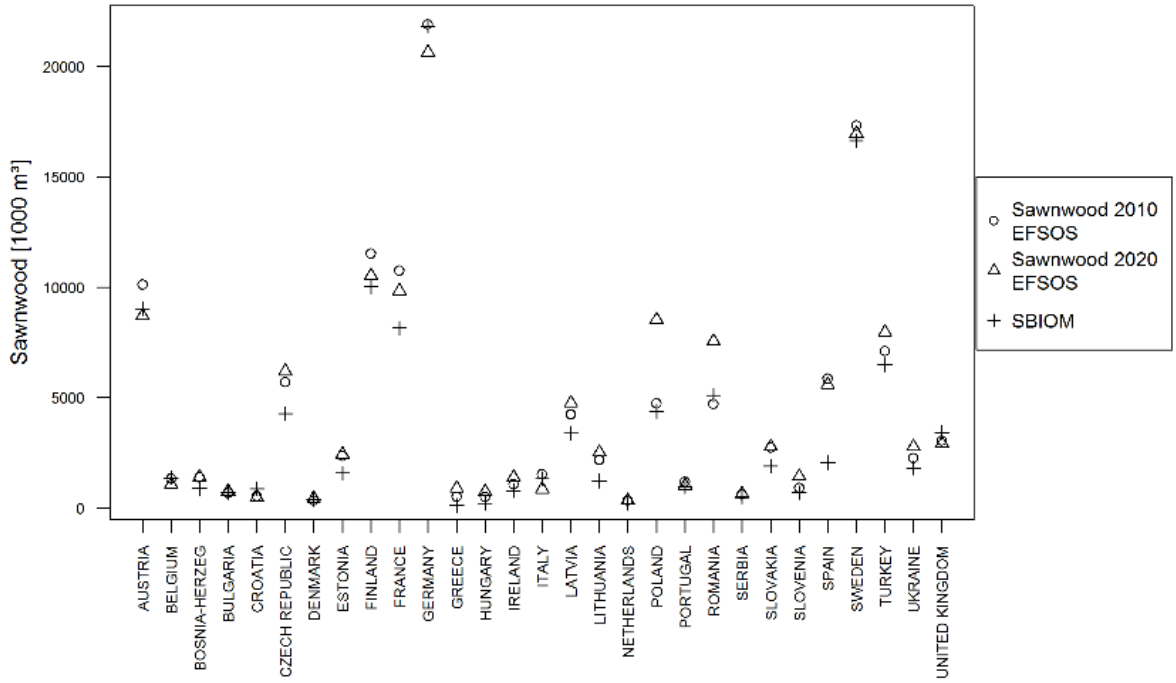

Figure A2.4 Sawnwood production, EFSOS 2 reference scenario projections and S2BIOM 2012 estimates

The visualisation of the figures from the "Historic Statistics" report of CEPI on pulp and paper production are shown in Figure 5. This figure shows the changes of pulp production for the CEPI member states which are: Austria, France, Netherlands, Romania, Sweden, Belgium, Germany, Norway, Slovak Republic United Kingdom, Czech Republic, Hungary, Poland, Slovenia, Finland, Italy, Portugal and Spain. It is for S2BIOM assumed that the changes in production after some bigger fluctuations in the past will be in 2020 and 2030 in the same dimension as in 2012. Hence the production quantities from 2012 are used for 2020 and 2030 as well.

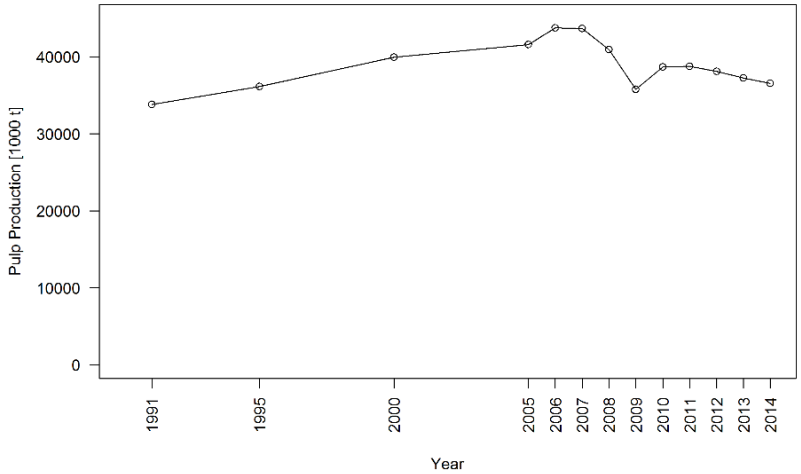

Figure A2.5 Development of Pulp production, CEPI data

The approach used is summarised by category in the table below.

Table A2.5: Approach used to estimate future production amount in the wood industry.

Sector	Approach
Saw mill residues, conifers	EFSOS II sawnwood, reference scenario
Saw mill residues, non-conifers	
Residues from industries producing semi - finished wood based panels	EFSOS II wood based panels production, reference scenario
Residues from further wood processing	EFSOS II sawnwood, reference scenario
Secondary residues from pulp and paper industry	Kept constant

Assessment of biowaste and post-consumer wood potentials

The availability of biowaste in 2012 on NUTS3 level was established as:

MSW generated per capita (kg/capita) x
biowaste fraction (%) x
population of the NUTS3 area (persons).

A further distinction has been made between the separately collected biowaste and biowaste as part of mixed waste.

In Arcadis and Eunomia (2010) projections have been provided of the shares of biowaste going to the different treatment options like landfill, incineration, MBT, composting, backyard composting, anaerobic digestion and others have been made for the years 2008-2020. It has been assumed that all countries meet the requirement of the landfill directive, e.g. that maximally 35% of the amount of biodegradable waste generated in base year 1995 is landfilled in 2020, even if current developments show that diversion from landfill has not been successful yet. Furthermore, the projections are based on policy views and current changes in treatment of biowaste in the member state concerned. For instance, some countries have a strong

preference for MBT, others for incineration with energy recovery. For the year 2030 the same shares between treatment options are used as in the year 2020. Currently no policies are known that influence the production of biowaste after 2030, therefore it is assumed that the projected status quo in 2020 will be maintained in 2030.

Projections on the development of the total quantity of biowaste are assumed to be proportional to population growth. The main scenario on population development from Eurostat has been used to predict the population in 2020.

The calculation of the post-consumer wood potential is calculated according to the following formula:

$PCW_{technical\ potential} = PCW_{material} + PCW_{energy} + PCW_{disposed}$
$PCW_{base\ potential} = PCW_{energy} + PCW_{disposed}$

in which:

- $PCW_{recovered}$ = PCW used for materials like panels and chipboards
- PCW_{energy} = PCW used for energy production
- $PCW_{disposed}$ = landfilled and/or incinerated with MSW

Eurostat gives data on "wood waste", but this includes not only post-consumer wood but processing wastes from agriculture forestry and fishing sectors. Because of this mixture of secondary wood processing and tertiary post-consumer wood within one category, Eurostat data could not be used to determine the potential of post-consumer wood. For S2BIOM, data on recovered wood were used from a forest biomass resource assessment done for the EUwood and EFSOS II studies (Mantau et al. 2010; UN-ECE/FAO 2011[4]). EUwood combines among others Eurostat and COST Action E31 data. The EFSOS II data on demolition wood is based on EU wood, but covers Europe as a whole instead of EU28. In order to determine the base potential PCW available for energy, it is necessary to estimate how much is used for material applications. In the Methodology report of the EUwood project[5], a table is given on the availability of *PCW recovered* [for material recycling] and *PCW energy* for 2007, page 119-120, which have been used in S2BIOM as well.

Assessment of cost levels for different biomass categories in S2BIOM

Because we are still in the early stages of a transition of fossil based feedstock towards bio-based feedstock there is hardly any information of enough quality to conduct a meaningful market analysis. In this light it is important to keep in mind that a distinction needs to be made between different types of cost and price levels specific per biomass type:

- Market prices exist for already traded biomass types (e.g. straw, wood chips and pellets based on primary and secondary forestry residues).
- Road-side-cost for biomass for which markets are (practically) not developed yet (e.g. many agricultural and forestry residues, dedicated crops for ligno-cellulosic and woody biomass and waste streams such as vegetal waste). These may cover the following cost:
    - Production cost (in case of dedicated crops, not for residues or waste)
    - Pre-treatment in field/forest (chipping, baling)
    - Collection up to road side/farm gate
- At-gate-cost which cover the cost at roadside plus transport and pre-treatment cost of biomass until the biomass reaches the conversion plant gate (e.g. bioethanol plant, power plant).

[4] UNECE (United Nations Economic Commission for Europe), FAO (Food and Agricultural Organization of the United Nations) 2011: The European Forest Sector Outlook Study II; Geneva
[5] EU Wood (2010) Methodology report, real potential for changes in growth and use of EU forests EUwood. Call for tenders No. TREN/D2/491-2008.

The cost assessed in S2BIOM are limited to the road-side cost. So, the cost from road side for transport and possible in-between treatment to the gate of the conversion installation or the pre-treatment installation are NOT included.

Cost assessment for agricultural biomass potentials

The overall methodology followed to gain insight in the minimum costs of production is the *Activity Based Costing* (ABC). It involves the whole production process of alternative production routes that can be divided in logical organisational units, i.e. activities. The general purpose of this model is to provide minimum cost prices for the primary production of biomass feedstock at the road side. ABC generates the costs of different components based on specific input and output associated with the choice of the means of production, varying with the local conditions and cost of inputs (e.g. labour, energy, fertilisers, lubricants etc.). Since the production of most biomass is spread over several years, often long-term cycles in which cost are incurred continuously while harvest only takes place once in so many years, the Net Present Values (NPV) of the future costs are calculated. This provides for compensating for the time preference of money. To account for the fact that the costs are declining in different periods of time in the future the Net Present Value annuity is applied. In this way annual, perennial crops and forest biomass cost are made comparable (=all expressed in present Euros).

The costs are automatically calculated for all field operations per year in a 60-year cycle in the case of agricultural biomass. The costs of wood production were not considered in this study as these costs need to be allocated to the main product, while here the focus is on the cost of the residues. Cost are presented as NPV per annum and expressed in € per ton dm or per GJ.

It is also important to note that the costs calculated in here are at the farm level cost. We are aware that the costs for the next link in the value chain might be higher because of rent seeking behaviour. However, in this approach we did not take account of it as we did not include a profit margin.
As explained in the former cost of agricultural biomass are calculated for *Net Present Value annuity* taking a 60-year coverage period. These 60 years are chosen to fit all possible cycles in the cost calculation as 60 is fully synchronizable to 1,3,5,10,15,20,30 and 60 years cycles. Cost differences after that period are negligible. In this way, cost for biomass from residues and from dedicated crops can be assessed with the same model and can be made comparable.

First the Net Present Values of all activities are calculated as follows:

Formula:
$NPv=Fv/(1+i)^n$
Where:

NPv = Net Present value
Fv = Future value
i = the interest rate used for discounting (set to 4%)
n = number of years to discount

Then the Net Present Value annuity is applied, assuming that the sum of NPVs cover the annual capital payments attracted against the same interest rate (4%) as the discount rate used for calculating the NPVs.

Formula:
$NPVa= \Sigma NPv*(1/((1-(1+i)^{-n})/i))$
Where:

NPVa = Net Present Value annuity
ΣNPv = sum of NPVs
n = number of years
i = the interest rate (set to 4%)

The cost also allow for national differentiation of cost according to main inputs having national specific prices levels. This organised through the **'Country inputs'** module in the ABC model. It contains detailed information concerning the prices of various resources needed as input for the production process of biomass specific per country. These are specified, either in absolute price levels or as an index related to the known price level in one or two specific countries (mostly Germany). This is necessary as prices of key production factors differ a lot at national level across Europe. National level price data (ex. VAT) included cover cost/prices for labour (skilled, unskilled and average), fuel, electricity, fertilizers (N, P2O5, K2), machinery, water, crop protection and land. Most of these data were gathered from statistical sources such as FADN (Farm Accountancy Data Network), Eurostat and OECD. Most cost levels were gathered for the year 2012.

The cost data elaboration also requires a feedstock specific approach. If costs are estimated for biomass that is specifically produced for energy or biobased products, i.e. in the case of dedicated crops the cost structure is clear and all cost can be allocated to the final product. All cost should include the fixed and variable cost of producing the biomass including land, machinery, seeds, input costs and on field harvesting costs. If the biomass is a waste, i.e. cuttings of landscape elements or grass from road side verges, the cost could be zero, as cutting and removing these cutting is part of normal management. However, bringing the biomass to the conversion installation requires some pre-treatment costs, e.g. for drying or densifying and then transport costs have to be made to bring it to the conversion installation. These costs will not be assessed here however as we concentrate on the road side cost.

Crop residues also require a separate approach as harvesting cost can usually be allocated to the main products, i.e. grain in the case of cereal straw, and not to the residue. However, the baling of the straw and the collection up to the roadside can be included in the costs.

For the elaboration of cost levels account also needs to be taken of the local circumstances and type of systems used for the production and harvesting of the biomass. This is particularly complex in the case of dedicated crops for which cost estimates are mostly and/or only available from pilot plots and practically no commercial plantations. Costs vary strongly per type of management, soil and climate zone. Furthermore, cost need to be allocated per ton harvested mass over the whole life-time of a plantation as harvest levels are very low in the first years and increase in time.
The costs are determined for 2012, the reference year and are kept constant in the future years 2020 and 2030. The reason for keeping cost constant in time has several advantages:

1) Estimations of future changes in prices for (fossil) energy (fuel & electricity), labour, and machinery are difficult to predict. If predictions are used this implies automatically adding additional uncertainties in the cost assessment.
2) If cost levels do not alter in time the uses of the cost-supply data in other models in and outside S2BIOM (e.g. Resolve and BeWhere) deliver results that can only be explained from the internal logic of the models and not by differences in cost level increases based on a large number of uncertainties.
3) The cost levels presented in S2BIOM can still be further adapted by other users applying their own assumptions on future cost level changes. This enables them to use the S2BIOM cost-supply data consistently with their own modelling assumptions.

Cost assessment for forest biomass

The estimation of harvesting and comminution costs is following the approach presented earlier by Ranta (2002, 2005), Ilavský et al. (2007), Anttila et al. (2011) and Laitila et al. (2015). In contrast to the cost estimates for energy crops, the production costs are not considered in the cost estimates.
The data are mostly determined by the S2Biom project. A survey of cost factors related to forest harvesting operations was carried out in cooperation with INFRES project (Dees et al. 2015).
The methodology can be divided into two main components: 1) the estimation of hourly machine costs, and 2) the estimation of productivity. All the cost estimations pertain to current cost level (year 2012).

The general work flow is illustrated in the figure below.

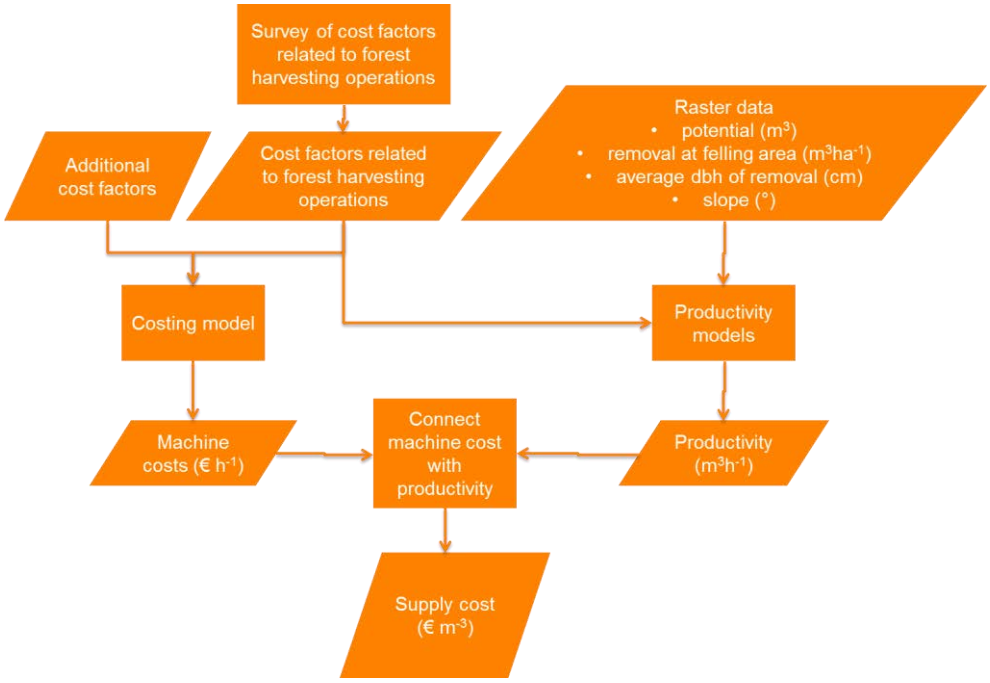

Figure A2.6 General work flow of the forest biomass cost calculations

Cost estimates for biowaste and post-consumer wood

This study follows the activity-based costing approach. In principle, the costs of harvesting collection and forwarding to the roadside need to be considered. The cost to put the biowaste in a container at roadside is assumed to be zero. The cost of further collection and processing is covered by the households and organisations that need to discard the biowaste, regardless its possible further application for energy production. Waste collection and treatment is part of the public tasks and the cost for it cannot be allocated to the processor of the waste. In case of biowaste we could define the municipal collection point as "at roadside". From this municipal collection point, the municipality can select which waste treatment option is preferred, within the framework of European and national policy, considering costs and sustainability of the treatment methods.

The cost of discarding post-consumer wood in a container at roadside is regarded zero. For instance, demolition activities are performed to make space for another building, and not with the purpose to generate wood waste. Demolition activities will follow legal instruction, i.e. put waste wood fractions in separate containers if this is required by law. For other sources of post-consumer wood such as packaging materials or household waste a similar approach can be applied. Packaging waste is of no value to organisations. Consumers bring wooden furniture to a central collection point, or put it at roadside for pick-up, not the sake of providing energy wood. Once collected and sorted, waste wood fractions have an economic value, which can be considerable if there is sufficient demand. However, as said, S2BIOM follows an activity based costing approach, considering the costs, not the economic value of the material. The roadside cost of demolition wood is therefore assumed zero.

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CELEBio

D.2.2 Country report: The Republic of North Macedonia

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Summary

North Macedonia has a surface of 25,713 km^2 with estimated 2,077,132 million inhabitants. N. Macedonia is an agricultural oriented country and this sector has positive impact on Macedonian's economy through increasing GDP and job creation. Almost 435,500 people, make whole or part of their income from agriculture activities. The great natural preconditions and an existing tradition enriched with newly developed skills create a variety of opportunities in agriculture, from high mountain pastures of over 2000m high, to the rich water valleys with a Mediterranean climate. The agribusiness industry in North Macedonia is one of the fastest growing industries with an over 10% increase in the last three years. Adding value to the excellent quality agricultural products, as demanded by the main European markets, is one of the core Macedonian businesses. The Government of the Republic of North Macedonia views its development as one of its strategic priorities, and is ready to commit substantial support for trade and investment in the sector. More than 1,007,095 ha of N. Macedonia's surface represents forest, and 1,264,139 ha is agricultural land as reported in 2018. There are excellent opportunities for investment in fruits and vegetables - production, storage, distribution and processing industries, together with wine production and sheep and goat cheese production.

Regarding the biomass, the main supply produced in N. Macedonia is primary biomass. Currently, biomass is mostly used for heating. The production of biomaterials and bioenergy is not as prevalent in N. Macedonia as food production. Woody biomass is the main export and greatest resource in N. Macedonia. Biofuels are not produced from crop residues. The biomass has a significant place in the energy balance of the N. Macedonia. It accounts for 154 ktoe (1,791 GWh, or 973,765 m^3), which is 14% of the total energy produced in the country (2018). The annual energy potential of gross consumption of biomass is 1,844 GWh. The agricultural biomass originates from crops residues (cereals and industrial crops, vineyards and orchards residues with a total potential of more than 241,000 tons d.m. and straw, which is currently unused for other than agricultural purposes, with a total potential of 159,000 tons per year). Wood and charcoal account for 80% of the total biomass currently used for energy purposes. Rice hulls and branches of fruit trees are also used for energy purposes in N. Macedonia, but much of the straw is used for fertilization, forage and cellulose. Therefore, it is not available for energy purposes.

Firewood is used mostly in the rural areas as solid fuel for heating purposes. From the total biomass consumption in the country, 90-95% is used by households, satisfying around 39% of their final energy consumption. The primary and secondary residues from agriculture are straw, stalks, maize stover, manure, prunings from permanent crops. The Livestock production in N. Macedonia includes breeding of cattle, horses, sheep, goats, pigs, poultry and rabbits, as well as bee-hives. With regards to the livestock production in the country, there is a total of 253,442 cattle, 195,443 pigs and 733,510 sheep. A total of 127,663 dairy cows produce around 361 million litres of milk per year, or an average of about 2,828 litres per dairy cow in a calendar year.

More than 436,800 household members, of whom 57% are men, work on individual farms. Over 94,000 people are hired seasonally on individual agricultural holdings. Based on the total standard output, farms are categorised according to their economic potential in 14 economic size classes. Of the total number of classified agricultural holdings, 49.6% are in the first class – up to 2,000 euros. Of the total number of farms, the majority (34.4%) specialise in field crops, while the fewest (2.1%) specialise in horticulture. Of the total agricultural output, crop production accounts for 69.5%, livestock production makes up 21.4%, while the rest belongs to services in agriculture.

Forests and forestland in N. Macedonia are characterized with great species diversity, but low quality and small annual growth. More than 70% of the forests are coppices, 90% are deciduous and almost 90% are state owned. The most dominant species is Beech, and then various oak species. Total wood reserve is estimated on around 70 mil m^3, and total annual growth is around 1,7 mil m^3. Very large part of the land considered as forest, are Mediterranean type of forest, characterized with small trees and bushes.

Major problems and limitations in the field of waste management in N. Macedonia are present in almost all areas of the existing waste management system, as well as in all relations in the society related to waste management. The current situation with waste management in N. Macedonia can be characterized as

substandard in terms of human and financial resources, as well as insufficient and ineffective in terms of monitoring and enforcing regulations, resulting in various dysfunctional systems in society and in many related adverse effects on the environment and human health.

N. Macedonia does not have a strongly developed bio-based industry. Most of these industries are small scale or in the phase of planning.
Regarding the environment, pollution is constantly increasing due to the old technologies and use of synthetic fertilizers, fossil resources and chemicals for protection of crops and livestock. Alternative methods of production that will follow EU regulations and policies are much needed. The agricultural sector is of great importance for the country. However, agricultural producers face difficulties in achieving efficient production and selling their products on the international markets. There are many barriers such as international agricultural policies, lack of finance, climate change, and insufficient state support.

The main regulatory bodies or institutions which adopt and implement the policy framework in the country are: Ministry of Agriculture, Forestry and Water Economy, Agency for Financial Support in Agriculture and Rural Development, Agency for Stimulation of Agriculture Development and the Agricultural Market Information System.

1 Introduction

1.1 Objectives and approach

The main objective of CELEBio is to contribute to the strengthening bioeconomy-related activities in Bulgaria, Czech Republic, Croatia, Hungary, Slovak Republic, Slovenia and neighbouring countries. To this end, one of the key activities is to develop seven comprehensive reports for the target countries and the wider neighbouring region on the availability of sustainable biomass, logistics, costs and biomass business opportunities assessed through an analysis of the Strengths, Weaknesses Opportunities and Threats (SWOT).

This report aims to provide the necessary background information needed to evaluate the possibilities for setting up bio-based production chains in North Macedonia.

The information structure and analysis presented in this report was developed by building on the method designed and applied by Van Dam et al. (2014) and was further refined through the execution of interviews with bio-based business developers and other experts. In these interviews further information was obtained on key factors that guide the choice of setting up bio-based activities in countries. Most of the experts stressed that all the identified factors are important and that a system approach is key in developing bio-based initiatives. If one link in the chain is missing, the bio-based initiative will not succeed. The identified factors are mapped in this report and will be the basis for performing a SWOT analysis for development of bio-based production chains.

In Annex 1 a further explanation is given of the approach used to set-up this country report.

1.2 Reading guide

This report is organised in nine chapters. Chapter 1 gives an overview of the country's key characteristics. In the chapters 2, 3, and 4 the biomass production including its current uses and opportunities for what biomass can be additionally mobilised, is summarized for respectively the agricultural, forest, and waste sector. First the main traditional production and availability of biomass for food, feed, forest biomass and wood products are discussed and how this is handled in further processing industries and/or used for domestic markets and exports. Subsequently an overview is given of additional biomass potentials that are likely to be still unused or only partly used and that are a good basis for development of new bio-based activities. In Chapter 5 a description is given of the current bio-based industries and markets, advanced bio-based initiatives, and future biomass valorisation options. Chapter 6 describes the infrastructure, logistics, and energy sector. Chapter 7 focusses on the innovation potential, particularly in the context of bio-based research and development options. The research and educational infrastructure are discussed and the potential for developing bio-based start-ups and Public-Private-partnerships will be taken into a consideration. Chapter 8 gives an overview of the policy framework and describes extensively what regulations, legislation, taxes and tariffs exist of relevance for the development of bio-based production chains. Additionally, attention will be paid to situations where regulation and support measures are actually missing and to which extend the rule of law situation influences the establishment of new bio-based activities. In Chapter 9 potential financing options related to the development of bio-based production chains are discussed.

1.3 Short characteristics of country

North Macedonia has a surface of 25,713 km². With estimated 2,077,132 million inhabitants for 2018 its corresponding population density is 83 km² estimated in 2018 given in (See table 1.3.1). The average income level is 446.37 euro, which is below the European mean and lower than the average of other Central European countries, but closer compared to CEE countries [1].

Table 1.1: Main population, land surface, GDP and trade characteristics of N. Macedonia benchmarked against EU average [1],[2],[3],[4], [5], [6]

Category	North Macedonia	EU	Unit
Population	2.07	512.4	million (2018)
Area (total)	0.0025	447	million ha (2018)
% population in urban areas	58%	44.9%	% of total population (2018)
% territory predominantly rural	42.04%	43.8%	% of total territory (2018)
% territory predominantly urban	57.96%	10.7%	% of total territory (2018)
Agricultural Area	1.2	173.3	million ha (2018)
Forest area	1.0	164.8	million ha (2018)
Population density	83	115	n°/km² (2018)
Agricultural Area per capita	0.6	0.34	ha/capita (2018)
Forest area per capita	0.48	0.32	ha/capita (2018)
GDP/capita	4,827 EUR	30,956	at current prices in 2017
	10, 900	30,956	GDP at purchasing power in 2017
GVA by Agriculture, forestry and fishing	7.2%	1.6%	% of total GVA (2018)

GDP = Gross Domestic Product; PPS = Purchasing Power Standard; GVA = Gross Value Added; UAA = Utilised Agricultural Area
Source: Eurostat most recent statistical data sources (Accessed August/September 2019) (https://ec.europa.eu/eurostat/data/database) and statistical factsheets (https://ec.europa.eu/agriculture/statistics/factsheets_en) for EU data

More than 1,007,095 ha of N. Macedonia's surface represents forest, and 1,264,139 ha is agricultural land as reported in 2018 [7]. There are consequently few urban areas, with most of the population concentrated in the capital city, Skopje (Figure 1.3.1). The population density however is lower than the European average. The GDP at purchasing power in N. Macedonia is below the European average [6].

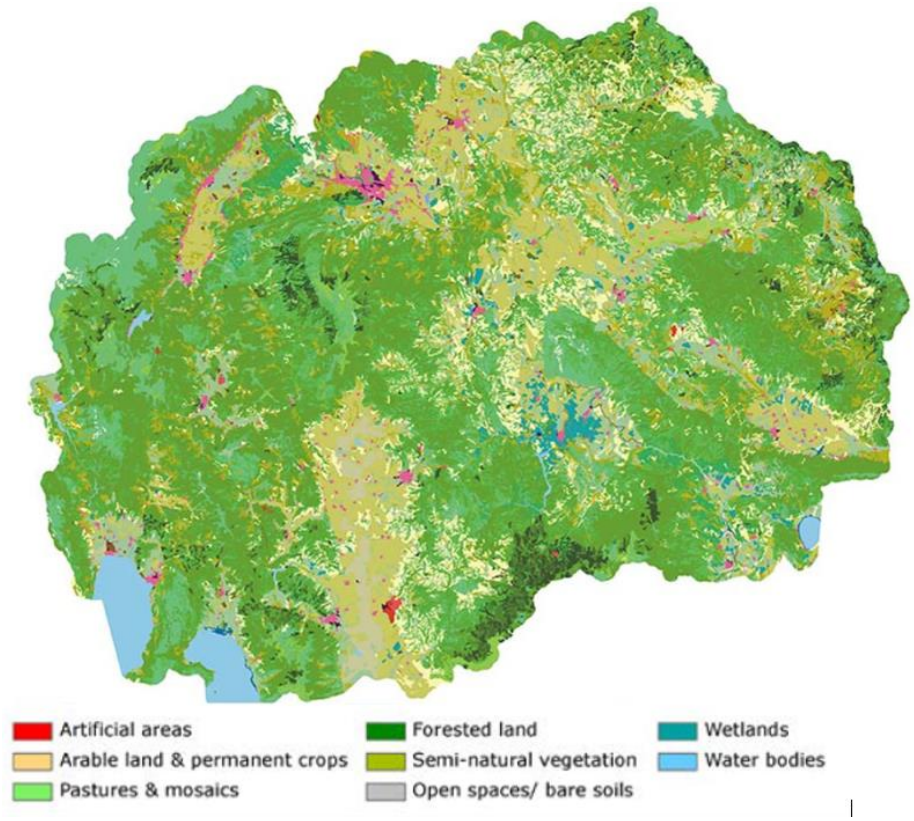


Figure 1.3.1: Main land cover distribution in N. Macedonia [8]

N. Macedonia shares its western border with Albania, the eastern border with Bulgaria, the southern border with Greece, while on the north is bordering with Serbia and Kosovo, which is shown on figure 1.3.2.

Figure 1.3.2: N. Macedonia and its bordering countries

The landlocked position in the south-central part of the Balkan Peninsula, or at the crossroad of South-Eastern Europe, makes the country an important transit route for inland road transport between Central Europe, the

Aegean Sea, the Black Sea and the Adriatic Sea. The favourable geographical position of the country has contributed to the development of international traffic on two trans-national axes: North South (Corridor X) and East-West (Corridor VIII) linked to the Trans-European Transport Network. Figure 1.3.3 shows the position of N. Macedonia in the Trans-Europe Transportation Network.

The existing transport infrastructure in the country consists road and rail network and two airports. The road network contains 899 km of national trunk roads, 3,778 km of regional roads and 9,733 km of local roads. The railway infrastructure in the N. Macedonia was established in 1873 with the first railway track from Skopje to Thessaloniki in Greece. The total length of the railway network consists of 699 km open line, with an additional 226 km of station and yard tracks, and also 102 km of industrial tracks. The railway open track lines are constructed as a single-track line, and only the sections of Corridor X are electrified along 235 km or about 34% of total length of open track network and 83 km length of station tracks. Whilst there are no significant geographic constraints to complete the implementation of the planned rail network along the Corridors, the main impediment to completion arises from lack of funds availability and in turn, the inability to attract funds from international financing institutions. In addition to the two airports for international civil aviation, there are five sport airports with grassy runways suitable for all types of sports aviation and six landing strips for aerial work that are mainly providing services for the agriculture and the forestry sectors [9].

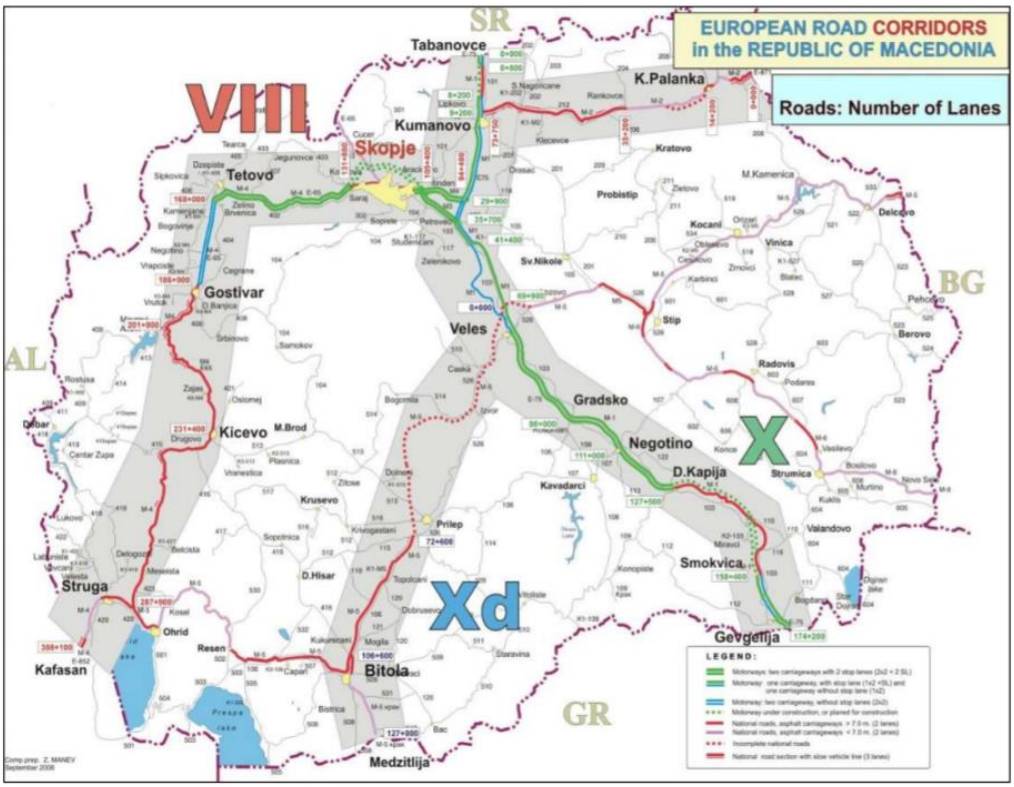


Figure 1.3.3 Position of Macedonia in the Trans-European Transportation Network [9]

Regarding the biomass, the main supply produced in N. Macedonia is primary biomass. Biomass is mostly used for heating (accounting for 39% of the total heat demand) and mainly in inefficient appliances [10]. The production of biomaterials and bioenergy is not as prevalent in N. Macedonia as food production. Woody biomass is the main export and greatest resource in N. Macedonia. Biofuels are not produced from crop residues.

2 Biomass supply: Agriculture

2.1 Introduction

N. Macedonia is an agricultural oriented country and this sector has positive impact on Macedonian's economy through increasing GDP and job creation. Regarding the environment, pollution is constantly increasing due to the old technologies and use of synthetic fertilizers, oil and chemicals for protection of crops and livestock. Alternative methods of production that will follow EU regulations and policies are much needed. The agricultural sector is of great importance for the country. However, agricultural producers face difficulties in achieving efficient production and selling their products on the international markets. There are many barriers such as international agricultural policies, lack of finance, climate change, and insufficient state support. In order to improve the conditions in the agricultural sector and thereby to increase the benefit of agriculture products, it is important to emphasize the necessity of using renewable energy sources (RES) and energy efficiency (EE) implementation in the agricultural sector. Furthermore, it is vital to raise awareness for further utilisation of biomass for energy and other uses and to implement lessons learnt and best practices to obtain maximum effect.
Two sources that are significant for exploitation of biomass in N. Macedonia:

- biomass from agriculture residues
- biomass from forest residues and waste from processing wood industry.

The biomass has a significant place in the energy balance of the N. Macedonia. It accounts for 154 ktoe (1,791 GWh, or 973,765 m^3), which is 14% of the total energy produced in the country (2018) [11]. The annual energy potential of gross consumption of biomass is 1,844 GWh. The agricultural biomass originates from crops residues (cereals and industrial crops, vineyards and orchards residues with a total potential of more than 241,000 tons d.m. and straw, which is currently unused for other than agricultural purposes, with a total potential of 159,000 tons per year). The types and the regional distribution of sources of biomass in N. Macedonia depend on the characteristics of each region. The biomass is most widespread in the agricultural and forest regions of the country. Wood and charcoal account for 80% of the total biomass used for energy purposes. Vine canes, rice hulls and branches of fruit trees are also used for energy purposes in N. Macedonia, but much of the straw is used for fertilization, forage and cellulose. Therefore, it is not available for energy purposes [12]. Firewood is used mostly in the rural areas as solid fuel for heating purposes. From the total biomass consumption in the country, 90-95% is used by households, satisfying around 39% of their final energy consumption [13].

In 2007, the State Statistical Office (SSO) carried out the Census of Agriculture, which provided a comprehensive picture of the structure of agriculture in the Republic of N. Macedonia. The 2007 Census of Agriculture was the foundation for the establishment of the Statistical Farm Register, which enables for strengthening agricultural statistics in line with the standards and methodologies of the EU. The first sample-based Farm Structure Survey was conducted in 2010, and the second sample survey was carried out in 2013. In the period from 10 to 30 June 2016, the State Statistical Office conducted the third sample-based Farm Structure Survey. This helped in conducting an overview of agriculture sector given below.

The share of agriculture in the gross domestic product of the Republic of N. Macedonia is around 10%, an indication of the importance of the agricultural sector in the Macedonian economy. The export value of agricultural products has increased continuously in recent years, from around 130 million euros in 2005 to 199 million euros in 2015. Of the total cultivated area, arable land and gardens cover more than 415,000 hectares, orchards around 16,000 hectares, while vineyards occupy over 23,000 hectares. Most of the arable land and gardens are used for cereals. With regards to the livestock production in the country, there is a total of 253,442 cattle, 195,443 pigs and 733,510 sheep. A total of 127,663 dairy cows produce around 361 million litres of milk per year, or an average of about 2,828 litres per dairy cow in a calendar year. More than 436,800 household members, of whom 57% are men, work on individual farms. Over 94,000 people are hired seasonally on individual agricultural holdings. Based on the total standard output, farms are categorised according to their economic potential in 14 economic size classes. Of the total number of classified agricultural holdings, 49.6% are in the first class – up to 2,000 euros. The type of farming of an agricultural holding is determined by the relative contribution of the standard output of the different characteristics of the holding to the total standard output of the holding. Of the total number of farms, the majority (34.4%) specialise in field crops, while the fewest (2.1%) specialise in

horticulture. Of the total agricultural output, crop production accounts for 69.5%, livestock production makes up 21.4%, while the rest belongs to services in agriculture [14].

2.2 Characterisation of current agriculture sector

Agriculture is widespread branch and very important economic activity in N. Macedonia. Agricultural and industrial plants, fruits and grapes have an important place for obtaining bioenergy from food industry. The country has relatively good soil and climatic conditions for more intense viticulture development and fruit growing. The most common are continental fruit plantations (apple tree, pear, peach, plum, cherry and etc.)[15]. Key characteristics of the agricultural sector in the country are presented in Table 2.2.1.

Table 2.1 Key characteristics for the agricultural sector in N. Macedonia [16], [17], [14], [18], [19], [20],[21], [22], [23]

Category	N. Macedonia	EU average	Unit
Agriculture in % of total employment	15.98 %	3.9%	% of total employment 2018
Agricultural area per capita	0.608	0.34	ha/capita
Cereal yield*	3.39	5.2	t/ha
Crop output in total output	69.5%	56%	% of total agricultural output value (2018)
Livestock output in total output	21.4%	44%	% of total agricultural output value (2018)
Agricultural income (2010=100)	124.4	121	Index 2010=100 (2018)
Livestock density	1.19	1.02	LSU/ha UAA
High input farms	28.6%	29%	%/ total farms 2016
Low input farms	71.3%	39%	%/ total farms 2016
Gross nutrient balance nitrogen	NA	51	kg of nutrient per ha (average 2011- 2015)
Gross nutrient balance phosphorus	NA	1	kg of nutrient per ha (average 2011- 2015)
Irrigated utilised agricultural area	24% -2007	n.a.	% of UAA 2016
Average farm size	1.8 - 2016	16.6	ha UAA/holding (2016)
% of agr. holdings < 5 ha	60.8%	62.6%	%/total no. of holdings

HNV= High Nature Value
**for N-Macedonia this only refers to wheat*

Numerous tables with data from the State Statistical Office are presented in Annex 3, providing various information for the agricultural sector, like number of agricultural holdings and number of employees and households engaged in agricultural activities, machinery used, also information on utilized agricultural land, arable land, irrigated area, area threated with fertilizers, etc. These tables refer to general data regarding the agriculture from 2013 and 2016, based on the surveys that are conducting in a certain period of time (three or more years.) Figure 2.2.1 shows more detailed distribution of the land cover in N. Macedonia, where the land used for agricultural purposes can be easily identified,

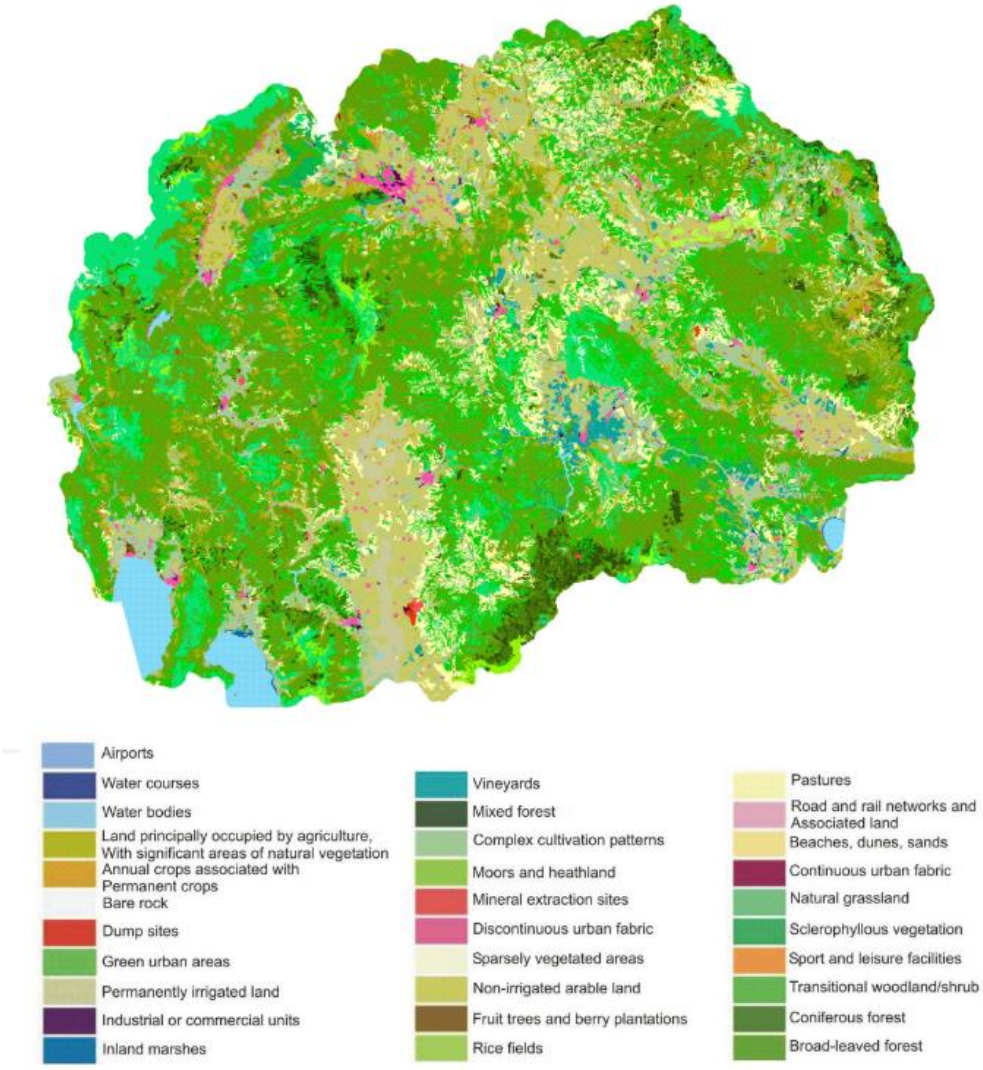


Figure 2.2.1 Detailed land cover distribution in N. Macedonia [24]

Currently agricultural holdings and farms are still leaving most of the crop residues on land and often burning or ploughing in the ground. Moreover, it is usually burnt, decomposed by itself, or serves for cattle grazing. However, a large part of these residues can be separated and processed in solid, liquid or gaseous fuels by combustion of which thermal energy or electricity can be obtained.

2.2.1 Crop production

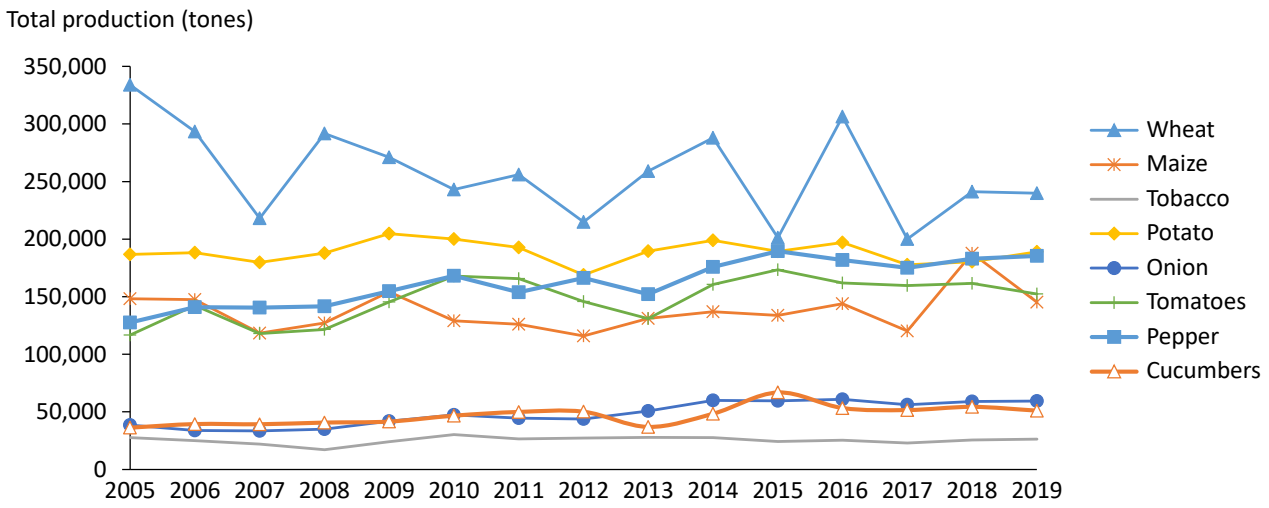
According the methodology of the State Statistical Office (SSO), cropland refers to cultivated land, used for performing agricultural activities for producing of annual yields. The cultivated area consists of arable land and gardens, orchards, vineyards and meadows. Arable land refers to land area where crop production takes place i.e. which is sown with field crops: cereals, industrial crops, vegetables and fodder crops, and accounts for 81% of the cultivated area (Table 2.2.2). This category includes fallow and uncultivated arable land.

Table 2.2 Agricultural area by category of use, 2018 (in ha)[7]

2018	Agricultural area	Cultivated land	Arable land and gardens	Orchards	Vineyards	Meadows	Pastures
ha	1,264,139	518,740	418,140	16,827	24,088	59,685	744,667

The State Statistical Office provides various data on crop production, and detailed tables with the latest - 2018 data are presented in Annex 3. Figure 2.2.2 gives overview of the most relevant crop production in the country in the last 15 years.

Figure 2.2.2. Production trend of most relevant crops in N. Macedonia



The cereal production includes cultivation of wheat, rye, barley, oats, maize, rice. Most of the cultivated area in 2018 is sown by wheat, i.e. around 73,000 ha. and the amount of wheat produced on this area was 241,106 tones, making the wheat yield for that year 3.4 tons per ha. The maize production is second largest with around 187,600 tons produced in 2018, or yield of 5.2 t/ha, from total 36,400 ha of sown area. Barley production is third in line with total production of 130,000 t, even though it is sown on area of 44,770 ha in 2018, resulting with yield of 3 t per ha. The highest yield has rice, with 6.1 t/ha, and cultivated area of 3,222 ha.

Other crop significant for the agricultural sector in N. Macedonia is tobacco, cultivated on area of 16,580 ha, with total production of around 25,550 tons in 2018, and modest yield of 1.5 t/ha. The sunflower is the main oil crop that is cultivated in N. Macedonia, grown on around 2,400 ha in 2018 which is modest compared to the other crops. The total amount produced in 2018 was 3,379 tons, making yield of 1.4 t/ha.

The vegetables production is one of the most important and traditional agriculture sectors which cultivated on area of around 50,000 ha, Vegetable production takes place mainly in the open field conditions, greenhouses and under plastic with or without heating. The production volume of the vegetable crops varies between 800 thousand tons to 1.200 thousand tons, depending on the climate conditions in some years. The production of potatoes and peppers is dominant, each with around 180,000 tons and 183,000 tons respectively in 2018, followed by tomatoes (161,600 tons), melons and watermelons (132,000 tons), cabbage (around 127,800 tons), onion (59,000 tons) and cucumbers (54,300 tons). The rest of vegetables cultivated in the country include of garlic, beans, peas, lentil etc. The highest yield in 2018 had the cucumber with 52.5 t/ha, then tomatoes and cabbages each with around 29 t/ha, and melons and watermelons with 25 t/ha.

From the perennial crops, the most present are the orchards using 16,827 ha of land and vineyards with 24,088 ha. The fruit trees cultivated in N. Macedonia include apples, plums, sour cherries, peaches, pears, cherries, apricots, quinces, walnuts, almonds, etc. Apple trees has the highest share with 4,875,902 of trees in 2018 and total production of 140,296 tons, making yield of 30 kg/ha. The number of vines in 2018 was estimated to 88,356,000, with total production of 294,497 tons or 12.4 t/ha.

2.2.2 Livestock production

The livestock production in N. Macedonia include breeding of cattle, horses, sheep, goats, pigs, poultry and rabbits, as well as bee-hives. The number of holdings that are registered in the country for each type of livestock are given in *Table 2.3*. The total number of livestock units in the country is 381,361, out of which 95% are individual agricultural holdings and the rest are business entities.

Table 2.3. Number of agricultural holdings with livestock, poultry, rabbits and beehives (included individual agricultural holdings and business entities)

2016	Cattle	Horses	Sheep	Goats	Pigs	Poultry	Rabbits (breeding females)	Bee-hives
Number	38,131	17,152	5,405	18,307	45,265	63,503	2,828	4,916

Table 2.4 Livestock units

LSU	2016		
	Livestock units	Livestock units per agricultural holding	Livestock units per ha utilised agricultural area
Total	381,361	2.14	1.19
Individual agricultural holdings	358,294	2.01	1.32
Business entities	23,067	82.38	0.47

Detailed tables on Livestock production based on the data from the State Statistical Office are provided in Annex 3.

According to the data of the State Statistical Office the total number of cattle increased by 0.4% in 2018, compared to 2017. The number of cattle increased by 0.9% in the individual agricultural holdings, whereas in business entities the number of cattle decreased by 14.8%. The number of pigs in business entities in 2018, compared to 2017 increased by 17.9%, while the number of pigs in the individual agricultural holdings decreased by 12.0%. Increasing of the number of sheep is recorded in individual agricultural holdings by 0.9%, while in the business entities it decreased by 17.2%. The number of goats in individual agricultural holdings increased by 27.8%, while the number of goats in business entities increased by 9.0%, compared to the previous year. The number of poultry in 2018 compared to the previous year, decreased by 0.6% [25].

Current statistical data on livestock production shows that the cow's milk production in 2018 was 404,230 thousand litters, which is an increase of 2.6% compared to 2017. An increase of 3.4% in 2018 was registered in sheep's milk production and also the production of goat's milk increased by 18.7%, compared to the previous year. The total production of meat decreased by 2.7% and production of mutton was up to 0.7% compared to the previous year. Production of other types of meat compared to the previous year decreased. Regarding the other livestock products, in 2018, in comparison with 2017, there was a decrease in the production of eggs and wool [26].

2.3 Biomass potentials from agricultural residues and unused lands

The primary and secondary residues from agriculture are straw, stalks, maize stover, manure, prunings from permanent crops.

While cultivating the arable land, a lot of residues from agricultural crops are left on fields as a source of nutrients or ploughed back in the soil. Sometimes the crop residues also burn at the site which often increases the risk of fire, making the burned bare soils are in danger of soil degradation. Therefore, the Government has established a regulation regarding residual biomass treatment by which farmers have to find a place for alternative uses for the residual biomass. To comply with Governmental regulations farmers have started with mechanical

processing of biomass in solid fuel which is easier for transport and utilization. A survey performed in [27] showed that some farmers use medium and small machinery for briquettes and pellets production. This kind of solid fuels are used for farmers own consumption or for market sale. They process biomass residues from their primary production which they found to be economic for transportation. The analysis shows that price for pellets production is around 50-60 Eur and its market price is 200-220 Eur. The price of briquettes production from straw (which is available in big quantities in the country) is 60-70 Eur, and their market price is 260 Eur. However, because of bigger benefit, many farms involved in the survey prefer utilization of biomass for own needs, than sale it on the market. On the other hand, the agricultural residues are used for biodiesel production. The first biodiesel producer in the Republic of N. Macedonia has started in 2007 with production capacity of 30 000 t/year. In the agricultural sector there are few small producers who use biodiesel for their own needs, but this branch is continuing to develop because of increased fuel prices [27].

For a selection of straw and other agricultural residues an estimate of the primary residual biomass was made in the S2BIOM project (see Annex II for explanation) and presented in the Tables below.

Table 2.5Straw and other agricultural residues in N. Macedonia,2020 (in ton d.m)(source: S2BIOM)

Name	Rice straw	Oil seed rape straw	Maize stover	Sunflower straw	Total
Vardarski	1,619	235	6,519	474	8,846
Istočen	1,407	204	5,667	412	7,690
Jugozapaden	1,422	207	5,728	416	7,773
Jugoistočen	1,101	160	4,434	322	6,017
Pelagoniski	1,953	284	7,865	571	10,672
Pološki	915	133	3,685	268	5,001
Severoistočen	871	126	3,507	255	4,759
Skopski	710	103	2,862	208	3,883
Total	9,997	1,452	40,267	2,925	54,641

Straw (mainly wheat, barley, and oats) is commonly used as a staple in livestock farms and part needs to be left on the land to maintain the soil carbon part. Therefore, partially can be used for energy purposes. A modern farm is usually producing one or two major commercial products such as: corn, soy, milk or meat. Because prices depend on supply and demand on the market, energy crops and plantations can play a significant role in maintaining financial farmers' base. In N. Macedonia, cattle corn and clover can be of interest to farmers [28].

Table 2.6 Residues of permanent crops, 2020 (in ton d.m,) (source S2BIOM)

Name	Residues from vineyards	Residues from fruit tree plantations (apples, pears and soft fruit)	Residues from olives tree plantations	Total
Vardarski	756	5,276	143	6,174
Istočen	657	4,586	124	5,367
Jugozapaden	664	4,636	125	5,425
Jugoistočen	514	3,588	97	4,199
Pelagoniski	912	6,365	172	7,448
Pološki	427	2,982	81	3,490
Severoistočen	406	2,838	77	3,321
Skopski	332	2,316	63	2,710
	4,667	32,587	880	38,134

Table 2.7 Biomass residues of agriculture and industrial crops

2018	Total production in tonnes	Ratio product/residue	residue
Potatoes	180,424	0.1	18,042.4
Beans- single maincrop	4,992	0.35	1,747.2
Cabbage	127,856	0.2	25,571.2
Tomatoes	161,621	0.08	12,929.68
Peppers	182,872	0.1	18,287.2
Garlic	4,134	0.18	744.12
Melons and watermelons	132,091	0.35	46,231.85
Fodder beet	376	0.09	33.84
Tobacco	16582	0.09	1492.38
Sunflower	2386	0.18	429.48

Box 2.1: Methodology of S2BIOM to calculate the crop residues potentials.
It identifies the part of the residues that can be removed from the field without adversely affecting the Soil Organic Carbon Content in the soil. For cereal straw a subtraction is also applied according to demand for straw for animal bedding & feed. For corn stover, rice straw, and sunflower and rape stubbles NO competing uses are assumed. The soil organic carbon balance is the difference between the inputs of carbon to the soil and the carbon outputs. A negative balance, i.e. outputs are larger than the inputs, will reduce the SOC stock and might lead to crop production losses on the long term. To calculate the soil carbon balance at regional level S2BIOM used the MITERRA-Europe model (Lesschen et al., 2011) to provide the input data and the "RothC-26.3" model (Coleman & Jenkins, 1999) to calculate the soil carbon dynamics in a spatially detailed assessment. For further details on the whole assessment of biomass potentials in S2BOM consult Dees et al[16] and a summary is given in Annex 2.

The average economically available energy from the agricultural residues is 6.72 PJ/year from the part collected by the farmers from their production and 0.36 PJ/year from the remaining part of the industrial production. That makes a total of 7.08 PJ/year. There is a significant share of biomass from cereal production 45.5% and waste from fruit slicing and vineyards 32.1%. Economically justified disposal of energy from livestock and poultry farming is 0.94 PJ/year. The relation of the theoretical to the technical and economic potential differs from different types of waste, but the total average is as follows: theoretical potential 19.03 PJ/year. (100%), technical potential 14.08 PJ/year (74.42%) and economic potential 7.08 PJ/year (37.20%). It should be noted that these relationships are of variable character, depending on the composition of crops, the organization of production and collection of biomass residues, as well as market conditions placement of the produced energy compared to other possible applications of biomass.

The use of biomass residues as fuel for heating processes in residential and commercial space, is a serious way to replace energy obtained from "fine" fuels, with a strong emphasis on the environment component of the process and reduction of emissions. The general calculation for substituted amount of energy is as follows:

- kg biomass residues replace 5 kWh of electricity
- kg of biomass residues replaces 0.4 kg of diesel oil used for heating
- kg biomass residues replaces 0.5 kg of natural gas [29].

Table 2.8 Energy value of waste biomass from agriculture and forestry [30]

Crop type	Energy value kWh/kg
Tree	
Deciduous	5.07
Coniferous	5.28
Fruit seeds	
Plum	5.03
Cherry	4.88
Sour cherry	4.88
Apricot	4.83
Peach	4.85
Peels	
Sunflower	4.08
Walnut	4.38
Straw	
Wheat	4.38
Rye	4.29
Barley	4.11
Oats	4.18
Corn	4.08
Rice	4.33

The data for the unused land is provided by the State Statistical office.

Table 2.9 Number of agricultural holdings and available area of the holdings (included individual agricultural holdings and business entities)

2016	Total utilised land, ha	Utilised agricultural area (own land), ha	Leased land, ha	Unutilised agricultural land, ha	Other land, ha
Number	320,738	217,557	103,181	23,826	21,898

Box 2.2: Evaluation of the biomass waste potential (Municipality of Bogdanci)

Agricultural residues: The total available area of agricultural land in the municipality is 3.402 ha, while the area of used agricultural land in the municipality is 3.305 ha. Most of the areas with arable land, gardens and home gardens are used for production of cereals (wheat and barley) and vegetables (cabbage, tomatoes, onions and potatoes). They cover over 90% of the arable areas. The most represented from the other crops are industrial plants, and the production of tobacco is the most dominant. With an average annual production of 3 tons of vine canes per hectare obtained by vine pruning, about 1.359 tons of waste biomass is obtained from the total area of 453 ha of vineyards. The practical availability of vine canes is estimated at 510 tons per year. Assuming that the thermal power of the canes is about 11,5 MJ/kg, the total potential of energy contained in them is:

510.000 kg/year x 11,5 MJ/kg = 5,860·106 MJ/year

or approximately 1.628 MWh/year or 140 toe per year.
With production of at least one ton of orchard pruning waste per hectare, at least 70 tons of waste biomass is obtained annually.

Livestock breeding residues: The mass contained in livestock manure is used for energy needs primarily through biogas which is produced with anaerobic fermentation. The livestock bred in the municipality area consists of sheep (1 542), cattle (335), horses (744), pigs (774) and poultry (4 122). The following table presents the average theoretical, technical and economic potential of manure from stall barn growing livestock in the Municipality of Bogdanci.

Average theoretical, technical and economic potential of manure from livestock breeding in the Municipality of Bogdanci

2018	Mass, kg/day	Theoretical t/year	Technical t/year	Economic t/year
Cattle	32.6	2 790	1 953	1 563
Horse	28	338	169	931
Pigs	2.4	338	169	51
Sheep	6.5	918	643	514
Poultry	0.15	158	111	66

In the Municipality of Bogdanci, manure of stall barn breeding livestock and poultry is estimated at about 3.125 tons per year from which a total of about 80 m^3 biogas can be obtained per year with a total energy of about 0,54 GWh or 47,5 toe per year (for comparison: for heating of the premises of the Technical Faculty in Bitola with usable area of approximately 6.000 m^2, about 45 tons of extra light household oil per year are needed.

The *Study on the potential and utilization of renewable energy sources in the cross-border region*)[9] has detailed analysis for 9 other municipalities.

Box 2.3: Example of waste biomass utilization for CHP in Southeast region

Type of waste biomass	Thousand tones/ year
Deforestation waste	2.3
Wood processing waste	2.3
Agriculture waste	7.0
Total	11.6

The total biomass waste of 12 thousand tons received from deforestation, wood processing and agriculture, in plants for cogeneration of heat and electricity can generate around 9-13 GWh of electricity and 22-33 GWh of heat, depending on the needs and the available consumption of thermal energy. According to the Decree passed by the Government, the thermoelectric plants using biomass as fuel can acquire the status of preferential producer if its installed power capacity is lower or equal to 3 MW. The highest percentage of participation of fossil fuels in the total energy value of the fuel consumed is 30%. Preferential tariffs for electricity generated by thermoelectric plants using biomass depend on the installed capacity of the power plant and the participation of fossil fuels in the total energy value of the fuel, such as:

- If the share of fossil fuels of the total energy value of fuel is less than or equal to 15%, preferential tariffs for electricity generated by thermo plants using biomass is 15 €/kWh;
- If the percentage share of the fossil fuels in the total energy value of the fuel consumed is greater than 15% and lower or equal to 30%, the reduced preferential tariffs are calculated according to the following formula:

$$PT = PT0 \times (1{,}15 - p \times 0{,}01) \times 0{,}01$$

where:
- PT is reduced preferential tariff
- PT0 is the tariff in the preceding paragraph (15 Euro cents), depending on the installed capacity of the power plant,
- p is designated percentage of participation of fossil fuels, determined by the Ministry of Economy.

The preferential producer has the right to use preferential tariffs for electricity produced by power plants using biomass as engine fuel in a period of 15 years. The total installed capacity of the preferential producers of electricity using biomass as engine fuel is limited by a Decision taken by the Government of the Republic of N. Macedonia to the total installed capacity of 10 MW. The potential of biomass waste is significant and it can optimally be used in two ways: by direct combustion or by pelletizing and briquetting. Due to the large number of factors affecting the economic viability of the use of energy from different sources, it is difficult to give an accurate assessment of which energy source is best in certain conditions. It must be emphasized that in the Republic of N. Macedonia there has been some previous experience of using specific types of biomass for energy needs through its combustion in boilers of several industrial capacities: wood and wood waste, rice paddy ("Zhito-Oriz" - Kochani) and vine canes ("Lozar" - Veles) which have not been operational for quite some time.

This project received funding from the BBI JU under the EU Horizon 2020 research and innovation programme under grant agreement No.838087

There is a large number of livestock that produce waste that can be used to obtain energy [31].

Livestock	Type of waste	Quantity kg/day	Dry kg/day	Biogas per animal (m^3/day)	Energy per animal (kWh/year)
Cattle	Liquid	51	5.4	1.6	3400
Cattle	Dry	32	5.6	1.6	3400
pigs	Liquid	16.7	1.3	0.46	970
pigs	Dry	9.9	2.9	0.46	970

Livestock waste

Livestock	Weight in kg	Waste mass in kg/day
cattle	500	32,6
horses	500	28
pigs	100	6,5
sheep	50	2,4
poultry	2.5	0,15

Box 2.4: Potential of Livestock breeding residues – South-east region of N. Macedonia

The waste mass contained in livestock manure is used for energy needs primarily through biogas produced by anaerobic fermentation. The biogas consists of methane and carbon dioxide in a ratio 2:1, and small amounts of NH_3 and H_2S. In the Southeast Region, the total waste mass of barn breeding livestock and poultry is estimated at 323 thousand tons per year. It can make a total of about 8,3 thousand m^3 biogas per year with a total energy of about 55 GWh.
However, the experience with the economically viable use of biogas in the region is quite modest and the real usable potential does not exceed 25% of the total potential. It is estimated that it can generate less than 5 GWh of electricity at maximum. According to the Decree passed by the Government, the thermoelectric plants using biogas as engine fuel, have highest percentage of participation of fossil fuels in the total energy value of the consumed fuel of 30%. The preferential tariffs for electricity generated and delivered by thermoelectric plants using biogas as engine fuel depend on the installed capacity of the power plant and the participation of fossil fuels in the total energy value of the fuel, as follows:

- If the percentage share of fossil fuels in the total energy value of the fuel is lower or equal to 10%, the preferential tariffs for electricity generated and delivered by thermoelectric plants using biogas is 18 Euro cents/kWh;
- If the percentage share of fossil fuels in the total energy value of the fuel consumed is greater than 10% and lower or equal to 20%, the preferential reduced tariffs are calculated according to the following formula:

$$PT = PT0 \times (1{,}10 - p \times 0{,}01) \times 0{,}01$$

where:
- PT is reduced preferential tariff
- PT0 is the tariff in the preceding paragraph (18 Euro cents), depending on the installed capacity of the power plant,
- P is designated percentage of participation of fossil fuels, established by the Ministry of Economy.

The preferential producer has the right to use preferential tariffs for electricity produced by power plants that use biogas as engine fuel for a period of 15 years. The total installed capacity of the preferential producers of electricity using biogas as engine fuel is limited by a Decision passed by the Government of the Republic of N. Macedonia to the total installed capacity of 6 MW.
Herewith, it is important to introduce the biogas plant Veze Sharri which generate electricity from waste with 1MW capacity and Novaci biogas plant with 5.9 MW capacity that utilizes the manure

Box 2.5: Manure management - pig farm in the city of Tetovo

Total animal waste from the farm: 10250 t/year. The waste that comes from the facilities where the throats are located is directed to the waste channels in the main collector. In the collection pool, the waste is separated into solid and liquid. Aerobic fermentation is performed on liquid waste. Hard manure is used as a biofertilizer. The extinct animals are thrown into a pit. Geotextile is placed in the pit - prevention of wastewater leakage in groundwater [31].

2.4 Secondary agricultural residues from processing industries

Secondary residues from agriculture are the agro-food processing residues such as pits, shelves, peelings that all have commercial uses such as for animal feed, or other bioproducts.

Food industries available in N. Macedonia include: Mill and bakery industry, Confectionery industry, Oil Processing and Production Industry, Fruit and vegetable processing industry, Dairy industry, Fish canning industry, Meat processing industry and Alcohol industry.

Despite the available untapped potential of arable agricultural land and pastures, the country is still a net importer of agricultural and food products, as evidenced by the difference between imports and exports in 2018. We are net exporters only of fruits, vegetables, beverages and tobacco, while for other products we are net importers [32].

Box 2.6: Methodology of S2BIOM to calculate the secondary residue potentials from food processing

All the secondary agricultural residues presented refer to residues of crops that are mostly grown and processed in the same country. Their assessment can therefore be based on production information (area and/or yield information) derived from national agricultural statistics.

For further details on the whole assessment of biomass potentials in S2BOM consult Dees et al (2017) and a summary is given in Annex 2.

For a selection of agrifood processing sectors an estimate of the secondary residual biomass was made in the S2BIOM project and presented in the Table below.

Table 2.10 Secondary residues (ton d.m.) from main agrofood sectors (source S2BIOM, see Box 2.3)

Name	Cotton gin residues	Rice husk	Pressed grapes dregs	Cereal bran	Total
Vardarski	225	463	604	545	1,838
Istočen	196	403	525	474	1,597
Jugozapaden	198	407	531	479	1,615
Jugoistočen	153	315	411	371	1,250
Pelagoniski	272	559	728	657	2,217
Pološki	127	262	341	308	1,039
Severoistočen	121	249	325	293	988
Skopski	99	203	265	239	807
	1,392	2,862	3,729	3,366	11,350

Secondary agricultural residues from animal farms is about 4.9 million tons / year of animal manure Animal nutrition management in slaughterhouse products and hanging animals on farms is far from the requirements of relevant EU legislation.

Proper management of by-products from agriculture and other related manufacturing activities such as manure, animal tissues and a variety of plant tissues, is closely related to the application of "good agricultural practice" and with the use of such by-products as renewable energy sources. Special priority will be given to the economically viable structure for separate collection of animal tissues belonging to different risk classes and an appropriate network will be formed of treatment and disposal facilities, especially with the introduction of high-capacity risk animal tissues (hazardous waste). Proper collection, handling and disposal / disposal of toxic agrochemicals residues (insecticides, fungicides) and contaminated packaging will be arranged through return system organized by the distribution, trade and manufacturing sectors.

There are no formal high-end collection systems risky animal tissues from slaughterhouses and livestock farms. Much of the plant tissue produced in agriculture is used again, in a way that is beneficial to the environment. Fertilizer obtained from coarse and from small goods are used entirely to fertilize the soil. Composting and anaerobic organic waste rot is generally not practiced or there is no capacity for it purpose. Current management and removal of animal tissues from slaughterhouses and livestock farms consist of burying in pits on farms or dumping in rural landfills for waste. In both situations, this is done with little or no participation and supervision by an authorized person veterinarian, mainly in an uncontrolled manner and far from the required sanitary standards.

2.5 Cost of main biomass source

Since for most agricultural residues no commodity market has developed yet it is very difficult to provide figures on prices. Instead cost estimates can be presented building on the S2BOM methodology and assessment. The cost refers to *Roadside cost* and these cover all biomass production collection and pre-treatment cost up to the road where the biomass is located. The roadside cost is only a fraction of the total 'at-gate-cost.' The road side costs are presented in Table 2.5.1 below; for further details on the cost calculation in S2BOM see Annex 2.

Table 2.11: Road side cost levels (€/ton d.m.) for agricultural biomass sources based on S2BIOM cost calculations

Road side cost for agricultural biomass	**Average (€ ton dm)** (2020 cost level)
Maize stover	8.4
Residues from vineyards	42,0
Residues from fruit tree plantations (apples, pears and soft fruit)	92.6
SRC unused lands	25
Dedicated crops on unused lands	25

2.6 Summary and conclusions in relation to SWOT elements

The extensive SWOT analyses was conducted with the National Strategy for agriculture and rural development. The common European model of agricultural policy has been transposed through the obligations undertaken by the Stabilization and Association Agreement. It is an indispensable horizontal principle and goal in the programming of the Macedonian agricultural policies in the next period. Additionally, when creating policies and measures taken into account are more pronounced climate change and efforts to reduce their negative impact on agriculture production [33].

Table 2.12: SWOT elements in relation to biomass supply from agriculture

Strengths	Weaknesses
• Long tradition in production of various primary products and processed foods; • High natural potential for agricultural production and timber production; • Good presentation of Macedonian agricultural and food processing industry in the countries of the region; • The agri-food sector is represented by functional associations and chambers of commerce that are active stakeholders in the development and implementation of development policies. • Available educational facilities and functional educational system in the field of agriculture, forestry and food industry; • Favourable agro-environmental potential; • Rich biodiversity; • Diverse soil and high natural value of arable land; • Extensive experience of applying traditional sustainable agricultural practices; • A large number of preserved rural communities with rich historical and cultural traditions; • Presence of road infrastructure with access to relatively smaller settlements in rural areas • Introduced ICT technologies that provide opportunities to improve access to services and develop new businesses; • Increased investments in rural infrastructure including rehabilitation of schools and health facilities in rural areas; • In EU accession process and policy framework already strongly aligned with EU requirements	• Dual structure of agriculture with a large share of small farms with very small average production capacities per holding; • High parcellation of agricultural land and private forest land with limited access to water and roads to the parcels; • Low level of education, inadequate qualifications, business and managerial skills of the workforce in agriculture and rural population; • Lack of seasonal labour in agriculture and aging of rural labour force; • Depreciated equipment and means of operation and application of obsolete technologies; • Lack of own capital and difficult access to credit for small agricultural holdings in particular; • Poor integration of food chains and lack of vertical and horizontal integration; • Low productivity in agriculture and food industry; • High share of low value-added agricultural products - unprocessed or semi-processed products in the export structure of agricultural and food products and insufficient diversification by export destinations; • Undeveloped system for vocational training in agriculture, food industry and forestry and insufficient access to quality advisory services; • Poor integration of researcher's capacities for development of agriculture and forestry and slow pace of innovations in the agricultural - food sector • Inefficient use of natural resources, including exploitation; • Improper use of irrigation water and inefficient systems with large water losses, etc.; • Constant trend of soil degradation, especially under the pressure of monocultures; • Reduction of areas under pastures and degradation of mountain pastures; • Negative population growth and migration out of rural areas especially young and female population; • Decrease in employment of the rural labour force (low educational status, lack of entrepreneurial spirit); • High dependence on agriculture and poor job opportunities in non-agricultural sectors; • Rural poverty and social exclusion; • Poor access and low quality of basic services for the population in rural areas (schools, health and social care, ICT penetration, recreation and recreation); • Degraded or lack of basic infrastructure (roads, water supply and sewerage); Weak social capital for local development

Opportunities	Threats
• New technologies in agriculture, food industry and forestry and also energy saving and renewable energy production; • Increasing revenues and increasing domestic demand for high quality agricultural and food products; • Improved access to EU markets and penetration of alternative markets; • Increasing domestic financial support and EU support for improving the competitiveness of agriculture, forestry and food industry; • Increasing foreign investment; • Increased interest in establishing cooperatives and in joint marketing and placement; • Opening new distribution centres for fresh fruits and vegetables; • Increasing environmental awareness; • Great interest in applying Agri-environmental practices and organic farming; • Increasing demand for rural tourism in the domestic and international market; • EU support for diversification of economic activities, improvement of basic services in rural areas	• Loss of specialized labour in agriculture and forestry due to migration; • Increasing the cost of inputs and reducing the available agricultural land; • Increase business costs to adjust to ever-increasing quality, food safety and environmental standards; • Increased competition in the domestic market; • Global climate change and the risks associated with natural disasters (i.e. floods, accidents, fires, droughts); • Loss of biodiversity; • Increase of pollution due to intensification of agriculture, industrial activities, transport and tourism; • Use of commercial varieties and species leads to the disappearance of traditional and indigenous varieties and breeds. • Reduction of the rural population • Increased mobility of rural labour force outside the country; • Increased quality of workforce requirements for businesses; • Increased competition in the domestic market; • Increasing disparities between rural and urban areas in economic development, education and access to basic services.

3 Biomass supply: Forestry

3.1 Introduction

Forests and forestland in N. Macedonia cover around 1.1 mil. ha and are characterized with great species diversity, but low quality and small annual growth. More than 70% of the forests are coppices, 90% are deciduous and almost 90% are state owned. The state-owned share is managed by a public enterprise "Macedonian Forests", composed of regional units that cover the entire territory of the Republic of N. Macedonia. Private forests account for 11% of the total forest area. The private forests are a relatively small area, less than 1 ha, scattered as individual or group lots which represent enclaves within the state forest. The most dominant species is beech, and then various oak species. Total wood reserve is estimated on around 70 mil m^3, and total annual growth is around 1,7 mil m^3. Very large part of the land considered as forest, are Mediterranean type of forest, characterized with small trees and bushes [34].

N. Macedonia has experience in the use of biomass residues from deforestation, wood processing, and agriculture, especially in using it for production of heat. However, this kind of biomass residues is suitable to use only in plants for combined production of heat and electricity.
Biomass residues include:

- deforestation residues,
- wood processing waste,
- agriculture residues,
- livestock breeding residues,
- industrial waste
- municipal solid waste

There is still lack of reliable data assessing the economic cost-effective potential, nor their sufficient experience in the performance of specific plants.

Box 2.7: Deforestation residues –case of Municipality of Bogdanci.

Forests cover an area of 2.720 ha of the Municipality of Bogdanci. The climatic features, distribution of precipitation and high temperatures do not provide opportunities for the development of highly productive forests. The felled amounts of timber from private forests are very small and are only used for heating (firewood). The possible annual logging, i.e. the total possible annual felled timber is just over 1,600 m^3. The planned gross annual logging of the Branch Forest Enterprise (BFE) "Kozhuf" - Gevgelija, on the territory of the Municipality of Bogdanci is about 1,270 m^3, with estimated normative primary residues (branches, thinings and tops) of 9.09% or about 115 m^3. Assuming that the volume of such residual biomass is about 650 kg/m^3, and the thermal power has a value of 14.5 MJ / kg, that is an energy potential of:

$$115\ m^3 \times 650\ kg/m^3 \times 14.5\ MJ/kg = 0.75x106\ MJ/year$$

which is 211 MWh/year or approximately 19 toe per year.

Table 3.1. Summary of the main characteristics of Macedonian forests [35].

2018	
Forrest area	1,007,095 ha
Afforestation	959 ha
Gross felled timber	802 000 m^3
Coniferous trees	74 000 m^3
Broad- leaved trees	728 000 m^{3}a
Length of forest roads	9,206 km

Table 3.2. Afforestation in and outside forest

2018	ha
Total	959
Afforestation in forest Cleared areas	413
Afforestation in forest Bare land	383
Afforestation outside forest Rocky and bare land	54
Afforestation outside forest Eroded land	80
Afforestation outside forest Agricultural and other types of land	29
Artificial afforestation by sowing	349
Artificial afforestation by planting	610

Box 2.8: Biomass-based heating

From the perspective of the ultimate consumer in the country, financial savings generated by receiving information about biomass heating are often very significant. In most cases, replacing an existing heating system with biomass-based heating technology can significantly reduce costs. For example:

- Heating with efficient heating stoves, as opposed to electrical appliances, will generate 40-74% savings.
- Heating with modern, efficient fireplaces, as opposed to old, inefficient fireplaces, will generate 51-53% savings.
- Heating small boilers on wood chips versus electrical appliances will generate 52-77% savings.
- Heating small boilers on wood chips versus small boilers on fuel oil / LPG will generate 49-70% savings.
- Heating wood pellet stoves versus electrical appliances will generate 12 to 51% savings.
- Heating small pellet boilers, as opposed to electrical appliances, will generate 22-59% savings.

Depending on the type of house, the most attractive options for biomass heating - which provide the greatest benefits for the citizens are:

In detached buildings:

- replacement of inefficient firewood stoves with efficient furnaces
- switching from electric heating appliances to efficient biomass heating stoves

In multi-store buildings:

- switching from electric heating appliances to wood chip heating boilers [36]

Table 3.3. Forest product by tree species in state forest (source SSO)

2018	m^3
Round wood	537,131
Logs, coniferous	27,825
Mining wood, coniferous	2,934
Other long coniferous wood	4,658
Stack coniferous wood	1,834
Fuel wood, coniferous	10,210
Logs, broad-leaved	61,797
Mining wood, broad-leaved	28
Other long broad-leaved wood	93
Stack broad-leaved wood	278
Fuel wood, broad-leaved	427,378
Other wood in the rough, including chopped wooden poles and stakes	96

According to certain analysis it is economically feasible that 65% of the technical potential of forest residues, 60% of the residues from wood processing, 90% of sawmill residues (saw dust and other secondary residues)

could be utilized for energy purposes. This results in a total possible economical production capacity for bioenergy or other bioeconomy uses of 1.22 PJ/year. (1.03PJ/ year from deciduous and 0.19PJ/ year from coniferous), i.e. 339 GWh [30].

Wood was and still is the primary fuel and a source of energy in more regions in N. Macedonia. Residues from forests are commonly used as fuel or as raw material in some technological processes in the wood processing industry (plywood etc.). The gross felled timber in Macedonia is assorted as fuelwood (80%), industrial wood (15%), and residue (5%).

In the forests in N. Macedonia, forest dumping sites are usually used to dry wood residues. Wood residues (tops, branches and wood from (early) thinning) is left few days or weeks (especially in summer) in order to reduce their moisture content below 30%. Most often the compaction of wood waste is done by: bundling or crushing and grinding. The price of fuel for the harvesting operation or pruning equipment must also be taken into account for price formation of biomass as a raw material for obtaining briquettes and pellets.

Box 2.9: Distribution of energy consumption for collection, baling and transport of biomass residues

Many studies have shown that of the total energy consumption on the processing of energy plantations, 43% (29,560 kWh/ha out of a total of 68,730 kWh/ha) is used for cutting and baling, 35% for transport (24,064 kWh/ha), and the rest of the energy is for seed material, planting, and storage. Regarding the total energy obtained (2,863,360 kWh/ha), the energy consumption is 2.5% (the ratio of the obtained and invested energy is 41.7). But it should be emphasized that this can reach up to 10%. During the process of crushing wood residues from deforestation, with a crusher driven by an internal combustion engine, fuel consumption (oil) is about 3.8 l/t (40 kWh/t). The energy consumption during the transport of biomass residues very much depends on the type of vehicle. Thus, for example, if the energy consumption for truck transport is 0.4 kWh/t when transported by rail, the consumption is 0.19 kWh/t and is almost twice lower. If biomass is transported pneumatically by pipelines, energy consumption is twice as high as truck transport. [28].

In N. Macedonia it is expected that the price of raw material (at no cost to transport) ranges around 10 €/t for sawmill waste wood. If you take the price of pellets today in N. Macedonia from 220 €/t, investment of 1 139,407 €, with 6% interest on the loan approved for 10 years and production at 3,200 t/yr. pellets, the investment would come back for 2.2 years [28].

About 71% of the area consists of low-stem and unmanaged forest land, which only make up 37% of the wood mass in Macedonian forests. Another important feature of N. Macedonia is the large areas with low forests and barren land, as well as land without forest cover suitable for forestation. Taking into consideration that by the type of cultivation 71% are low forests that have no technical mass, it is logical to use them for firewood production. Out of the total forest products, firewood accounts for 90%, but that information cannot be considered accurate as most of the population is supplied with wood from illegal logging that cannot be registered. Wood biomass as energy source can be used only for heating households, but is not sufficient to produce significant amounts of electricity. There is a considerable potential of residues from wood biomass, but they are used individually and without any organized strategy [12].

General information on the forestry sector are also provided in the tables in Annex 3.

Table 3.4. Forest land area

2018	Total	Forest area	Other forest land	Barren land
ha	1,122,753	1,007,095	100,207	15,451

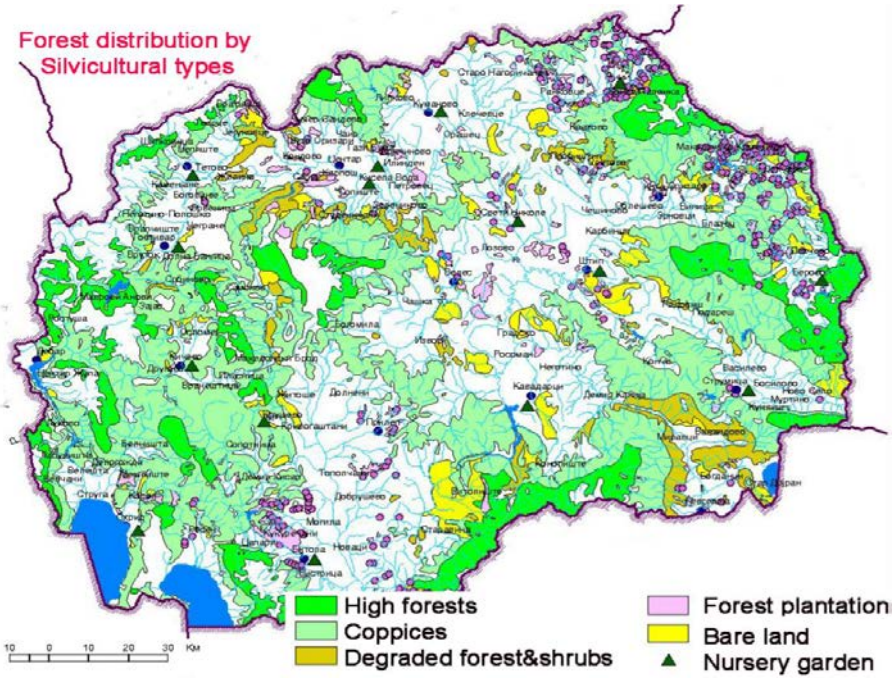
The Gross felled timber, inside and outside forests in N. Macedonia is shown in the tables.

Table 3.5. Gross Felled timber outside forest

2018	Total	Industrial wood	Fuel wood	Residue
000 m³	802	121	639	42

Table 3.6. Gross felled timber, inside forests

2018	Total	State forests	Private forest
m³	54 062	7 727	46 335



Forest distribution [12]

3.2 Primary residual biomass resources from forestry

Primary forestry residues

During planned deforestation, forest tree pruning, forest tree cutting for road construction and cutting of burned and diseased trees produce residues in the form of branches, parts of trees, barks, roots, woodchips etc. The residues from woodcutting is on average about 70 thousand m³ per year which on average covers 9.5% of the total cut. The residue from the cutting of forests in N. Macedonia amounts to about 14% of the total cutting or about 120 thousand m³. That it is a result of obsolete machinery used for cutting and deliberately leaving bigger residues for further unrecorded use and that, by using more modern techniques of cutting, residues should normally not exceed 7% of the total cut or about 60 thousand m³ per year. This makes it 39 thousand tons per year. A very small part of this residues, 40 - 100 m³ annually, is used by forest companies to heat the premises while the rest is left in the woods. Assuming that in N. Macedonia around 40% of the forest residues can be used in smaller plants for combined production of heat and power that would be set in the nearest location with heat consumption. This would result with 24 thousand m³ per year, i.e. nearly 15.6 thousand tons per year [12].

Wood processing residues

In N. Macedonia, about 130 thousand m³ of industrial wood is processed per year. There are over 100 companies dealing with wood processing. Most of them are small sawmills. A number of major companies deal only with production of carpentry, furniture; and a certain number of companies deal with primary and secondary wood processing. The residues generated during wood processing consists of woodchips, sawdust, bark, cut-outs from log ends, splinters, fine wood dust etc. It is estimated that larger companies, dealing with primary and secondary wood processing, process about 40 thousand m³ technical wood annually. Consequently, they produce about 15 thousand m³ of wood residues. Most of it is used in their own boilers to produce steam and for heating up the premises. Some of the dust is used for production of briquettes and pallets. This quantity of biomass has already been included in the statistics of consumption of biomass combustion. However, some of the boilers are very old and can be expected to be replaced with new plants for combined heat and power. Assuming this percentage amounts to 40%, the available biomass for this purpose is around 6 thousand m³ of wood residues per year. Smaller companies, most of them sawmills, process about 90 thousand m³ technical wood and produce about 45 thousand m³ of wood residues per year. This wood residues are not used generally. The problem is that these companies mostly do not need heat. If 30% of these residues was used in small plants, it would make 13 thousand m³ of wood residues per year. The total potential of wood processing residues that could economically be used for combined generation of heat and electricity is estimated at 19 thousand m³ or about 12.4 thousand tons of wood residues per year.

Table 3.7 Primary forestry potentials (kt on d.m.), 2020 Base potential (source S2BIOM)

Country region	Final fellings	Thinnings	Logging residues from final fellings	Logging residues from thinnings	Total
Vardarski	81	80	13	6	180
Istočen	54	53	11	5	123
Jugozapaden	89	85	10	4	188
Jugoistočen	60	59	9	4	132
Pelagoniski	85	84	12	6	188
Pološki	67	63	4	2	136
Severoistočen	34	33	4	2	74
Skopski	39	39	3	1	82
	508	496	67	31	1,102

3.3 Secondary biomass resources from wood processing industries

Wood industry or timber industry is - usually private - economic sector that deals with forestry, logging and production of forest products, timber or timber for construction, basic forest and wood products (e.g. furniture) and secondary products such as wood cellulose for cellulose and paper industry. Some of the largest producers are also among the largest forest owners. The wood industry plays a dominant role in today's wood economy. In a narrower sense, the conditions, forest and timber industry indicate different sectors, in internationalized world, where there is a tendency towards huge integrated businesses covering the whole range of forestry and private primary and secondary forest or plantation through the process of felling in wood processing and trade and transport (for example wood sawing, forest rail). Processing and products differ as soft and hard. While softwood is primarily used in the production of firewood, cellulose and paper, hardwood is mainly used to make furniture, floors and more. Both types can be useful for building (residential) (wooden cottages, wooden cabins, wooden construction)[37].

In the wood industry, the country has tendency for production growth except for the production of sawn lumber from pine and beech, parquet and production of the category other which includes the production of pallets, crates and boxes in the period 2011-2016. N. Macedonia, although rich in raw materials, does not reach the required capacities in the production of wood products, and especially in the manufacture of furniture. Due to

the existence of a large number of small and less productive sawmills, the country's wood sector faces insufficient processing and production of wood products. Since the saw mills had begun work without investing in their technology in the 90s of the last century, they worked with obsolete machines and equipment. If it is invested in modern technology and new equipment, sufficient profit could be realized with minimal investments. Furniture production is the most important segment of the wood sector. N. Macedonia belongs to the group of unprepared countries in which in recent years there is no systemic investment in this sector. On the whole, the Macedonian wood industry is a marginal supplier on the international market. The activity manufacture of wood and wood products includes: sawn lumber from pine, sawn lumber from beech, veneer and plywood production, parquet, windows, doors and others (pallets, crates, boxes). The average production of sawn lumber from pine is 3883 m^3, while the production of sawn lumber from beech is smaller than 2360 m^3. The average annual production of veneer and plywood boards is negligible with only 714 m^3. The parquet produced an average of 5962 m^3 in the analysed period. Thus, the average annual production of windows was 2095, while 2118 doors were produced in the given period. The category other has the highest average production of 9927 m^3 which includes production of pallets, crates, boxes in the studied period [38].

The State Statistical Office do not offer many data on this industry or the secondary biomass resources. Some of the information are outdated, however they are solid base for different projections or extrapolations.

2018	Manufacture industry
Wood secondary residues - tonnes	3 002

2017	Active entities
Wood processing, wood products and cork	439
Production of furniture	1 219

Table.3.8. Secondary forestry potentials (kt on d.m.), 2020 Base potential (source S2BIOM)

Country region	Sawdust	Other residues	Residues from industries producing semi-finished wood-based panels	Residues from further wood processing - Bark	Total
Vardarski	3	2	2	1	8
Istočen	2	2	2	1	7
Jugozapaden	3	2	2	2	9
Jugoistočen	2	2	1	1	7
Pelagoniski	3	2	2	2	9
Pološki	1	1	1	3	6
Severoistočen	2	1	1	1	6
Skopski	2	1	1	5	8
	19	13	11	17	60

3.4 Summary and conclusions in relation to SWOT elements

Table 3.9: SWOT elements in relation to biomass supply from forestry [39]

Strengths	Weaknesses
• Closeness and connection to European borders and markets • Favourable climatic conditions for agricultural development • Recognized agricultural region - Southeast region • Rich natural, cultural and historical heritage • Productive and prosperous SMEs • Human resources • Existence of economic zones • Commitment of municipalities to common economic development • Developed civil sector • Brands from Southeast Region • Euroregion of the Balkan area and one of the very few Euroregion composed of European member states (Greece and Bulgaria) and non-member states	• Underdeveloped infrastructure • Insufficient utilization of natural resources • Insufficient promotion of tourist potentials • Fragmentation of arable surfaces • Brain drains • Insufficient education of farmers • Lack of direct investment • Adverse financial environment • The presence of the grey economy • Absence of organized and standardized agricultural production • Significant share of old low-stemmed forests; • High risk of damage to forests from natural disasters; •
Opportunities	**Threats**
• Opportunities for new economic zones • Possibility of regional infrastructure connectivity • Construction of Agro Stock Exchange • Opportunity for agricultural development - healthy food production, livestock development through the construction of new farms, the establishment of agricultural clusters and the construction of a factory for finalize agricultural products and their distribution • Opportunity to access foreign markets	• Endangering the environment - large industries that would pollute, however, polluting solid residues and plastics occur in places due to under-developed awareness among the population • Globalization and market liberalization threaten domestic production as it is not yet ready for new competition • Outflow of human resources • Lack of own energy sources

4 Biomass supply: Waste

4.1 Introduction

The waste management strategy is the result of a government decision, both as an executive and in that context represents the main solutions of the N. Macedonia related to the goals of environmental protection, with economic and social goals, activities and measures for mitigating current environmental impacts and addressing related issues waste management in the future. Compliance of legislation with the *Acquis Communautaire* as an inevitable process in bringing N. Macedonia closer to membership the European Union is a useful tool in establishing an efficient and sustainable waste management system. Major problems and limitations in the field of waste management in N. Macedonia are present in almost all areas of the existing waste management system, as well as in all relations in the society related to waste management. The current situation with waste management in N. Macedonia can be characterized as substandard in terms of human and financial resources, as well as insufficient and ineffective in terms of monitoring and enforcing regulations, resulting in various dysfunctional systems in society and in many related adverse effects on the environment and human health.

The processes of reuse, recycling and renewal of materials/energy from waste fractions must be encouraged to improve resource utilization and only unusable fractions will be left for disposal. Proper management of biodegradable waste present in communal waste and waste treatment wastewater, agricultural and food waste from the food industry and the beverage industry can contribute significantly to reducing emissions greenhouse gases. Such an approach means that every piece of waste is seen more than just how source of pollution, but also as a potential resource that can be used, and this will be resulting in the separation of economic growth and the amount of waste generated.

Since waste can be a secondary raw material, sustainable management with waste means optimal utilization of potential waste resources as replacement for non-renewable natural resources, taking into account economic, environmental and social aspects. Such sustainable development can open up options for recycling the separately collected waste fractions of the source itself, as well as for the production of biogas and soil materials from various industrial, agricultural sources, and even from households. For a country with limited natural energy resources, renewable energy resources such as waste wood, animal by-products, manure, sludge from wastewater and other types of biomass can become comparatively more important raw materials for the production of gaseous, liquid and solid fuels from waste [40].

4.2 Waste from biological resources

The use of compost and other means of promoting soil layers seem to be the first priority in terms of sustainable management of biodegradable waste fraction. But for application in agriculture, special quality requirements must be met in relation to the type of crops, the content of toxic and bio-accumulating substances in the layers and soils, as well as groundwater protection levels. Therefore, the use of soil material prepared from biodegradable waste appears to be a viable long-term option for projects for the revitalization of risk landfills and other animal loads.

Regardless of origin, biomass is one of the most important renewable energy sources, even as component of municipal solid waste. For a country with limited natural energy resources, with exception to fuelwood and hydro-energy potential, other renewable energy resources such as residues and other post-consumer wood, manure, arsenic fertilizer, sewage sludge and other types of biomass may become increasingly important raw material for the production of gaseous, liquid and solid fuels from waste, for transport and for energy production, in industry and in households. All types of biomass utilization will contribute significantly to reducing greenhouse gas emissions.

Municipal Solid Waste

The term municipal solid waste (MSW) implies waste collected from households, along with the maintenance of public hygiene and collection of park waste, commercial and institutional waste, construction and industrial waste that is similar to household waste. Municipal solid waste can be treated as an energy resource if it contains organic substances.

The solid waste is deposited in many landfills in N. Macedonia. There are 55 active landfills without any permit, but only Drisla landfill (serving the Skopje Region) is well managed and has working permit. It is estimated that the number of illegal landfills (dumpsites), especially in rural municipalities, is about 1 000. Regional integrated management of municipal solid waste is planned to be established in the upcoming period. Seven regional landfills are planned for the territory of N. Macedonia. The total amount of municipal solid waste in N. Macedonia reaches 700 thousand tons per year, of which around 200 thousand tons belong to the regional landfill Drisla, and the other regional landfills make 50 - 100 thousand tons. The lower calorific power of municipal waste in N. Macedonia is estimated at 7.860 kJ/kg. In the estimated value, paper and plastic participate in the total waste weight with 24% and 6% respectively. National average statistics: 300 kg per capita, per year for urban and 200 kg per capita of rural settlements.

Table 4.1. Waste amount by waste category [41]

2016	tones
Total	1 437 492
Post-consumer wood	179 930
Livestock waste and mixes food waste	4 070
Agriculture waste	1 131
Municipal mixed waste	41 313

Table 4.2. Generated waste by waste category [42]

2018/ tones	Agriculture, forestry and fishing	Manufacturing
Animal and mixed food waste	-	10 440
Vegetal waste	2 373	5 072
Households and similar waste	23	4 214

4.3 Current waste treatment and unused potentials estimates

- Utility waste management scheme

Reducing the amount of municipal waste at the source can be achieved quickly and at a low cost, by encouraging the multiple use of primary packaging, through composting of the organic fractions of households' waste, green waste from gardens and green waste from public and private green areas. Composting will be implemented in order to recycle soil biomass locally or in combination with organic waste from agricultural production [40].

Preparation of the appropriate technical and investment documentation for the intended capacities for the management of special waste streams, for the reduction of biodegradable waste for disposal, for the use of waste energy and for its use in energy production can be considered after more detailed knowledge of quantities and for the composition of waste streams. Investments in process capacity may shift towards the end or further in the period for the implementation of the waste management strategy. The total capital costs associated with transposing the EU's Basic Directives in the domain of waste management in the Macedonian legal framework and their full implementation is estimated at around € 400 million. More sophisticated technological facilities for biotechnological and thermal treatment waste will require additional capital investment.

In the current phase of institutional and economic development in N. Macedonia, the practical scope for application of financial / economic instruments is limited. Environmental fees paid by waste generators according to the amount of non-hazardous / hazardous waste generated, according to the type / quantity of imported and manufactured plastic products and packaging of plastic masses, according to the type / quantity of imported waste and waste for production lead accumulators and by type / quantity of imported or manufactured oil waste or oil and waste oils, become part of the integral state budget; the collected fees are the basis for financing the priority activities in the field of environment; waste management programs compete with other environmental programs.

4.4 Summary and conclusions in relation to SWOT elements

Table 4.3: SWOT analysis in relation to waste sector in N. Macedonia [40]

Strengths	Weaknesses
• Regional waste management plans have been developed	• Most of the waste is mixed waste and land filled • political and legal framework; organization of institutions and human resources, • covering costs and financing services and investments, • the consciousness of the entities involved and informing them, • all stages of technical management from collection to waste disposal, • existence / remediation of animal loads environment, • impacts on human health and the environment / natural environment with potential impact on the Macedonian economy
Opportunities • There is still large room for improving the waste separation, collection and treatment and processing of waste. Now almost all household waste is going to landfill • harmonization of policy and legislation • establishing effective institutional and organizational set-up • strengthening human resources and capacities • introduction of stable financial resources and appropriate economic mechanisms • raising public awareness and awareness of all parties involved • Establish a data / information collection system • establishment of a technically modern waste management system • application of efficient and cost-effective techniques for managing the separated flows of • waste through private sector participation in order to achieve a 100% collection rate • waste and optimal level of waste material / energy utilization; • introduction of landfills for hazardous and non-hazardous waste • gradual closure and / or repair of existing municipal waste dumpsites and / or industrial ecological hotspots	Threats • To maintain control over all flows of generated waste, • To reduce the amount of waste generated, • To use the material and energy value of the waste, • To reduce the amounts of hazardous substances in the waste, • to ensure acceptable disposal from the aspect of environmental protection, • to prevent the formation of new environmental burdens that will have to solve future generations, • to repair the environmental burdens that are negative environmental and human health impacts • large investments need to be made to make the waste sector more circular, avoid land fill.

5 Bio-based industries, products and markets

5.1 Current bio - based industries

N. Macedonia do not have strongly developed bio-based industry. Most of these industries are small scale or in the phase of planning.

5.1.1 Identified bio - based products

1. Wild chestnut laundry detergent

Link: http://dobrazemja.org/mk/sredstvo-za-alishta-od-div-kosten/
Raw material: Wild chestnut
Description: The leaf and the fruit of the wild chestnut contain saponins which make them suitable for replacing chemical washing detergents. Once the chestnuts are blended (or soaked in water), a bowl is filled with water, chestnuts are added and left overnight (or if watered, chestnuts can be used after 30 minutes). Then the liquid from the jar is drained and ready to be used. The same liquid can also be used as a natural hair shampoo. Essential oil can be added for better odor.

2. Essential mint oil

Link: http://dobrazemja.org/mk/esentsijalno-maslo-od-nane/
Raw material: Mint leaves
Description: Mint leaves are lightly interpreted, enough to release the peppermint aroma. Then the leaves are placed in a jar and base oil is added. The jar should be left in warm place (not directly exposed to the sun) for 24 hours. The next day, the oil should be strained through the gauze and the process should be repeated for the next 3 days with new round of fresh mint leaves, until the desired intensity of the aroma of the oil is achieved. Few drops of essential mint oil can be added for home-made cosmetics to flavor the cleansers. It can also be used as a massage oil or if plain cooking oil was used as a base oil, the essential oil of mint can be utilized as a food supplement.

3. Reed briquettes

Link: https://apla.mk/index.php/denes/item/2282-resen-i-ushte-tri-grchki-opshtini-kje-proizveduvaat-briketi-od-trska
Raw material: Reed
Description: The project "Less Residues 2" will be implement in the next two years through the IPA Cross-Border Cooperation Program between the Municipality of Resen and three Greek municipalities. The project deals with management and treatment of organic residues, composting and sustainable use of the reed in the Nature Park "Ezerani", from which briquettes will be produced. The project will carry out researches on food residues in households and catering facilities, residues collection methods and bio-residues public awareness. An action plan and study for sustainable use of reeds in Ezerani will also be developed, followed by procurement of reed and grass water harvesting machinery, organic residues collection containers and briquette production equipment.

4. Goat milk soap

Link:http://www.marili.com.mk/dropion/?page=2536&fbclid=IwAR0jienRqkiioDfI7c2tcQKPkeQWP0cIlQXwYiL4sYgMiPdTmqfRH6riZoI
Raw material: Goat milk
Description: "Stojnevi" had an idea to create a natural soap that can be used for the whole-body skin and act as a healing agent against the chemical soaps that often irritate the skin. This goat milk soap is created through a cold process, without removing all the useful ingredients of fresh goat milk and cold pressed organic edible oils. Essential drops of other herbal oils are added, which further enrich the soap. The real benefit of this soap is in the richness of the vitamins it contains, like E, A, B6 and B12. But also, the combination of edible oils rich in vitamins A, D, E and K, as well as minerals: calcium, phosphorus, sodium, potassium and iron, omega-3 and omega-6 fatty acids, and the antioxidants they contain nourish the skin, slow down its aging and accelerate regeneration. Goat milk soap is rich with alpha hydroxyl acids that remove dead skin cells and encourage the

growth of new and healthy cells. Also, it contains selenium, which has been shown to protect the skin from harmful UV rays from the sun.

5. Soaps from: cold pressed flaxseed/pumpkin/sesame/black cumin/chia seeds oil

Link: http://filla.com.mk/en/sapuni/
Raw material: Flax, pumpkin, sesame, black cumin, chia seeds
Description: These soaps are all natural, handmade, vegan friendly, made from various cold pressed oils. Cold pressed oil is a type of fresh juice squeezed from the seeds of particular plants, containing their natural nutrients. It is an unrefined and lacks heat treatment rich in essential fatty acids, vitamins soluble in oil, lecithin, phytosterols and minerals valuable for people's health. The seeds are processed by using a technology for cold seed pressing which means that the oil is mechanically pressed on a low temperature. As a result of the essential fatty acids present in flaxseed oil, the flaxseed soap will provide better skin care, regenerate and soothe. Cold pressed pumpkin seed soap is source of vitamins E, K, B, Mn, Ca. Cold pressed black cumin soap is rich in vitamin B, folic acid, Ca, Fe, Cu, Zn and P. Due to the high levels of Vitamin E and the B-complex group of vitamins present in sesame oil, this soap abounds with extracts containing powerful bioactive molecules. Cold pressed chia seeds soap is great source of Omega-3 and Omega-6 fatty acids, antioxidants, Vitamin C, E, protein and phenolic acids.

6. Diesel fuel from residues

Link: https://meta.mk/na-tehnoloshko-metalurshkiot-fakultet-uspeshno-se-proizveduva-dizel-gorivo-od-otpad/
Raw material: Industrial, forestry and agricultural residues, fats and oils
Description: Plastics, tires, motor oils, biomass, food industry mass and organic residues can be raw material for different fuels. Research done by the Institute of Chemical and Control Engineering in Skopje has confirmed that solid and liquid organic residues can find its proper application through its conversion to high calorie fuel. The fuel obtained, depending on its quality, the raw material, as well as the conditions for its production, can be used as a fuel for cars, industry or as a household fuel. For the past ten years researchers have worked intensively on developing new technologies for the production of liquid fuel - biodiesel from used fats and oils. For the past two years they have dedicated to produce diesel fuel from plastic, rubber and used engine oil. In addition, biofuels were obtained from industrial and forestry residues, as well as from agricultural residues.

7. Edible packaging films for food packaging

Link: http://www.fznh.ukim.edu.mk/jafes/VOL%2065_2015/Trudovi_PDF/053%20Dijana_Milosavjeva_19_27.pdf
Raw material: Beeswax, coconut oil and sunflower oil
Description: The lipid nucleus coating extends the shelf life of strawberries. The research is done by 13 daily monitoring of strawberries. For the experiment three types of strawberries have been used: regular strawberries, strawberries with PVC film and strawberries with lipid shell. Lipid edible shell is made of beeswax, coconut oil and sunflower oil. Researchers were tracking the change of color, mass, and vitamin C concentration in each group of strawberries. Strawberries coated with lipid edible packaging film showed better results than PVC film strawberries and regular strawberries. Lipid sheath in fact by retaining moisture in the strawberries and preserving vitamin C contributes to the extension of the shelf life of strawberries. This kind of packaging is better choice for storing food than PVC films, because they are biodegradable and do not affect the growth of packaging residues.

8. Bio-hygienic aloe tights

Link: https://inovativnost.mk/2019/08/31/сања-лазаревска-иновацијата-на-нашат/
Raw material: Aloe vera
Description: Bio-hygienic aloe tights, which will nourish your feet but also protect the environment as they decompose ten times faster than the standard ones, are the latest product of the Macedonian company For Lady. The innovation of bio-hygienic aloe tights solves another major problem facing the garment industry, which is residues. The production of aloe tights protects the environment from the mass production of products that take decades to decompose and represent a huge burden on planet Earth. "All the socks and tights we produce today are made of plastic and the breakdown time is over 50 years. Aloe tights can decompose for five years. The textile industry is one of the largest polluters on the planet, and research on this topic shows that almost five percent of landfill residues is the result of this industry. " This activity is supported by the Fund for innovation and technology development.

9. Eco-pencils

Link: https://www.radiomof.mk/so-eko-molivchinja-ministerstvata-sakaat-da-ja-podignat-svesta-za-zhivotnata-sredina-kaj-prvachinjata/
Raw material: Garden plant seeds
Description: Eco-pencils carry seeds from various garden plants and they can be planted after they are consumed. Students will be able to enjoy growing and nurturing a plant that will grow from seed. This activity is supported by the Ministry of environment and physical planning.

10. Eco-friendly fabrics

Link:https://www.youtube.com/watch?v=lObICAp0KW4&fbclid=IwAR3gT-EiOTLaf6oQ4gHe1-jc4Y1eq-7T6KMKLLEybsoyiJPwcBCtHueOx7k
Raw material: Organic plant-based cellulosic banana and corn fiber
Description: Macedonian designers are battling pollution and labour exploitation in the fashion industry, which is the second polluter in a row. Water is not available to the same degree as before and more alternatives need to be found. The collection consists of eco-friendly fabrics, made of organic plant-based cellulosic banana and corn fiber. The clothes in this collection are hypoallergenic, do not bend and do not receive the scent easily. This activity is supported by the Ministry of Culture of North Macedonia.

11. Organic cosmetics

Link:https://tocka.com.mk/vesti/320266/bellina-bio-shop-vo-cekor-so-svetskite-trendovi-za-organska-kozmetika
Description: Bellina has announced the opening of a modern store (Bio Shop), which will specialize in certified natural and organic cosmetics. This will be the first store of its kind in N. Macedonia, with a strictly defined concept and the highest standards for products that will be on sale. The idea came from the need for natural and organic products, with safe ingredients, without harmful chemicals.

12. Eco-friendly coatings

Link:https://tocka.com.mk/vesti/320266/bellina-bio-shop-vo-cekor-so-svetskite-trendovi-za-organska-kozmetika
Raw material: beeswax
Description: Wax coatings are intended for storing food, especially fruits, vegetables, spices or bread. The wrap "breathes" allows the food to stay fresh longer, which reduces excessive food residues. They are reusable packaging, as they can be used for six months or more. They are made of cotton material in different patterns and beeswax, which is supplied by Macedonian beekeepers. They are very easy to maintain, after each use they can be washed in warm water with a mild detergent and ready for use again. But what's important is that wax coatings are an environmental replacement for disposable plastic or aluminium foils in which most of us store food. With the warmth of the palms, the ecological sheath softens and can be shaped every time again and again in the shape of products. Depending on the frequency of use, the wrapper can be composted after losing its basic function.

13. Organic clothing

Link: http://www.zegin.com.mk/home/articles-overview/ORGANSKA-OBLEKA.html
Raw material: cotton, yucca, bamboo and corn
Description: Organic clothing is made from materials that grow organically according to organic farming standards. Raw materials must be grown without pesticides, fertilizers and heavy machinery. Bleaching and chemical dyes must not be used during the manufacturing process. Organic clothing can be made of cotton, yucca, bamboo and corn.

5.1.2 Regional bio-based initiatives

Biomass heating plants in remote municipalities in N. Macedonia are examples of successful push Strategies.

- Biomass heating for primary school in Berovo

In May 2013 National Association of Private Forest Owners in N. Macedonia (NAPFO) assisted by CNVP Macedonia has successfully finished a project of installation of biomass boiler and heating system for primary school in village Dvorishte - municipality of Berovo. The project implementation started in December 2011 and

ended on 31 May 2013 and worth 47.000 euros. Dvorishte is located 14 km from Berovo town (app. 175 km SW from Skopje, a few km from border with Bulgaria) with a population of around 757 inhabitants. In total, Berovo municipality has app. 14.000 inhabitants – this is the historical centre of Maleševska region (farming area), known for its cheese, farming (mountain potatoes), livestock (sheep) and wood products. Dvorishte school is attended by 150 children and before the project the school was heated with fuel oil, which was considered as an expensive and non-sustainable option. The project also supported NAPFO with a wood chipping machine to grind the wood residues while NAPFO organised local private forest owners to collect the wood residues from the private forests in the municipality and to produce biomass fuel. Advanced biomass boiler, installed for heating has an energy efficiency of 95% and such system was installed for the first time in Eastern part of N. Macedonia.
The forests in Macedonia according to ownership are divided in state and private forest. Owners of private forests are generally part of the population living in rural areas of the country. In these areas the possibilities for achievement of revenue and employment are lower than in urban areas and this emphasises the importance of this pioneering project. According to the last census in N. Macedonia, over 70% of households used fire wood as a source for heating. Only 2% of households have installed central heating and firewood is mainly consumed on the most traditional way (inefficient heating ovens)[43].

- Another example is noted in the municipality of Mogila.

By processing the residues straw from the fields in Mogila into a factory under the jurisdiction of the municipality, pellets are produced that are used to heat the municipal building, the sports hall and the schools in the municipality. The employees of the public utility company "Pela Hygiene" collect straw in the area of the village of Mogila. Apart from the building of the Municipality, the school in the village of Noshpal will be heated with pellets from last year, and from the next heating season the school in the village of Dobrushevo will be heated. This year, at least 1,000 and at most 2,000 bales of straw are planned, from which the pellets will be produced. In the next period, the remaining straw will be collected, which should be fermented for a period of 15 to 30 days. With this method of using residues straw for pellet production, in addition to reducing heating costs, care is taken to reduce ambient air pollution. The Mogila straw pellet factory is part of a project launched two years ago, funded by the European Union, in the area of cross-border co-operation with Greece [44].

5.2 Advanced bio-based initiatives: demo and pilot plants and major innovation activities

- Using biomass hot water boiler in combination with solar collectors.

The principle scheme of a system for obtaining energy from rbiomass combined with a solar collector can be utilized. There is a built-in heat battery in the system, allowing flexibility in supplying consumers with thermal energy for heating and sanitation. This combined system can be very convenient in the areas of N. Macedonia where there are many sunny days per year [12].

- Available Technologies for the Utilization of Waste as Energy Potential

In order to define which technology is the most appropriate for a particular region one needs to consider many factors, including local methods of collection, processing and disposal of municipal solid residues, and local regulations regarding the environment. According to the Study for awarding a concession for regional integrated solid waste management in Southeastern Macedonia, and some additional analyses, the procedures for energy valorisation of municipal solid waste available for application in practice, the use of incineration and landfill gas are considered as the most promising in N. Macedonia [12].

5.3 Future Biomass valorisation options

In terms of solving the problem by using expensive energy to heat the space there is complete concept of heat treatment system of biomass, which is one of the cheapest energy that is entirely of domestic origin. The biomass heating system for implementation, in its final phase includes the establishment of an integrated system intended

for heating buildings of a total of 3 mil. m^2/year, with average energy consumption of 100-120 kWh/m^2/year, calculated for 183 heating days/year, for an average annual temperature of 6°C. This in turn means the production/sale/consumption of biomass of 20 kg/m^2/year or the annual supply need in the final phase of the system is 60,000 t/year. The average expected annual price the heating is 1.5-2 EUR/m^2/year, and the equipment is fully owned by the user, and as an annual the cost of refuelling is charged (nearly 100 EUR/t).

If the sanitary space is included in the space heating hot water or heating the indoor pool (which in any case pays off to be covered using biomass as energy source), the cost of heating increases by a small percentage (depending on how much water is covered and what is the dynamics of its consumption / cooling). To this price is added the cost for annual current and intervention maintenance and "on line" control from the Dispatch Centre, which is additionally 1 EUR/m^2/year, which means max. total of 3 EUR/m^2/year.

The systems offered meet all EU criteria for the use of RES, reduction of CO_2 emissions and substitution of fossil fuels (oil, gas). As such, they are subsidized by side of the EU's credit instruments, as follows:

- EE loan for 7 years, with 7% interest and security with bill of exchange (fastest);
- EE Criterion, distributed through domestic banks, at 5-7 years, with 6-7% annual interest with a grant in the amount of 20% refunded after full loan repayment (thus practically the loan is interest free);
- One-time grant to promote the business and increase its competitiveness through introduction of a cheap source of heating, up to 50% of the investment or max. 12,000 EUR;
- Investment grant for larger projects up to 50% of the investment, intended for public institutions or companies with public service (schools, municipalities, kindergartens, faculties, hospitals);
- Loans and similar banking products for development of rural regions in the Republic of N. Macedonia, with the possibility of covering up to 50% of the investment, based on improving the business and increasing competitiveness with introduction of cheap heating using biomass/RDF as the cheapest fuel.

It should be borne in mind that firewood is the cheapest medium, but no automation is possible of the system, seen for micro and mini boilers, while the use of fruit seeds as fuel is limited quantitative capacity in the Republic of N. Macedonia (i.e. there are not enough fruit seeds). Therefore, the use of processed biomass is proposed as pellet or wood chips obtained from a secondary plant biomass, as a serious energy source, which can be used in heating facilities. In the stated context is the continuous trend of the price of biomass in the past 20 years, which as an energy source from a local source is present on the market in the past period in different forms (firewood, waste wood, wood bran, straw, rice, grape cuttings and loops, various waste agrarian biomass, communal waste, etc.). With its organized use, the rural areas of the country are developed and substitutes for the imported "fine and expensive" fuels with domestic ones are replaced.

The system would have installed power of 267 kW for hot water production, with steel burner and cast elements iron. The "Marine" type hot water and sanitary hot water boiler works on several types' biomass fuel is fully automatic and is designed and manufactured for wood-cellulose biomass as well as for G30 and G50 wood chips and pellets, biomass and fuels from agro-industrial waste: shells, fruit seeds, etc. The efficiency is according to Class 3 of the European standard EN 303-5. Due to the automatic functions, the boiler is suitable for heat supply to: local heating networks, industries, commercial buildings, farms, green houses, swimming pools, residential buildings, hotels etc. The boiler configuration can be installed on a traditional radio system or on a modern one system such as underfloor heating, wall heating, heaters or solar panels.

The financial offer could reach around 119,580 EUR. Other technical components of the system are: Automatic boiler configuration (267kW), transport system, main biomass tank (60 m^3), thermomechanical installations, command and control system and chipper machine[30].

5.4 Summary and conclusions in relation to SWOT elements

Republic of N. Macedonia as developing country has a small number of farms that have applied environmentally friendly technologies. Multiple benefits that are perceived by using RES and EE measures can be analysed through economic, social and environmental aspects. Using RES and EE measures contribute to

achieving economic benefits through minimising production costs, achieving a higher price of certain products, and increasing the production quantity. Adherence to required standards and regulations in production allows achieving more competitive products and their sale on big foreign markets. At the same time, this kind of production is encouraged through subsidising farmers funded by Governmental and IPARD funds. At the moment, in process is the last face of implementing measure for subsidizing farmers who use RES. This is expected to give additional incentive for investment in RES and EE as environmentally friendly technologies. Social aspects are seen through increasing the employment of rural population and development of rural areas. This process allows sustainability of individual farms, and therefore rural development, minimizing migration of rural population into big cities and survival of villages in the country. Consequently, utilisation of RES influence on reduction of farm waste which represent one of the biggest problems because farmers have to find a solution for its disposal. In this way, waste residuals of plants and livestock manures can bring additional profit for farmers. In terms of environmental aspect, utilisation of RES and EE measures contribute to reduction of environmental pollution. This happens through minimising energy and fuel consumption which influence on minimising CO_2 and other emissions. Indirectly, all this influence in mitigating climate change and minimising risk of appearance of different heart and lung diseases in humans and animals. To increase information and public awareness it is necessary to increase education level and to provide continuous trainings to farmers. This approach will contribute to exchange of information and experience, bigger interest for implementation of environmentally friendly technologies and efficient energy practices, but also will increase the quality of agricultural production on macro level.

The main SWOT analysis findings considering the bio-based industries, products and markets are summarised in table 5.1.

Table 5.1: SWOT analysis of bio-based industries, products and markets in N. Macedonia [12]

Strengths • Abundant biomass resources • Willing industrial partners • Increasing revenues in the municipal budget; • Reducing energy consumption from the conventional fuels in the municipality; • Increasing the security for energy supply; • Increasing employment; • Reducing harmful gasses and emissions of greenhouse gases in the atmosphere; • Increasing the share of used funds from the European funds for RES projects; • Increasing the welfare and reducing the risk for the health of the population.	Weaknesses • Lack of support (institutional and financial) • Unreadiness of the producers and market
Opportunities • Companies with strong bio-based interests / state-of-the-art chemicals or plastic production • Energy analysis in the municipalities. • Creation of teams that are trained to l lead the overall process. • Preparation of Feasibility Study and identification of possible sources for financing for development of such industries. • Preparation of technical documentation, and action plan for development of bio-based industries or products. • Possibility to acquire a status of a preferential producer from renewable energy sources.	Threats • Loss of competitive market advantage • Not developing own bio-based processes (buying them)

6 Infrastructure, logistics and energy sector

6.1 Existing industrial hubs and harbours

The Technological Industrial Development zones are listed in all the cities in the country. However, there is no record for any major bio-based industry in these zones.

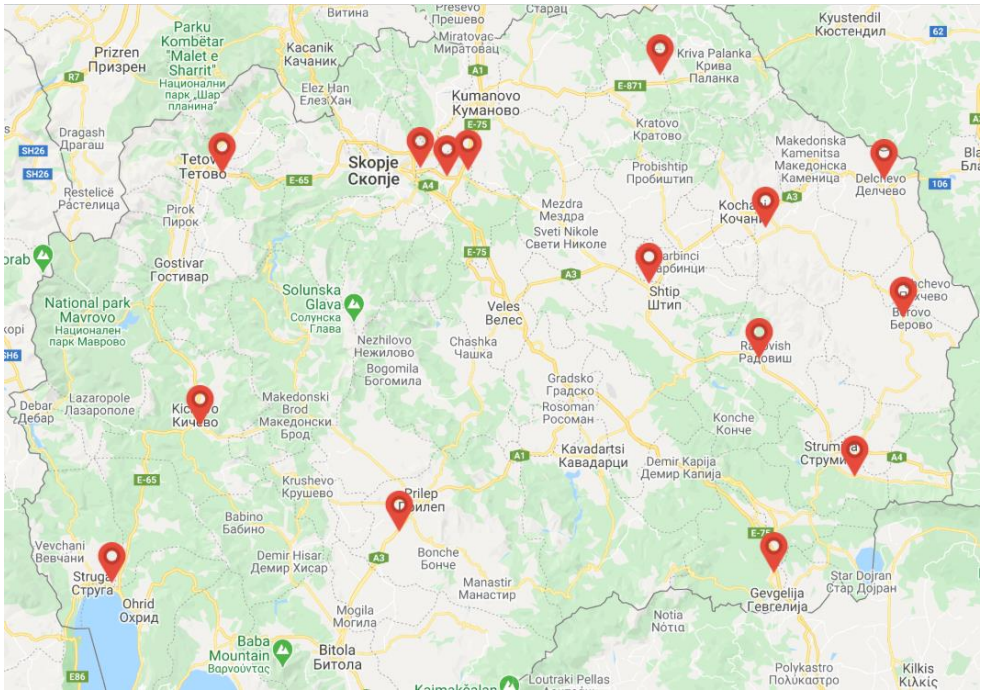


Figure 6.1.1. Location of the Technological Industrial Development Zones in N. Macedonia

The total surface area of the Technological Industrial Development Zone Skopje 1 is 140 hectares. TIDZ Skopje 1 occupies a first-class location – 10 km east of the capital Skopje, on the crossroad of the Corridors 8 and 10. The total area of the Skopje 2 free zone is 96.75 hectares. Skopje 2 is located directly next to the Skopje 1 free zone. The total projected area of the Skopje 3 free zone is 43.84 hectares. TIDZ Skopje has direct highway exchange with corridor 8 and is just 3.3 km away from E-75 Highway. Alexander the Great International Airport is 5 km away from the TIDZ Skopje (1 km airline distance) and is suitable for cargo and passengers' intercontinental flights. The nearest national rail station is located 6.5 km from TIDZ Skopje and the nearest sea port is in Thessaloniki (Greece), 230 km away from the Zone. However, all of the tenants of the TIDZ are in the field of automotive industry, electric appliances and products.

The total area of the Tetovo free zone is 94.74 hectares. It is located on the E-65 highway, 3 km east of the city of Tetovo. The Tetovo free zone is just 35 km away from the capital Skopje. The national rail station is 4 km away from the location, and the nearest international airport, Alexander the Great in Skopje, is 67 km away via the Skopje ring road. Thessaloniki seaport in Greece is 287 km away and the port of Durrës in Albania is 293 km away from the Tetovo free zone.

The total area of the Stip free zone is 206.43 hectars. It is located northwest from the city of Stip, upon entering from the Skopje direction. The Stip free zone has road connections to Skopje and Kocani through interstate M5 and through the new Skopje-Stip highway, currently under construction, the region will have a direct and short road connection to the capital Skopje. The national rail station is 2.5 km away from the free zone, and the nearest international airport, Alexander the Great in Skopje, is 75 km away. The nearest seaport is in Thessaloniki, Greece, 225 km away from the zone. Municipality of Stip counts around 50,000 citizens and it is the largest center of textile industry in the region.

The total area of the Rankovce free zone is 40.2 hectares. The zone is located near the border crossing Deve Bair towards Bulgaria and has a direct road connection with the planned motorway on Corridor 8 (section Kumanovo-Kriva Palanka) and the planned railway Corridor 8. The settlements that surround the Rankovce free zone have a total population of over 176,000 inhabitants

The total area of the Prilep free zone is 67.50 hectares and it is located in the Alinci locality, south of the city of Prilep. The surface area of the zone can be expanded an additional 35.71ha. The free zone has direct access to the highway that links Prilep and Bitola. The settlements that surround the Prilep free zone have a total population of approximately 260,000 inhabitants.

The total area of the Vinica free zone is 21.04 hectares and it is located 4.5 km from the city of Vinica, specifically on the west side of the planned highway that connects Stip and Delchevo. The settlements that surround the Vinica free zone have a total population of over 83,000 inhabitants.

The total area of the Delchevo free zone is 20.83 hectares and is located northeast of the city of Delchevo. The scope of the project is located on the main road that connects Kochani – Delchevo – border crossing Deve Bair with Bulgaria. The settlements that surround the Delchevo free zone have a total population of over 24,000 inhabitants.

The total area of the Strumica free zone is 24.77 hectares and is located 7 kilometers east of the city of Strumica, specifically to the south of the regional road which connects Kuklish –Bansko – Novo Konjarevo. The settlements that surround the Strumica free zone have a total population of approximately 85,000 inhabitants. The extensive hydrographic network, the great number of sunny days, the climate and the favorable pedologic conditions characterize the region as predominantly agricultural. The large-scale production of high-quality early vegetables, fruits and industrial crops enable the development of the canning and food processing industry, for which this region is renowned.

The total area of the Berovo free zone is 17.38 hectares and it is located near the city of Berovo. The Berovo free zone is situated on the regional road connecting Berovo and Dabile. The settlements that surround the Berovo free zone have a total population of over 18,000 inhabitants.

The total area of the Gevgelija free zone is 50.25 hectares and it is located southwest of the vilage of Perdejci, on the right side of the Skopje-Gevgelija highway. The Gevgelija free zone is situated near the border crossing point Bogorodica towards Greece and has direct road connections to Thessaloniki Port. The settlements that surround the Gevgelija free zone have a total population of approximately 67,000 inhabitants.

The total area of the Struga free zone is 30.01 hectares and is located in the village of Misleshevo, 4.5 km from the city of Struga towards the city of Ohrid. The area has direct access to the Pan-European Corridor 8 project. The settlements that surround the Struga free zone have a total population of over 161,000 inhabitants.

The total area of the Radovish free zone is 9.75 hectares and is located at the entrance of the city of Radovis. The zone is near the main road that connects Stip – Radovis – Strumica and the interchange. The settlements that surround the Radovish free zone have a total population of over 45,000 inhabitants.

The Kicevo free zone is divided in two covering a distance of approximately 1.2 kilometers, with section 1 covering an area of 13.5 hectares and section 2 an area of 16.06 hectares. The total coverage area is 29.56 hectares and is located southeast of the town of Kicevo, specifically, both sections are located to the left and right of the regional road connecting Kicevo and Makedonski Brod. The settlements that surround the Kicevo free zone have a total population of over 77,000 inhabitants [45].

As the country is landlocked, there are no harbours at country level. The closest ports are port of Durres in Albania and port of Thessaloniki in Greece.

6.2 Existing railways

Data regarding railway transport and infrastructure was compiled by the State Statistical Office.

2018	Total
Passenger carried, number	540 066
Goods carried, tonnes	1 678 992
Length of rail track in km	683

Goods carries by type

2018	Thousand tones
Agricultural, hunting and forestry products, fish and other fishing products	849
Food, beverages and tobacco products	88 869
Wood and wood products and cork (except furniture), items of straw and knitting materials, cellulose, paper and paper products, printing materials and recorded records	90 184
Furniture, other manufactured goods, not mentioned elsewhere	307
Secondary raw materials, municipal waste and other waste	-

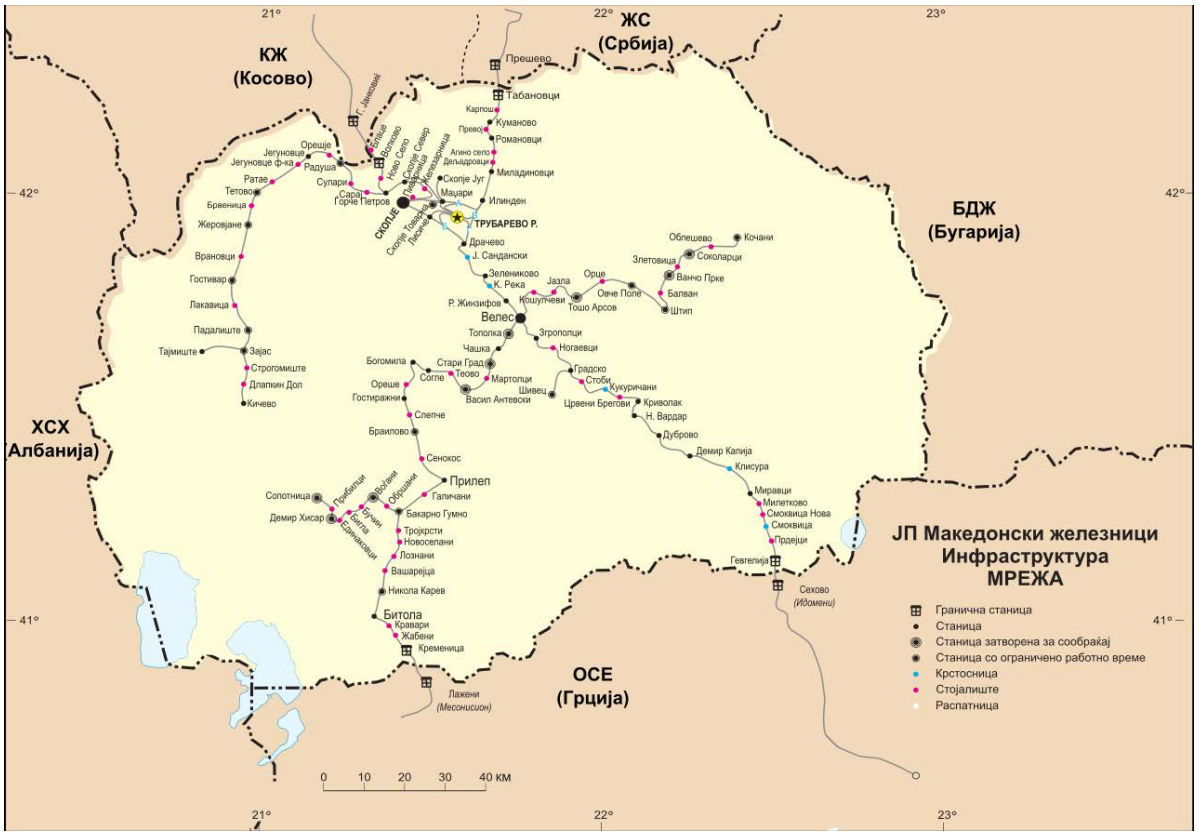


Figure 6.2.1 Railway infrastructure of N. Macedonia [46]

The situation related to rail transport is grave on the whole territory of the Republic of N. Macedonia. The situation is bad both in terms of the rail tracks and in terms of the rail fleet and the accompanying infrastructure. The negative trend in rail transport is evident both in transport and turnover of goods. The first standard gauge line in the area, from Skopje to Thessaloniki was built in 1873. It is connected to Kosovo via Volkovo in the northwest, to Serbia via Tabanovci in the north and to Greece via Gevgelija in the southeast and via Kremenica in the southwest. North Macedonia's main rail line between the Serbian and Greek borders, from Tabanovci to

Gevgelija, is entirely electrified. All domestic lines are operated by Macedonian Railways, with links from Skopje to Tetovo, Gostivar and Kicevo in the west, to Volkovo in the northwest, to Kumanovo and Tabanovci in the north, to Sveti Nikole, Štip, and Kocani in the east, to Veles, Negotino and Gevgelija in the south - southeast and to Bogomila, Prilep and Bitola in the southwest. There is a possibility to achieve an enhanced rail transport linkage of the Southeast region by constructing a railway line and connecting Shtip and the railway line passing near Petrich (Republic of Bulgaria). A second possibility would be to link with the railway line passing near village Miravci, Municipality of Valandovo [47].

Future Plans:

Corridor VIII
In the planning stage is a project to construct new rail links connecting to the existing east–west line (Beljakovci, Kumanovo, Skopje, Tetovo, Gostivar and Kičevo). An 89 km link in the East, from Kumanovo to the Bulgarian border, which would connect North Macedonia to Varna (Bulgaria) and to the Black Sea. A 66 km link in the West, from Kičevo to the Albanian border, which would connect North Macedonia to Durres (Albania) and to the Adriatic Sea.

Corridor X
The Ministry of Transport and Communication has begun studies for the renewal and reconstruction of several section of the corridor X:

- Renewal and reconstruction of railway track on the 16 km section between Bitola and Kremenica as a part of the Xd branch of Corridor X
- Reconstruction of the 14 km railway section between Kumanovo and Deljadrovci
- Reconstruction of the 35 km railway section between Dračevo and Veles [48].

6.3 Existing road infrastructure

The main axes of the state road network are the two Pan-European corridors, Corridor VIII (east - west) and Corridor X (north - south). Road transport and infrastructure play a key role in terms of economic development, in increasing the number of tourists in the region, as well as in improving the standard of living of the population. Institutions in charge of road infrastructure in the region are: Ministry of Transport and Communications, Public Enterprise for State Roads and the municipalities. Public roads, according to their state, economic, commercial and traffic significance and their level of construction are divided into state and municipal. According to the state, economic, commercial and traffic significance, as well as their level of construction, some of the state roads are categorised as highways, express roads and motorways (A-motorways) and serve to connect the Republic of N. Macedonia with the European road system and to maintain continuity of the international road network (international corridors – E roads), and to connect the road network with international road border crossings and to achieve traffic connection with the roads of neighbouring countries.

All state roads are divided into:

- A-Motorways (highways, express roads, motorways),
- R1 – Regional roads of first category and
- R2 – Regional roads of second category.

Total of 14,559 km of road network is in Republic of N. Macedonia. The first motorway runs from the Tabanovce border crossing with Serbia (for Preševo), passing Kumanovo (A2 junction), Petrovec (Skopje Airport) near Skopje (A3 junction), Veles, Gradsko (A5 junction) Negotino (A7 junction), and continuing onto the main border crossing with Greece, Bogorodica-Evzoni near Gevgelija. The A2 is a route that connects Kriva Palanka and the Deve Bair border crossing with Bulgaria with Ohrid. The route passes Skopje through the ring-road and enters the already constructed motorway that connects Tetovo with Gostivar. Currently, only a small section of the route A3 is a motorway (the one that goes along A4 from Štip to Kadrifakovo), while some sections are in the process of turning into express roads. The A4 connects Kosovo with Skopje and continues southeast towards Štip, Radoviš, and Strumica, eventually reaching the border with Bulgaria near Novo Selo.

Highways and motorways are in a relatively good condition. However, some of the regional and local roads have not been constructed yet or their construction is not yet finished. The worst situation was identified in mountainous villages and in areas with specific development needs, where significant investments are necessary. There is a positive trend of improvement of the situation [47].

The condition of the road network is on a far lower level compared to European standards. Communication connections are good, nevertheless the condition of roads themselves, as well as of the vertical and horizontal signalisation, is poor. Investments are essential in order to improve the road network between populated areas, as well as local roads leading to natural, cultural and tourist sites. Especially large investments are needed in the areas with specific development needs, taking into consideration the fact that most of those areas are located in rural and border areas. Furthermore, investments are necessary in the road infrastructure and in the infrastructure leading to existing industrial and economic zones.

Data for the existing road transportation and infrastructure was used from the State Statistical Office.

Road transportation - passenger and freight

2018	
Busses, number	996
Number of seats in busses	43 881
Passed km of vehicles, thousand	69 085
Carried passengers, thousand	8 516
Passed km of freight vehicles, thousand	960
Carried goods -total, thousand tones	69 139
Cars / 1000 person	200

Carried goods in road freight transportation by type

2018	Thousand tones
Agricultural, hunting and forestry products, fish and other fishing products	2 742
Food, beverages and tobacco products	4 819
Wood and wood products and cork (except furniture), items of straw and knitting materials, cellulose, paper and paper products, printing materials and recorded records	401
Furniture, other manufactured goods, not mentioned elsewhere	48
Secondary raw materials, municipal waste and other waste	745

Road network

2018	Total in km	asphalt	cobbled street	Dirt and uncompleted
local	9 878	5 373	810	3 695
regional	3 779	2 917	441	421
highways	902	827	-	75
International E- roads	553	-	-	-

6.4 Energy sector

Utilization of certain energy sources is necessary for efficient agricultural production. In the Republic of N. Macedonia main source of energy is electricity. Electricity production has total capacity of around 1835MW, from which 45% are produced by thermal power plants working on coal, and 37% are produced by hydropower plants. The country is energy dependent and imports 30% of the total energy. Electricity produced from coal fired power plants make up ~60% of total domestic production. The other energy sources used in agriculture are biomass (mostly wood for heating) and oil derivatives. To reduce consumption and imports of electricity, and

subsequently, to influence on minimising environmental pollution, new alternatives are required and some of them are energy efficiency measures (EE) and renewable energy sources (RES). They contribute to reduce production and living costs, but also improve economic conditions in rural areas. In the last few years, utilization of RES and EE is supported by the Macedonian Governments' policy through the Ministry of Economy and Energy Agency. It is based on implementing measures and regulations in accordance with EU laws. The analysis show that utilization of RES is expected to rise on 23% until 2020. The agricultural sector in the Republic of N. Macedonia has favourable conditions to use hydropower, biomass, geothermal, solar and wind energy.

The current production of thermal energy from biomass waste is not possible to be determined due to lack of data as a result of the unorganized collection and use of biomass waste (waste from logging and wood processing and waste from agriculture). The estimated production of thermal energy from biomass waste includes waste from logging and processing of wood and waste from agriculture (pruning of vineyards)[12].

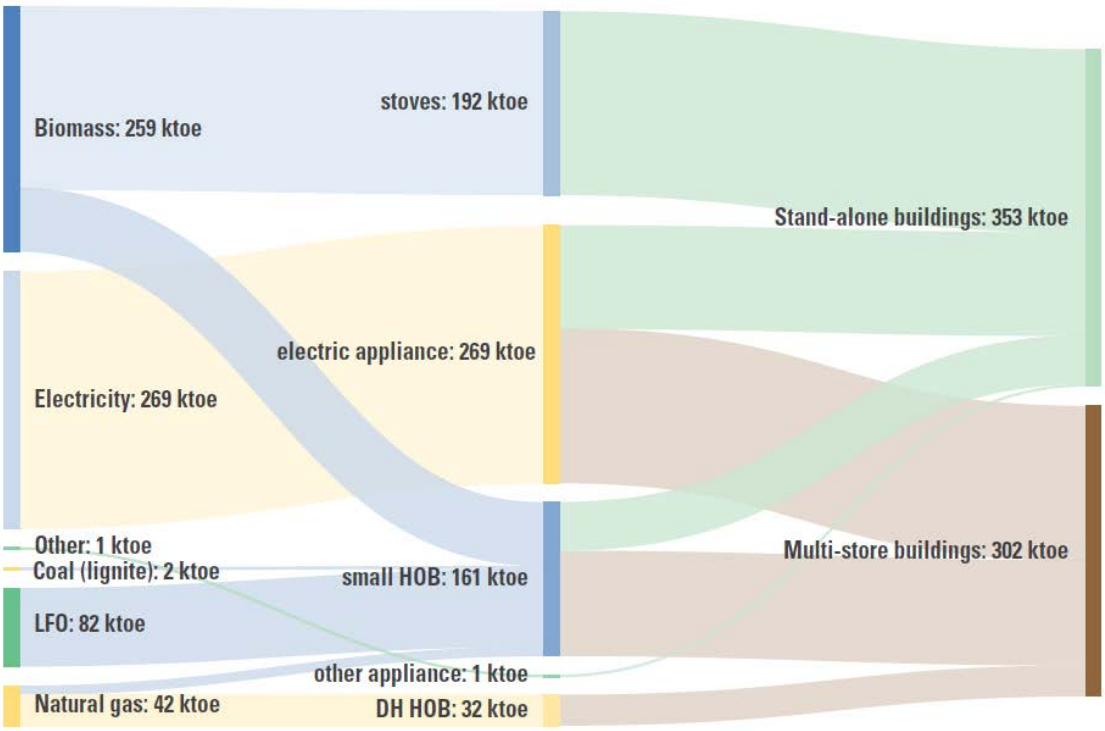


Figure 6.4.1: Biomass flows in N. Macedonia in heating system, 2017s [10]

General conclusions from the Sankey diagram for N. Macedonia (Figure 6.4.1: Biomass flows in N. Macedonia in heating system, 2017s *[10]*) (quantities below are all expressed in ktoe) are that the main biomass supply produced in N. Macedonia is primary biomass. Biomass, as a fuel for heat production accounts for 39% of the total, or 259 ktoe. In regards to the biomass potential and supply, the sustainable technical potential excluding energy crops is 315 ktoe. The biomass consumption is 270 ktoe and biomass available to supply an increase in biomass-based heating over and above the current consumption is 60 ktoe [10].

Table 6.1. Biomass and biogas potential in the Southeast region

GWh	Biomass potential	Reducing CO_2 emissions (thousand tonnes per year)	Biogas potential	Reducing CO_2 emissions (thousand tonnes per year)
Southeast region	42.22	12.26	4.63	4.96

Table 6.2. Energy overview [49], [13]

Category	N. Macedonia	EU average	Unit
Primary energy consumption	1.69 (2018)	3.22	toe/capita (2012)
Energy dependence	30	55.4	%
Renewable energy share	19%	17.9	%
GHG emissions	5.9	9.47	ton CO_2-eq/capita
Bioenergy in RE		69	%
Bioenergy in total energy	10%	10.6	%
Biofuels prod. Capacity		0.051	ton/capita
CHP	13%	17.3%	% gross electricity generation
District heating	240.6	7,404	km
	0.1	0.3	m/capita

Table 6.3. Energy balance, 2018 – biomass, biofuels

ktoe	Firewood	Fruit tree waste and other plant waste	Pellets and briquets	Biogas	Biodiesel
Total primary production	151.98	2.48	4.12	4.78	-
Imports	5.15	-	27.70	-	0.13
Stock change	0.67	-	0.13	-	-0.04
Exports	0.01	-	0.37	-	-
Gross inland consumption	57.80	2.48	31.57	4.78	0.08
Transformation input	-	-	-	4.78	-
Biogas plant	-	-	-	4.78	-
Consumption of the energy branch	0.01	-	-	-	-
Available for final consumption	157.79	2.48	31.57	-	-
Final energy consumption	157.79	2.48	31.57	-	-
Industry	2.10	-	4.11	-	-
Iron & steel industry	0.00	-	-	-	-
Chemical industry	0.00	-	-	-	-
Glass, pottery & building mat. industry	0.00	-	0.01	-	-
Ore-extraction industry	0.00	-	0.00	-	-
Food, drink & tobacco industry	1.40	-	3.22	-	-
Textile, leather & clothing industry	0.33	-	0.08	-	-
Paper and printing	0.02	-	0.04	-	-
Engineering & other metal industry	0.12	-	0.11	-	-
Other industries	0.20	-	0.62	-	-
Households, commerce, pub. auth., etc.	155.69	2.48	27.46	-	-
Households	150.68	2.48	26.70	-	-
Agriculture	1.37	-	-	-	-
Other	3.63	-	0.75	-	-

6.5 Summary and conclusions in relation to SWOT elements

Table 6.4: SWOT analysis of Infrastructure, logistics and energy sector of N. Macedonia

Strengths • Well-developed motorway network • Established positions in EU hinterland transport • Strong position rail transport in freight	Weaknesses • Poor quality of state road transport • In some areas obsolescent rail network • Lack of inland waterway network • Lack of inland road/rail logistic terminals • No access to the sea
Opportunities • Established strong position of rail (esp. in freight transport) • Competition of other corridors (to Bulgaria, and Albania) • Utilization of RES potential for energy purposes	Threats • Worrying condition of the state road network • Worrying condition of the rail network

7 Skills, education, research and innovation potential

7.1 Research infrastructure

According to social and economic changes, the priority is to develop production model for improving the quantity and quality of agricultural production. In addition to scientific research work within the faculties, research and development institutions, who are also conducting research to support the development of agriculture and forestry, are following: Agricultural Institute, Institute of Animal Science (integrated with the Faculty of Veterinary Medicine) in Skopje, Institute of Tobacco in Prilep and Hydro Biological Institute in Ohrid.

All public research activities, including agriculture, are funded through The Ministry of Education and Science, and in addition to the salaries of persons with scientific titles, by way of public competition is also funded programs for scientific research. According to the Law on Higher Education, scientific institutes within the university as its own units, can also perform higher education activity (second and third cycle university studies) in scientific areas that are established, if they are accredited to perform this type of study and have a solution to start with work, determined by the statute of the university.

The Agricultural Institute mainly performs four activities: scientific research, educational, publishing and application activities. The research work is aimed at finding technical-technological solutions and their application in production. The acquired knowledge about genetic variability of domestic populations and intruded varieties of more important field, horticultural, vine and fruit species, allow scientific research to be focused on creating new higher yielding and higher quality genotypes than the total agricultural crop production. As a result of the selection work so far, the Institute has created and recognized numerous varieties of 92 field crops and appears as a collaborator on specialist, master's and doctoral topics, but also manufacturer's consulting services.

The Institute of Animal Science has developed an electronic marking and tracking system for both expand this activity is proposed to form a central office with computers and operators of databases to enter the details on a regular weekly basis for each farm.

Veterinary Institute and Faculty of Veterinary Medicine - Veterinary Laboratories - in accordance with the Law on Veterinary Health, the laboratories belonging to the Faculty of Veterinary Medicine (FVM) works as a national designated laboratory for implementation laboratory analyses from the official controls of the Veterinary Administration. The analyzes are performed in the following laboratories: Food Institute - (Food Microbiology Laboratory, Laboratory for Food Quality, Residues and Contaminants Laboratory, Quality Control Laboratory milk) and the Veterinary Institute (Laboratory of Serology, Laboratory of TSE) by appropriate trained staff. The laboratories have been completely reconstructed and well equipped with calibrated equipment and controlled environment. The number of employees who perform the examinations according to the accredited methods in the current conditions are sufficient. In the future, their number will increase as needed. The continuity of the quality system is ensured through regular internal and external audit. The implementation of the MKC ISO / IEC 17025: 2006 standard and the FVMS accreditation is guarantee to customers that test results are reliable and up to date national and international standards and regulations.

Scientific Institute of Tobacco - Prilep, as one of the oldest institutes in the Balkans (87 years existence) through its scientific research and applied activity in all segments of production, processing and maintaining the variety and quality of oriental aromatic tobacco, contributes to tobacco being the leading agricultural product in the export of the Republic of N. Macedonia. The institute has its own test field for the production of varietal seeds, greenhouse, complete laboratory, meteorological station and library [50].

7.2 Education infrastructure

The Macedonian education system, under the authority of the Ministry of Education and Science, has passed through reforms to modernize the curriculum and educational activities. In 2004, the government adopted National Education Development Program for the period 2005-2015, for comprehensive reform in this area

based on the processes of democracy, decentralization, autonomy, pluralism, multiculturalism and globalization, as well as international educational standards of knowledge and skills and principles of lifelong learning. Agricultural, veterinary, food, forest and wood processing directions are present in public high schools. Most students attend classes in high school agricultural schools are from rural areas. The Macedonian system for agricultural higher education includes several educational institutions: Faculty of Agricultural Sciences and Food-Skopje, Faculty of Veterinary Medicine-Skopje, Faculty of Forestry -Skopje (all within the University "St. Cyril and Methodius" in Skopje); Faculty of Biotechnical Sciences - Bitola (within the University "St. Kliment Ohridski" in Bitola); Faculty of Agriculture (part of Goce Delchev University from Stip) and the Faculty of Food Technology and Nutrition (as part of Tetovo State University). The development system includes cooperation with educational institutions in terms of strengthening study program, student exchange, scholarship for home students for further education abroad, etc. The educational activities of the faculties are mainly financed through the Ministry of education and science and partly from own income. These changes should provide the required number of new specialized professionals, required in the activities of individual farms, small and medium-sized enterprises in the food industry, as well as for scientific research work in specialized institutions. Most of the enrolled students study at the state university "St. Cyril and Methodius" in Skopje, and then at the Faculty of Agriculture in Stip and the Universities in Bitola [50].

The following data was obtained from the SSO.

Table 7.1. Graduated students

2018	number
Faculty of Biotechnical Sciences, UKLO	22
Faculty of Veterinary Medicine, UKLO	5
Faculty of Veterinary Medicine, UKIM	8
Faculty of Agricultural Sciences and Food, UKIM	102
Faculty of Forestry, UKIM	13
Faculty of Design and Technologies of Furniture and Interior, UKIM	51
Faculty of Agriculture, UGD	78
Faculty of Food Technology, SUT	16

Table 7.2. Household members who work at individual agricultural holdings and employees at business entities, by level of education

2016	number
No education	10 389
Incomplete primary education	35 735
Primary education	152 093
Secondary education (agricultural)	17 549
Secondary education (agricultural)	187 636
Higher vocational education (agricultural)	1 017
Higher vocational education (other)	7 531
University level education (agricultural)	2 770
University level education (other)	23 659
Master's degree and Doctorate (agricultural sciences)	715
Master's degree and Doctorate (other)	627

7.3 Environment for start-ups

- Project proposals for utilising biomass

There are few project proposals for utilising RES for reducing energy consumption in facilities owned by the municipalities that will contribute to a drastic reduction of CO_2 emissions in the atmosphere and will increase the level of environmental protection. The project proposals are in accordance with the international regulations and the EU directives which refer to energy efficiency and using renewable energy sources, as well as in accordance with the domestic (national) regulations, laws and by-laws, the Strategy for Energy Development

in N. Macedonia and the Strategy for utilising RES. The project proposals refer to biomass and biogas and are in accordance with the needs and the opportunities of the municipalities of the Southeast planning region. The requirements and the opportunities of the already mentioned municipalities emerged from the general analysis of the current situation with available resources – RES on their territories, the level of the current utilization of RES, the potentials, the tradition and other additional factors: the capacity of human resources, financial capabilities, enthusiasm, motivation etc. The project proposals are shown with the same methodological matrix of two units which will provide an overview of all the important parameters in the project in terms of cost-efficiency if a loan is taken for its implementation and contains the following components: (1) Basic characteristics of the renewable energy source and (2) Financial analysis of the renewable energy source.

Below are given three project proposals for using biomass as renewable energy source with technical and economic indicators which will help to choose the most suitable project for the particular municipality. A more detailed and specific example for using biomass as a renewable energy source is given in order to improve energy efficiency and give a significant protection of the material and financial resources in a primary school - a typical example present in every municipality in the studied planning region [12].

Box 2.10: Project proposals

- Project Proposal 1: Production of thermal energy (steam and hot water) from biomass

In all municipalities in the Southeast planning region, there are small or large amounts of biomass in the existing forests as well as in agricultural waste products. Using this potential for production of thermal energy (steam or hot water) is a specific proposal and its qualitative values are given in the Study. Combustion of biomass in a firebox. Saturated vapor with pressure of 4-15 bars is produced. Small and average units with a capacity of 1-15 MW thermal power.

- Project Proposal 2: CHP plant which operates on biomass (back pressure turbine)

Apart for thermal energy, the plant is used for production of electrical energy as well. The maximum steam pressure is usually 20 bars and the installed capacity from 0,1 - 5 MW.

- Project Proposal 3: Production of electricity from biomass-condensation turbine

The main parts of the plant are: fuel purifier, system for fuel supply, system for water purification, medium and high-pressure steam boiler, gas purification system, ash purification system, steam turbine and an equipment for production of electricity.

- Center for joint offer

The Strumica region is the largest producer and exporter of early vegetable products in N. Macedonia. The production of early vegetable products is realized in a protected space in: greenhouses in which the most modern production technology is applied, i.e. application of modern irrigation and feeding systems (drip system), application of heating systems, use of high-quality hybrid varieties, application of modern and ecologically controlled production protection. The production in the Strumica region is realized on the following areas by crops, as follows:

Type of crop	Average yield in tone/ha
Tomatoes in greenhouse	80-90
Pepper in greenhouse	40-50
Pepper	45-50
Spacy peppers	10-15
Cucumbers in greenhouse	80-90
Pickles in greenhouse	50-65
Cabbage in greenhouse/ cabbage	40-50
Watermelon	30-40
Potato in greenhouse	15-20
Potato	20-30

In addition to the production in greenhouses owned by individual agricultural producers, the production also takes place in greenhouses owned by private companies and which economically gravitate around Strumica and the Strumica region (151 ha).

In the Strumica region, two institutions take care of the successful implementation of early vegetable production, namely the Institute of Southern Cultures, the Agency for Agricultural Promotion and several private consultants and advisors who contribute to educating agricultural producers, the application of new technologies, new hybrid high quality cards. Individual agricultural producers in the Strumica region are organized into several associations and one regional union that includes associations from the region. Motivated by the existing potentials where there are real opportunities for their increase and quality improvement.

The Center for joint offer of early vegetable products will be organized on the basis of partnership between the private sector (traders, buyers, processors), local government and representatives of agricultural producers and associations. The center for joint supply of early vegetable products will have 30,000 m^2 of space. The total investment for the project Center for Joint Supply of Early Orchard Products is around 5,000,000 Euro. The center for joint supply of early vegetable products will be composed of several components, the most important of which are the two components: An integral part in which the production will be accepted by the producers and its additional processing up to "finished product". In this part, calibration, standardization, certification, packaging, declaration, and palletization, i.e. obtaining of "finished product" will be performed. The collection part will be equipped with lines for additional processing of early vegetable products, i.e. calibrators, packaging machines, declaration and palletizing, services for standardization and certification of early vegetable products. This "finished product" will be delivered to the next component of the Center for Joint Supply of Early Orchard Products and that is the Sales Composite which will accept the "finished product" and will further distribute and sell it. In this part, storage, cooling, distribution and sale of the "finished product" will be performed. The sales part will be informatively related to the Collective part and to Centers of this or similar type with the neighbouring and European countries.
In the structure of organizing the Center for joint offer of early vegetable products, two Funds will have a significant place:

- The market research and promotion fund, which will have the task to research the market (supply and demand), to build a strategy for the next harvest, and to promote its own products and potentials;
- The Fund for Compensation of Unrealized Revenues in Sales, which in conditions of retention of certain markets and fight with competing products would compensate the unrealized income[51].

Expected results:

- Increased export quantities of early vegetable products;
- Presence on the markets of the European Union, having in mind that the early vegetable products from the Republic of N. Macedonia have preferential customs rates;
- High quality product;
- Organized supply of production and planned way of production of early vegetable crops;
- Permanent and continuous supply of early vegetable products;
- Achieving long-term higher average production prices;
- Benefits for primary producers, owners of greenhouses, market, large scale traders and food processing industries;
- Increased agriculture residues and secondary agricultural residues from processing industries [51].

7.4 Public private partnerships

New modern cooperatives are the solution for the fragmented Macedonian agriculture. The model is based on the experiences of European countries and those in the neighbourhood adapted to the Macedonian conditions. It is estimated that 70% of Macedonian farmers will fail if the country does not solve the problem of wasteful and unplanned production before joining the EU. Admission to the new cooperatives is voluntary, and people will need to build on the principles of reward. In order for farmers to decide to join a cooperative, this should be on several grounds, including land, livestock, labour, means of production or stock. Thus, the new cooperatives are something between the private and the public sector. It is a private initiative, but people are

working for common interests. This trend in N. Macedonia was started many years ago, but then it did not come to life. Lately, it is again a current trend, and at the initiative of the state, which is accepted by more and more farmers. They will have multiple benefits in the purchase of products for production, raw materials, fertilizers, and at the same time will reduce the price of the product. At the same time, as associations, they will be able to compete on the market, to have unified production with certain standards. They will also be able to choose their representative manager who will protect their interests in front of the government, the market and exports. The Agency for Promotion and Development of Agriculture is actively involved in the assistance of farmers for forming a cooperative. The Government will finance a manager for the cooperatives who will manage all the things for them (take care of modernizing the process and increasing production and reducing costs, thus making them more profitable on the collectible European market). Some farmers still view the cooperative with suspicion and equate it with the period of the 1950s and 1960s when their property was confiscated. Experts point out that the goal of the new cooperatives is for the producer to have the inalienable right to own land. The cooperatives are also covered from the legal aspect by the Cooperative law. This law regulates the conditions, manner and procedure for establishment, registration, operation, type and scope of agricultural cooperatives, incentives and the development of the agricultural cooperative as well as the supervision over the operation of agricultural cooperatives [52].

Subsidies for the establishment and operation of agricultural cooperatives exists and the financial support is non-refundable. Cooperatives have the right to request subsidies in the amount of one monthly average salary for the director and a veterinarian in the first year of establishment. Subsidies for insurance policies for cooperatives are higher and amount to 70 to 80 percent depending on the size of the cooperative, but not more than three million denars per year. So far, 40 agricultural cooperatives have been registered in N. Macedonia, with a total capacity of 990 hectares of arable land, 260 bee families, 450 cattle, 250 sheep and 200 goats [53].

The importance of such cooperatives is in terms of land consolidation and production, greater competitiveness and better placement of agricultural products. The establishment of cooperatives will increase yields, and thus farmers will be more efficiently prepared for the upcoming European integration of the country and will be competitive in European markets.

7.5 Summary and conclusions in relation to SWOT elements

Table 7.3: SWOT analysis of Skills, education, research and innovation potential of N. Macedonia

Strengths • Highly-skilled engineering professionals are educated, which are very flexible or adaptable	Weaknesses • Lacking medium TRL (3–6) research/development infrastructure, slowing down development.
Opportunities • Setting up pilots in order to speed up development of the country	Threats • The loss of engineers due to brain drain migration • Competitiveness due to PPP pilots lacking

8 Policy framework: Regulations, legislation, rule of law & taxes and tariffs

8.1 Introduction

The main regulatory bodies or institutions which adopt and implement the policy framework in the country are:

1. Ministry of Agriculture, Forestry and Water Economy http://mzsv.gov.mk
2. Agency for Financial Support in Agriculture and Rural Development http://www.ipardpa.gov.mk/Root/mak/default_mak.asp
3. The IPARD Program 2014-2020 http://ipard.gov.mk/mk/pocetna/
4. Agency for Stimulation of Agriculture Development http://agencija.gov.mk
5. Agricultural Market Information System http://zpis.gov.mk/Default

One of the lead documents that guide the development of the agricultural economy and rural integration is the National Strategy for Agriculture and Rural Development (NARDS) 2014-2020. This strategy was adopted in December 2014 and refers to a period of 2014-2020. The main goal of the strategy is to increase the international competitiveness of agricultural production and agro-food industry, and securing sustainable development of rural areas. The Strategy reflects the continuity of the country's priorities to improve the development of the agriculture areas, to provide support to the agricultural sector in achieving a sufficient level of competitiveness to cope with challenges of the open and changeable market and to boost the development of rural areas [33].

Progressive steps have been made with the latest Energy Development Strategy adopted December 2019. The strategy envisions direction for development of the energy sector in North Macedonia, taking into account the energy policy trends at global and European level, and particularly in the framework of the Energy Community for the period 2020-2040. The Strategy defines six strategic goals for North Macedonia, mapped along five energy pillars, and as such it is in line with the five dimensions of EU Energy Union. These strategic goals have an important role in energy system planning and can be achieved with different approaches, by 2030: at least 40% reduction in GHG; 32% energy from RES; 32.5% improvement in EE. The Energy Development Strategy gives an overview of future integration of RES, i.e. development of technologies for utilization of biomass and biofuels [13].

North Macedonia adopted its National Renewable Action Plan (NREAP) in November 2015, setting the renewable energy target share in final energy consumption at 21 % by 2020 (up from 17.4 % in 2009). Out of this, the share of renewables in electricity is seen at 25.6 % (up from 16.7 % in 2009), 24.6 % in the residential sector (28.9 % in 2009) and finally, 10 % in the transport sector (up from 0.4 % in 2009). North Macedonia plans to increase its renewables capacities to around 800 MW or 2060 GWh by 2020. Nearly all of this new capacity (709 MW or 1835 GWh) is seen coming from hydropower plants with over 10MW installed capacity. RES target for 2020 is 23% in gross final energy consumption according to the Decision 2018/MC-EnC. In 2017 update of NREAP, North Macedonia decreased their target from 28% to 23.9% RE in gross final energy consumption in 2020. This change was made considering the revised data for biomass consumption baseline data (resulting in a lower 2009 baseline RES share – 17.2%, compared with 21.9% that was the baseline taken into account for the first calculations in 2012)[54].

The legal framework regarding the AFOLU (Agriculture, Forestry and Other land use) sector is quite convenient and comprehensive.
The most important document regulating the rural and agriculture issues is the Law on agriculture and rural development. It was adopted in May 2017.
The objectives of the national agricultural policy of the Republic of N. Macedonia are aimed at:

- providing stable production of quality, cheaper food and providing the population with sufficient amounts of food,
- increasing the competitiveness of agriculture,
- ensuring a stable level of income of the agricultural economy,
- sustainable development of rural areas,

- optimal use of natural resources by respecting the principles of protection of nature and the environment.

The objectives shall be realized through measures and instruments of the policies for:

1) arrangement and support of agricultural markets,
2) direct payments,
3) rural development.

This law regulates the planning of the development of agriculture and rural development, the objectives of the national agricultural policy, planning, monitoring and assessment of the national agricultural policy, partnership with social and economic partners in the field of agriculture, measures for regulation and support of agricultural markets, direct payments and rural development, state aid in agriculture and rural development, forms of organizing and associating in agriculture and control of the implementation of measures and oversight of implementation [55].

The Law on Organic Agricultural Production was adopted in 2010 with an objectives of establishing a sustainable management system for agriculture, production of high quality products and production of a wide range of food and other agricultural products which meet the requirements of consumers and which must not harm the environment, human health, plant health or animal health and their well-being. This law regulates the production, preparation, processing, finishing, storage, transportation, distribution, advertising, sales, labeling and control of organic products in which organic methods are used production [56].

The Law on Agricultural Land aims at:

- rational use of agricultural land as a limited natural resource,
- protection of agricultural land,
- providing legal certainty to the owners and users of agriculture land.

Furthermore, this law regulates the use, disposal, protection and conversion of agricultural land [57].

Beside these laws, there is a regulation on the Quality of Agricultural Products. The purpose of this law is to regulate:

- the quality standards of the agricultural products,
- the markets for the agricultural products,
- information system for the markets of agricultural products,
- protection of agricultural and food products with geographical name and guaranteed mark traditional specialty,
- the measures and activities undertaken by the bodies and institutions for ensuring the quality of agricultural products,
- working conditions to be met by the operators and institutions that control the quality in agriculture.

This law regulates the markets for agricultural products, quality standards, classification, quality labeling and information system for cereals and rice, food for animals, fresh fruits and vegetables, eggs and poultry meat, beef, pork, mutton and goat meat, milk and dairy products, bee products, protection of agricultural and food products with geographical name and label for guaranteed traditional specialty, control and supervision over the implementation of the provisions of this Law [58].

Key legal document that regulates the forestry sector is the Law on forests. The objectives of this law are:

- to permanently preserve the area under the forest, to increase their value and to provide the largest increase according to the natural conditions of the location,
- to ensure sustainable management, planning, forest management and preservation of forests and forest land in a manner and to the extent that they are permanently maintains and enhances their production capacity, biological diversity, ability to rebuild and vitality in the interest of current and future development the economic, ecological and social functions of the forest, while not being disrupt the ecosystem.

This law regulates planning, management, business, cultivation, protection and use, forest protection as a natural resource and forest land, the realization of the general useful functions of the forests, the right and the obligations of forest use, financing, and other issues of importance to forests and forest land on the principle of biological, economic, social and environmental friendliness. The provisions of this Law shall apply to all forests and forest land without given ownership and purpose [59].

The basic national waste management legislation consists only of the Law for waste management, which is a legal act and prescribes the general rules which apply to waste and hazardous waste issues. It also provides a legal basis for enacting a number of bylaws, rules or guidelines. Management Law waste has important links with other legal acts that regulate tasks and competencies related to organizational and operational issues in the domain of waste management, in particular the basic Law on Environment provisions on environmental permits, environmental impact assessment procedure, greenhouse gas emissions.
The objectives of this law are:

- avoidance and, as far as possible, reduce the amount of waste generated;
- utilization of usable waste ingredients;
- sustainable development, by preserving and saving natural resources;
- prevention of negative effects of waste on the animal environment, life and human health;
- disposal of waste in a manner that is acceptable to the environment;
- high degree of protection of the environment, life and health of people

This article regulates waste management, principles and objectives waste management; plans and programs for management waste; rights and obligations of legal and natural persons in connection with waste management; the requirements and obligations of legal and natural persons who produce products and packaging and who on end of life cycle burdens the environment; the manner and conditions under which collection may take place, transportation, treatment, storage, processing and disposal of waste; import, export and transit of waste; monitoring; information system; financing and management oversight with waste [60].

Other laws that might corelate are:

1. Law on Reproductive Material of Forest Trees[1]
2. Law on Forestry and Hunting Inspection[2]
3. Law on Establishing Accounting Data Network of Agricultural holdings[3]
4. Law on Fertilizers[4]
5. Cooperative Law [5]

Many by-laws are covering special issues related of the agriculture mostly, but also of the forestry sector. Moreover, several programs are present such Program for Financial Support to Agriculture[6], 2017 and Rural Development Financial Support Program[7], 2018.
This sector aimed at constant improvement and gathering more data. Multiple projects have been prepared:

1. Introduction of National Land Consolidation Program (MAINLAND)[8]
2. National Agro-Environmental Zoning Project (regionalization of agricultural production)[9]
3. Macedonian Soil Information System (MASIS)[10]

[1] http://arhiva.mzsv.gov.mk/files/zakon_za_reproduktiven_materijal_od_sumski_vidovi_drvja.pdf
[2] http://arhiva.mzsv.gov.mk/files/zakon_za_sumarska_i_lovna_inspekcija.pdf
[3] http://arhiva.mzsv.gov.mk/files/Zakon_za_vospostavuvanje_mreza_na_smetkovodstveni_podatoci_od_zemjodelski_stopanstva.pdf
[4] http://arhiva.mzsv.gov.mk/files/Zakon_za_gjubrinja.pdf
[5] http://agencija.gov.mk/download/3аконодавство/13172649369Zakonzazadrugite.pdf
[6] http://www.mzsv.gov.mk/CMS/Upload/docs/finansika_podrska_na_zemjodelstvoto.pdf
[7] http://www.mzsv.gov.mk/CMS/Upload/docs/Програма_за_финансиска_поддршка_на_руралниот_развој_за_2018_година.pdf
[8] http://www.fao.org/in-action/mainstreaming-national-land-consolidation-programme/mk/
[9] http://www.fao.org/geospatial/projects/detail/en/c/1119427/
[10] http://www.maksoil.ukim.mk/masis/

8.1.1 The government framework program for the transition to BBI, green, circular economy

Due to its exceptional importance in the processes of agricultural restructuring economies, the introduction of new technologies and standards in production, the transfer of knowledge of farmers and improving application to public support schemes (and especially for the absorption of IPARD funds), state funding of advisory services will be systematized and improved in terms of access and quality of services and accountability of realized assets. This will be achieved through the establishment of National Agricultural Advisory System according to European standards for which it will be adopted special law. In addition to the completion of the National Agricultural Advisory System, the knowledge transfer to farmers will be supported through measures to support the organization and holding mandatory trainings and information sessions, establishing demonstration agricultural holdings and implementation of research projects [61].

8.1.2 Rural Development Program (2014-2020)

In order to achieve the set goals, the long-term planning of national agricultural policy is achieved through the adoption of a National strategy for agriculture and rural development for a period of seven years (Article 6) as basic strategic document of the agricultural policy in the Republic of N. Macedonia. The implementation of the National Strategy is realized through multi-year National Program for Agricultural Development and Rural Development which covers a period of five years and annual programs for financial support in agriculture and financial support of rural development for the implementation of the multi-year national program.

The National Program for Agricultural Development and Rural Development is planned and operational document for the implementation of the national policy for agriculture and rural development that links strategic policy documents, above all National Strategy for Agriculture and Rural Development and the Multiannual budget planning, with annual operating programs and annual regulations for implementation of agricultural and rural policies.

The national program especially contains:

- instruments and measures and activities for implementation of the measures,
- schedule and deadlines for implementation,
- indicative financial framework for their implementation

The realization of the strategic goal will be achieved by reaching the specific goals of agricultural policy for the period 2014-2020 in the following areas of intervention:

1. Restructuring and modernization of the agricultural-food sector
2. Market regulation, food chain organization and improvement the quality of agricultural products
3. Improving living conditions and economic activities in rural areas
4. Continuous access to knowledge and investment in human capital agriculture
5. Completing the functionality of the food safety system
6. Sustainable management of natural resources and mitigation of the impact of climate change in agriculture

In order to achieve the goals of agricultural policy, the Government of the Republic N. Macedonia in its Work Program for the period 2017-2020 projected further increase the financial resources to support the development of agriculture and rural areas that will amount to 160 million euros per year, that is, an increase of 10 million euros compared to the planned amount in accordance with the NSRF 2014-2020 [33].

8.2 Summary and conclusions in relation to SWOT elements

As a general conclusion it can be stressed that the existing potential of renewable energy sources, even though they cannot increase significantly the amount of domestic production of electricity from renewable sources, through its support in heating households, getting hot water from RES, assistance in mitigating, energy

consumption can drastically improve the living standards of the population, as well as be a strong stimulation for the socio-economic development of local municipalities. The obligations of N. Macedonia as a country and the local governments as a third authority which in accordance with the decentralized position of the structures of the country related to the Strategy for using renewable energy sources in the Republic of N. Macedonia by 2020, will be fully completed. Republic of N. Macedonia, as a country - candidate for EU membership is up to date with trends in Europe and constantly harmonizes its legislation with the EU as is illustrated in this chapter by the large amount of new and adapted laws addressing agriculture, rural development, waste management, renewable energy and GHG mitigation targets, environment and biodiversity conservation and transition to BBE and more circularity. The main regulation which regulates the RES market was adopted, as well as the feed-in tariffs and other subsidies for all those who invest in this sector. The municipalities as local authorities have open arms to invest and to attract investors who will expand the use of renewable energy sources in their local communities. However, despite all these development activities, there are still many barriers that prevent full expansion in utilising RES [12].

Table 8.1: SWOT analysis of Bioeconomy Policy Framework of N. Macedonia [12]

Strengths	Weaknesses
• The measures that are present are specific in the field of bioeconomy • There is a growing awareness that structural changes in policies are needed for the development of bioeconomy	• No explicit legislative bioeconomy support and stimulation, only measures that contribute to bioeconomy development • Most measures rely on voluntary pledges from the private sector • Limited resources for possible measure implementation • A lack of a circular agricultural policy • A lack of financial incentive/ subsidies to foster bioeconomy development • Low feed-in tariffs set by the state • Slow and inefficient administration at state and local level • The political uncertainty and corruption • Lack of data and research • Ad-hoc investment instead of strategic and predictable financing • Insufficient knowledge of technical features, capabilities and performance of equipment and systems for RES • Limited experience with public private partnerships (policies can only facilitate, but economic actors and consumers have to make the transition to a more biobased and circular economy happen)
Opportunities	**Threats**
• Future policies should focus on clusters: pairing innovation centres with industry and state • Policies for improved biomass managing, increase in the use of forest wood and stimulation of the use of recognized certificates	• No new and bioeconomy-specific policies and legislation (status quo) • Ignoring of the raising awareness of the need for structural change in policy • Continuous relying on voluntary pledges from companies

9 Financing

9.1 Introduction

There are several financial instruments and policies identified in regards to the bio-based sector.

Feed-in tariffs are economic instrument that aim to increase the share of RES-E. It started 2011 and still it is an ongoing activity. In the N. Macedonia, the electricity market operator is obliged to pay a fixed feed-in tariff to RES plant operators for the electricity generated from renewable energy sources. Electricity suppliers and retailers are obligated by the electricity market operator to buy the quantity of electricity produced by the preferential producers, corresponding to electricity demand of their consumers, understood as certain percentage of the total envisaged electricity demand of in N. Macedonia [62].

Within the latest Decree for support measures for RES electricity generation – 2019, the installed power must not exceed:

- 1 MW for biomass thermal power plant,
- 1 MW for biogas thermal power plant,

whereas in the previous decree (from 2013) the limit for installed capacity for biomass thermal power plant was 3MW [63].

However, the period of using preferential tariffs and the preferential electricity tariff produced and delivered in power system yet remain the same. Moreover, there is updated Decision on total installed capacity from preferential producers[11]. The above-mentioned secondary legislative is in line with the Energy Law [12] (adopted in 2018).

The Green for Growth Fund, Southeast Europe (GGF) is a financial instrument, moreover in the field of loans and investment subsidies. Started in 2009 and still support its initial purpose is to enhance energy efficiency and foster the use of RE through reduction of energy consumption and CO_2 emissions. The GGF provides refinancing to financial institutions for on-lending to enterprises and private households seeking to finance energy efficiency projects. The GGF also invests directly in small to medium-scale renewable energy projects. To maximize the impact of the Fund's investment activities, the GGF's Technical Assistance Facility offers capacity building support to local financial institutions and partners. The GGF was initiated as a public-private partnership in December 2009 by the KfW Development Bank (KfW) and the European Investment Bank (EIB) with the financial support of the European Commission, the German Federal Ministry for Economic Cooperation and Development (BMZ), and the European Bank for Reconstruction and Development (EBRD). Its growing investor base comprises donor agencies, international financial institutions and institutional private investors, and recently added the International Finance Corporation (IFC) and Netherlands Development Finance Company (FMO) [64].

As a country level incentive, the National Programme for financial support of Agriculture and Rural Development could be emphasized as good practice. So far two programmes have been adopted 2013 – 2017 and 2018 – 2020. This economic instrument, i.e. investment subsidy supports the agricultural production and rural development. The National Program for Agricultural Development and Rural Development is a planning and operational document for the implementation of the national policy for agriculture and rural development that connects strategic policy documents, primarily the National Strategy for Agriculture and Rural Development and multi-year budget planning, with annual operational programs and annual regulations for the implementation of agricultural and rural policies.
According to Article 7 of the Law on Agriculture and Rural Development, the national program in particular contains:

- instruments and measures and activities for implementation of the measures,
- schedule and deadlines for implementation,
- indicative financial framework for their implementation [65], [61].

[11] http://www.economy.gov.mk/Upload/Documents/ilovepdf_com-1.pdf (available only in Macedonian language)
[12] http://www.economy.gov.mk/Upload/Documents/Zakon%20za%20energetika%20MK.pdf

One of the most significant economic instruments which provide investment subsidies is the EU Instrument for Pre-Accession Assistance – II, more specific the Rural Development (IPARD II) Programme (2014 – 2020) that started in 2014. This continuing activity encourages more balanced development in rural areas. The main goal is to improve the food safety standards and to make the farming and food production sector more competitive. The IPARD II objectives largely coincide with the main strategic objectives of the National Strategy for Agriculture and Rural Development (NSARD) 2014-2020.
The Programme includes 11 measures that can be grouped into the following priority areas:

1. Enhancing farm viability and competitiveness of all types of agriculture and primary food-processing;
2. Restoring, preserving and enhancing ecosystems dependent on agriculture and forestry;
3. Promoting balanced territorial development in rural areas;
4. Transfer of knowledge and strengthening public administration capacity in implementation of rural development programmes.

The Instrument for Pre-Accession Assistance for Agricultural Development and Rural Development from European Union - IPARD for the period 2014-2020, as well as the third IPARD program document for the period after 2020. This support is programmed in compliance with the concluded agreements and agreements with the European Union for the use of instruments for pre-accession financial assistance and EU planning documents. In addition to the two sources mentioned earlier, part of the funding for agricultural policy is provided by donor projects, but also by the funds of local self-government units in co-financing certain rural measures development. The total planned amount of funds required for the implementation of policies support from the national agricultural policy for the entire program period until 2022 amounts to 781,670,000 euros [66], [67].

Another economic instrument concerning the tax reductions is the Law on Concessions: RES-E exclusion concession procedure[13]. The law started in 2005 and few year later in 2013 was amended. Its primary objective is to stimulate investments in biomass and biogas (RES-E plants). Based on the provisions of the Law on Concessions, biomass and biogas RES-E plants are excluded from obligatory concession procedure for the construction of RES-E plants.

Although there are numerous financial programmes, the last identified instrument in this report is the Regional Energy Efficiency Programme (REEP) and its extension REEP plus. This activity ensures investment subsidies and loans from 2013 and further on. The general idea is to stimulate investments in energy efficiency and use of renewable energy. The REEP aims to support energy efficiency investments in both public and private sectors and encourages the public sector to take leadership role as agreed in the National Energy Efficiency Action Plans.
Energy Efficiency in public procurement: Under the scope of the REEP Current obligations on energy efficiency in public procurement are set by the following EU Directives that must be transposed and properly implemented by the Western Balkan countries as Contracting Parties of the Energy Community:

- Directive 2006/32/EC (Article 5 "Energy end-use efficiency in the public sector" and Annex VI "List of eligible energy efficient public procurement measures")
- Directive 2010/30/EU (Article 9 – "Public procurement and incentives").

The Western Balkans Sustainable Energy Direct Financing Facility (WeBSEDFF) provided investment subsidies and loans to support small and medium RE projects. But it came to an end in 2015.

REEP consists of three windows:
- support to policy dialogue and the development of the energy service company or energy savings company (ESCO) concept;
- provision of funding and grants to financial institutions for on-lending to private and public sectors energy efficiency and renewable projects (WeBSEFF II);
- direct financing of larger renewables and energy efficiency projects of primarily industrial companies (WeBSEDFF II).

REEP Plus will continue to address policy barriers and bring additional benefits through a combination of project preparation support and medium-term financing to households, public and private sector for energy efficiency

[13] https://s2biom.vito.be/node/1263

(EE) and renewable energy (RE) investments with a main focus on the residential sector. It will follow a similar structure to the original REEP with the addition of a residential component under Window 2. The Direct Lending Facility will continue to cover both municipal and private sector investments in sustainable energy, including small renewable energy projects [68].

Furthermore, other bilateral and multilateral assistance apply for the country. Representatives of the donor community, international organisations and financial institutions i.e. the Swedish, the Dutch and the Swiss Embassies (SDC) and FAO, USAID, UNDP, KfW, WB and GIZ have also actively provided support through bilateral and multilateral projects.

The government's priority is to increase of agricultural land, yield and quality of agricultural products that should enable higher incomes of agricultural holdings. Politics will be also aimed at increasing the industrial processing facilities that will be export-oriented and will create products with higher added value.

For the policy of direct payments are allocated the largest amount of total financial support provided from the state for agriculture and rural development of 74% on average for the period until 2022. Basic direct payments by arable land or per head livestock are the initial basis on which other additional payments are upgraded regardless of the policy to which those direct payments belong (market-price support, rural development or state aid). This as a step towards providing full equalization of support per unit area agricultural land unrelated to the type of production at the time of accession to the EU. Additional direct payments are schemes of direct payments that are replenishment of the amount of basic payments as a percentage of the same or absolute amount of funds. In addition to the measure of organic production and additional financial support in the amount of up to 15% of the basic payments as assistance for performing agricultural activity in areas with limited opportunities, from 2018 in this group are includes the support of biodiversity that until 2017 was granted within of the annual direct payment program. Direct payments for variable input elements in agricultural production is a support that is granted in order to influence the increased domestic production of inputs in agricultural production, primarily seedlings or seed material, for breeding of high-yielding head of cattle with monitored genetic origin or achieving better utilization of certain services in agriculture.

Additionally, in order to provide more available financial funds for the realization of investments in improving the competitiveness of agricultural production, starting from 2018, a new measure for supporting the costs for the purchase of fuel for agricultural machinery with which they will be provide compensation for the costs of the purchased fuel for agricultural machinery in height up to 50%.

Market interventions will be carried out to a limited extent by observing market relations and competition aimed at intercepting and depreciating the negative impact of external factors. The measures will be introduced accordingly the assessment of the necessity for their introduction in conditions of need to overcome major market disruptions occur and ensuring revenue stability agricultural producers. Planned instruments in the field of market regulation are:

- compensation for losses in farmers' incomes,
- intervention measures for stabilization of the markets for agricultural products,
- measures to encourage consumption,
- measures to limit production,
- support of producer organizations.

As part of the future system is the planned establishment of an intervention fund intended to stabilize farmers' incomes. This financial reserve in the amount of 6 million euros is a new instrument intended to support the sector in the event of crises that affect production and / or distribution.

Increasing allocations and the number of investment agreement measures and other structural measures of rural development policy in this programming period are envisaged to ranges from 23 to 28% of the total allocated funds for financial support of agriculture and rural development in the period until 2022.

Because capital grants for modernization and adaptation to EU standards of agricultural holdings and processing facilities and support for diversification of economic activities in rural areas are included in the IPARD program, emphasis on nationally funded policy rural development is given to the measures for capital

investments in infrastructure. Providing solid urban and transport infrastructure in and out of rural areas settlements will provide improved living conditions and a positive impact on development of economic activities.

With the funds that will be provided for the recapitalization of the financial instrument Agricultural Credit Discount Fund (ZKDF) within the Macedonian Bank for development support (MBDP) through which favorable loans will be implemented farms intended for agriculture, now supplemented by the approval of a line for favourable interest rates on loans up to 2% per annum intended for special priority categories users (economies in restructuring, to improve food safety and quality, young farmers)[61].

The only issue I miss is whether there are resources available for improving waste management. Are their stimulation programmes such as taxation of waste, waste separation stimulation measures or taxation of waste (e.g. Pay as you Throw schemes), investment susbsidies on installations for composting, pot-separation, biogas etc.

9.2 Summary and conclusions in relation to SWOT elements

Table 9.1: SWOT analysis of Bioeconomy Financing of N. Macedonia. [12]

Strengths	Weaknesses
• Educated labour force, good language skills, and willingness to learn • Areas of excellence in academia and industrial research • Streamlined investment promotion and incentives • Increase in demand for bio-based products in export-oriented companies (e.g. automotive industry)	• Finding funds for the transition from experimental pilot to industrial pilot • Finding funds for the transition from industrial pilot to market • Small scope of international projects, platforms, networks that are based in specific measure • Weak investment activity in processing activities in the direction of transitioning to bio-based alternatives • Weak supporting activity of financial institutions towards bioeconomy projects (e.g. venture capital funds)
Opportunities	**Threats**
• Enhance State or Government funding and subsidies for fostering bioeconomy • Better use of available EU funding in the field of bioeconomy • Promoting cluster formation • Regional resource connecting (RDI, production, logistics) • Giving the opportunity for physical entities to invest in RES; • Transfer of knowledge between the municipalities; • The granting of loans with low interest rates for so-called "Green projects" to physical and legal entities, as well as to local governments that have good project proposals s; • Further development of the financial and administrative capacities of municipalities through creating special funds for investment in RES; • To intensify the investments, administrative changes and adjustments, such as marking the	• Stagnant or reduced Government funding and use of EU funds • Possible risky nature of investment • A lack of agencies providing equity and loans for bio-based initiatives

construction zones for facilities for using RES is inevitable; • Establishing ESCO1 - companies which will be the engines of the expansionist plans and development policies for utilising RES in agricultural production; • Providing benefits for the investors in the municipalities if they utilise RES in their projects through freeing them from income tax, reduction of customs tariffs for equipment and devices used for RES; • Providing subsidies by the municipality in order to attract investments in the sector of RES; • Reducing communal taxes for building capacity for production of energy from renewable sources; • Considering the opportunities for making contracts for public - private partnership; • Cooperation between the municipalities and the civil sector and using certain funds that the civil sector receives; • Building an entrepreneurial spirit by the municipalities by initiating collaborations and projects in the field of RES; • Establishing a Fund for utilising RES in the Southeast planning region; • Increasing the cooperation on a regional level.	

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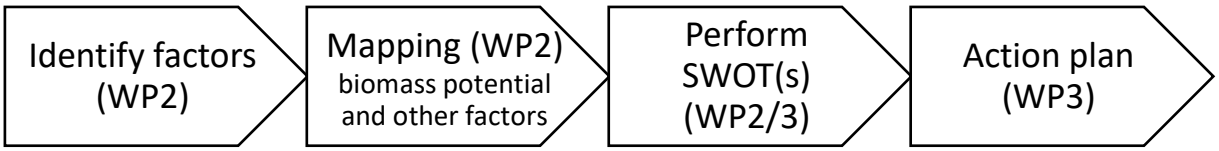
Annex 1 Approach guiding the structure and contents of this report

Identification of factors that are important for establishing bio-based production chains in a country

One of the objectives of the CELEBio project is to map opportunities in the target countries for setting up bio-based business activities. This includes the mapping of the biomass feedstock potentials, and other key success factors for establishing bio-based production chains, e.g. business activities, what bio-based products can be generated, and what is the market demand of these products.
The BBI is focused on the next bio-based products and markets: Chemicals, Plastics (polymers, materials, packaging), Specialties (surfactants, lubricants, pharmaceuticals, nutraceuticals, cosmetics), Textiles, Food ingredients and feed, Advanced biofuels.

To be able to perform SWOT(s) and generate action plans, the first step is to identify which factors are important. These factors should be determined based on the perspective of both entrepreneurs/business developers and governments. The identified factors should be mapped and will be the basis for performing a SWOT (Strength, Weakness, Opportunity and Threat) analysis for development of biobased production chains.



Based on input from industry and business developers a logical set of factors was identified that guide the choice of investing in the bio-based economy and location of conversion plants (Van Dam et al., 2014). This set is expanded/updated (amongst others based on the BBI project BIOFOREVER (bioforever.org)). Via an interview sheet, different stakeholders (15) from different countries (the Netherlands, Croatia, Czech Republic, Hungary, and Slovenia) were asked to comment on the factors and rank them.

Highest ranked factors:

- Feedstock supply: price, security of supply, quality
- Product market: price, off-take security
- Regulations, legislation, and rule of law

Medium raked factors:

- Financing: investors, subsidies, guarantees, risk minimization options
- Taxes and Tariffs
- By-product valorization: heat, CO2, fodder, lignin

Lowest ranked factors:

- Infrastructure: what part of the chain is already available (harbor, industries)
- Logistics: cost, reliable
- Technology: TRL, robustness, yield, CAPEX, OPEX
- Sustainability: economical, environmental, and social aspects

Overall, the ranking of the factors only differed slightly. Most of the experts mentioned that all the identified factors are important and that a system approach is key in developing biobased initiatives. If one link in the chain is missing, the biobased initiative will not succeed.

According the experts the most important stakeholders for establishing biobased production chains are:

- Producers/suppliers of biomass
- Chemical industry
- Energy industry
- R&D organizations
- Regulatory authority
- Environmental organizations
- Public

Annex 2 Explanation of the S2BIOM approach to assessing lignocellulosic biomass potentials from agriculture, forestry and residues

In S2BIOM project the core biomass cost supply data was generated in WP1 for 37 European countries at regional level. Lignocellulosic biomass assessed by S2BIOM includes biomass originating from the following:

- Primary residues from agriculture
- Dedicated cropping of lignocellulos biomass on agricultural area
- Wood production and primary residues from forests
- Other land use
- Secondary residues from wood industry
- Secondary residues of industry utilising agricultural products
- Waste collection/ tertiary residues

Data have been assessed for 2012, 2020 and 2030. They are provided for several 'potentials' including: a technical potential; a base potential considering currently applied sustainability practises; and further potential levels that are determined considering changing sustainability restrictions, mobilisation measures and different constraints to account for competing use.

The technical potential represents the absolute maximum amount of lignocellulosic biomass potentially available for energy use assuming the absolute minimum of technical constraints and the absolute minimum constraints by competing uses. This potential is provided to illustrate the maximum that would be available without consideration of sustainability constraints.

The base potential can be defined as the technical potential considering agreed sustainability standards for agricultural forestry and land management. The base potential is thus considered as the sustainable technical potential, considering agreed sustainability standards in CAP (Common Agricultural Policy) for agricultural farming practices and land management and in agreed (national and regional) forestry management plans for forests (equivalent to current potentials described in EFSOS II). This also includes the consideration of legal restrictions such as restrictions from management plans in protected areas and sustainability restrictions from current legislation. Further restrictions resulting from RED (Renewable Energy Directive) and CAP are considered as restrictions in the base potential as well. CAP sustainable agricultural farming practices include applying conservation of Soil Organic Carbon (SOC) (e.g. Cross Compliance issues of 'maintaining agricultural land in good farming and management condition' and avoiding soil erosion).

The user-defined potentials vary in terms of type and number of considerations per biomass type. Following the general nomenclature of potentials the user defined potentials can also be considered as sustainable technical potentials but differ in the constraints considered vs the base potential and among each other. The user can choose the type of biomass and the considerations he would like to employ and calculate the respective potential accordingly. This flexibility is meant to help the user to understand the effect on the total biomass potential of one type of consideration against the other. These can include both increased potentials (e.g. because of enhanced biomass production) or more strongly constrained potentials (e.g. because of selection of stricter sustainability constraints).

Technical, base and one user defined (UD) potential has been assessed for all biomass groups. For forest biomass many more user defined potentials were quantified. See underneath:

Table A2.1: Overview of agricultural residual biomass potential types and considerations in S2BIOM.

	Area/ Basis	Yield, Growth	Technical & environmental constraints on the biomass retrieval (per area)	Consideration of competing use	Mobilisation
Technical (straw & stubbles)	Area in 2012, 2020, 2030 with cereals, rice, sunflower, rape, corn maize	Growth based on regional growing conditions & management. Yield according to regional averages including expected developments in yield towards 2020 and 2030	Maximum volume of straw and stubbles that could be harvested in 2012, 2020 and 2030	None	None
Technical (prunings permanent crops)	Area in 2012, 2020, 2030 with fruit trees, vineyards, olive & citrus	Growth based on regional growing conditions & management. Yield according to regional averages including expected developments in yield towards 2020 and 2030	Maximum volume of prunings and cuttings that could be harvested in 2012, 2020 and 2030	None	None
Technical (sugarbeet leaves & tops)	Area in 2012, 2020, 2030 with sugar beet	Growth based on regional growing conditions & management. Yield according to regional averages including expected developments in yield towards 2020 and 2030	Maximum volume of sugarbeet leaves and tops that could be harvested in 2012, 2020 and 2030	None	None
Base (straw & stubbles)	As for technical potential	As for technical potential	Only the biomass part can be removed that is not needed to keep the SOC stable. This is assessed according to carbon content that is removed with the residue and the SOC level in the soil that has to be maintained.	None	None
Base (prunings permanent crops)	As for technical potential	As for technical potential		None	None
Base (sugar beet leaves & tops)	As for technical potential	As for technical potential	Removal of leaves and tops from field is only allowed in Nitrate vulnerable zones where nitrogen surplus needs to be declined through removal of nitrogen rich biomass.	None	None
User potential (straw & stubbles)	As for technical potential	As for technical potential	As in base	In cereal straw a subtraction is applied according to demand for straw for animal bedding & feed . For rice straw, corn stover and sunflower and rape stubbles no competing uses are assumed.	None
User potential (prunings & cuttings)	As for technical potential	As for technical potential	All pruned material is available that is currently according to real practices NOT used to maintain the SOC and fertility of the soil. So the part that is now removed to the side of the field for energy uses or that is burned with & without energy recovery is seen as potential and can be removed. This follows the common treatment practices of prunings as assessed in the EUROpruning project.	None	The potential that is NOT used for SOC and fertility maintenance according to current practices needs to be mobilised gradually as it requires a change in management. It is therefore assumed; it becomes available from 50% in 2012 to 60% in 2020 and 70% in 2030.

This project received funding from the BBI JU under the EU Horizon 2020 research and innovation programme under grant agreement No.838087

Table A2.2: Overview of woody biomass potential types used in S2BIOM.

	Area/ Basis	Yield, Growth	Technical & environmental constraints on the biomass retrieval (per area)	Consideration of competing use	Mobilisation
Technical	Forest area available for wood supply. This excludes protected and protective areas, where harvesting is not allowed according to protection purpose.	Growth based on regional to national growing conditions, including changes in biomass increment due to climate change. Yield according to regional management guidelines for age limits for thinnings and final fellings.	Maximum volume of stemwood that could be harvested annually during 50-year periods. Technical constraints on residue and stump extraction (recovery rate)	None	None
High	As for technical potential	As for technical potential	As for technical potential, but considering additional less stringent constraints (compared with base potential) for residue and stump extraction: Site productivity -Soil and water protection: ruggedness, soil depth, soil surface texture, soil compaction risk -Biodiversity (protected forest areas) -Soil bearing capacity.	None	None
Base	As for technical potential	As for technical potential	As for technical potential, but considering additional constraints for residue and stump extraction: -Site productivity -Soil and water protection: ruggedness, soil depth, soil surface texture, soil compaction risk -Biodiversity (protected forest areas) -Soil bearing capacity.	None	None
User potential - option 1	Reduction of FAWS by 5%	As for technical potential	Equivalent to increase of protected forest area by 5%.	None	None
User potential - option 2	Reduction of FAWS by 5%	As for technical potential	Increase of protected forest area by 5% and increase in retained trees by 5%.	None	Reduction in harvest by 5%
User potential - option 3	As for technical potential	As for technical potential	No stump extraction.	None	None
User potential - option 4	Reduction of FAWS by 5%	As for technical potential	Increase in protected forest by 5% plus increase in retained trees by 5% plus no stump extraction	None	Reduction in potentials by 5%
User potential - option 5	As for base potential	As for base potential	As for base potential	Roundwood production for material use (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Pulpwood, Round & Split + Other Industrial Roundwood) in period 2010-2014) subtracted from BP.	None
User potential - option 6	As for base potential	As for base potential	As for base potential	Roundwood production for material use excl. for pulp and paper and board industry (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Other Industrial Roundwood) in period 2010-2014) subtracted from UP4.	None
User potential - option 7	As for user potential - option 4	As for user potential - option 4	As for user potential - option 4	Roundwood production for material use (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Pulpwood, Round & Split + Other Industrial Roundwood) in period 2010-2014 subtracted from BP.	As for user potential - option 4

	Area/ Basis	Yield, Growth	Technical & environmental constraints on the biomass retrieval (per area)	Consideration of competing use	Mobilisation
User potential - option 8	As for user potential - option 4	As for user potential - option 4	As for user potential - option 4	Roundwood production for material use excl. for pulp and paper and board industry (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Other Industrial Roundwood in period 2010-2014) subtracted from UP4.	As for user potential - option 4

Table A2.3: Overview of potentials calculated for biowaste and wood waste.

Technical potential The Technical potential represents the amount of biomass assuming only technical constraints and a minimum of constraints by competing uses. In case of biowaste no constraints are considered in the technical potential. In case of post-consumer wood, the technical potential assumes that 5% of all wood waste cannot be recovered and used for energy application for technical reasons. Competing uses (current material application of the wood) are not taken into account.
Base potential This is the sustainable technical potential, considering currently agreed sustainability standards. In case of biowaste the base potential equals the technical potential. In case of post-consumer wood, the base potential takes into account the current material application of recovered wood, and assumes that this material application remains constant in 2020 and 2030
User defined potential The user-defined potentials vary in terms of type and number of considerations per biomass type. The user can choose the type of biomass and the considerations he would like to add and calculate the respective potential. This flexibility is meant to help the user to understand the effect on the total biomass potential of one type of consideration against the other. In case of biowaste no user-defined potentials have been developed. In case of post-consumer wood, one user-defined potential has been developed. This user defined potential on cascading use of post-consumer wood takes into account the current material application of post-consumer wood in 2012, and assumes that the material application of non-hazardous post-consumer wood will increase to 49.2% in 2020 and 61.5% in 2030, or remain stable if current (2012) material use is higher.

Primary agricultural residual biomass assessments

For the assessment in S2BIOM (like for Biomass Policies) land-use and livestock production levels are used based on the most recent CAPRI baseline run 2008-2050, providing intermediate results for 2010, 2020, 2030 and 2050.

The potential supply of agricultural residues was estimated for the period from 2012, 2020 and 2030. It uses as main input the cultivated land and main crop production and yield combinations made for these years by the CAPRI model. Residual biomass covered in S2BIOM from agriculture comes from primary residues from arable crops (straw and stubbles) and pruning, cutting and harvesting residues from permanent crops.

The assessment of residues from arable crops builds on methodologies and assessments already done in Biomass Policies and Bioboost. The assessment for vineyards, olive groves and fruit plantation residues bases builds on work done in EuroPruning project.

The aim of S2BIOM was to identify the part of the residues that can be removed from the field without adversely affecting the SOC content in the soil.

It is the carbon balance module in the MITERRA-Europe that has been further adapted in S2BIOM (and Biomass Policies) to take account of removal of straw (and also prunings, see next). This was done by incorporating the RothC model (Coleman and Jenkinson, 1999) into MITERRA-Europe. RothC (version 26.3) is a model of the turnover of organic carbon in non-waterlogged soils that allows for the effects of soil type, temperature, moisture

content and plant cover on the turnover process. It uses a monthly time step to calculate total organic carbon (ton C ha-1), microbial biomass carbon (ton C ha-1) and Δ14C (from which the radiocarbon age of the soil can be calculated) on a years to centuries timescale (Coleman and Jenkinson, 1999). For this study RothC was only used to calculate the current SOC balance based on the current carbon inputs to assess taking account of soil types (including Soil C levels) the sustainable crop residue removal rates at which the carbon C in the soil remains constant.

Primary forest biomass potential assessment

The potential supply of woody biomass was estimated for the period from 2012 to 2030 for stemwood; branches and harvest losses (further: 'logging residues'); and stumps and coarse roots (further: 'stumps') (Table 20). First, we estimated the theoretical potential of forest biomass supply in Europe based on detailed forest inventory data. This theoretical potential was defined as the overall, maximum amount of forest biomass that could be harvested annually within fundamental bio-physical limits (adapted from Vis and Dees 2011, Dees et al. 2012), taking into account increment, the age-structure and stocking level of the forests. Second, multiple environmental and technical constraints were defined and quantified that reduce the amount of biomass that can be extracted from forests for different biomass potential types. Third, the theoretical potentials from the first step were combined with the constraints for the biomass potential types.

This sequence of steps is based on the approach developed and applied within the EUwood and EFSOS II studies (Verkerk et al. 2011; UNECE et al. 2011; Verkerk 2015). The approach in S2BIOM differs from previous studies in several ways, with the main difference being that that woody biomass potentials have been estimated using a typology of potentials developed within S2BIOM. Other changes include (i) an updated of the forest inventory data used as a basis to estimate biomass potentials; (ii) extension of the geographical scope to include all 37 S2Biom countries; (iii) improvements to set the of constraints; and (iv) improve the potential estimates at regional level by spatially disaggregating estimated biomass potentials. All improvements are described below.

The large-scale European Forest Information SCENario model was applied (EFISCEN) (Sallnäs, 1990) to assess the theoretical potential of forest biomass at regional to national level. Versions 3.1.3 (Schelhaas et al. 2007) and 4.1 (Verkerk et al. 2016a) were used because the former version is included in a script to estimated biomass potentials Verkerk et al. (2011), while the latter version has the ability to directly store results in a database, which is used to run the EFISCEN disaggregation tool (Verkerk et al. 2016b). EFISCEN describes the state of the forest as an area distribution over age- and volume-classes in matrices, based on data on the forest area available for wood supply (FAWS), average growing stock and net annual increment collected from NFIs. Forest development is determined by different natural processes (e.g. increment) and is influenced by human actions (e.g. management). A detailed model description is given by Schelhaas et al. (2007; 2016).
National forest inventory data on area, growing stock and net annual increment are used to initialize the EFISCEN model.

The amount of wood that can be felled in a time-step is controlled by a basic management regime that defines the period during which thinnings can take place and a minimum age for final harvest. Age-limits for thinnings and final fellings were based on conventional forest management according to handbooks at regional to national level (Nabuurs et al. 2007) and by consulting national correspondents (UNECE-FAO 2011). The amount of stemwood potential removed as logs was estimated by subtracting harvest losses from the stemwood felling potential. Harvest losses were estimated using the ratio between fellings and removals as reported by UNECE-FAO (2000) for coniferous and broadleaved species separately.

Branches together with harvest losses represent logging residues that can be potentially extracted as well. In addition, stumps could potentially be extracted, separately from logging residues. The volume of branches, stumps and coarse roots was estimated from stemwood volume (incl. harvest losses) using age-dependent, species-specific biomass distribution functions (Vilén et al., 2005; Romano et al., 2009; Mokany et al., 2006; Anderl et al. 2009). We assumed no difference in basic wood density between stems and other tree compartments, due to lack of information.

Climate change is accounted using results from LPJmL (Sitch et al. 2003, Bondeau et al. 2007). Data are an average for several climate models for the A1b SRES scenario. Annual tree Net Primary Production (NPP) in gC/m2 for 3 individual years (2010, 2020, 2030) was calculated with LPJmL and used to scale the increment functions used in EFISCEN.

Secondary biomass potentials from agro-food industry

For an overview of the calculation methods and assumptions of secondary biomass sources from agro-food industries see the table below.

Table A2.4: Overview of assessment rules applied in S2BIOM to assess potentials for olive stones, rice husk, pressed grapes residues and cereal bran.

Biomass type	Area / Source	Residue factor	Technical & Environmental constraints
Olive-stones	CAPRI & national statistics: Area with all olive trees (table=oil olives) 2012, 2020, 2030	Olive pits make up between 10%-12.5% of the weight of olive according to Garcia et al. (2012) and Pattarra et al., (2010)	Base= pits from all oil olives + 30% of table olives
Rice husk	CAPRI & national statistics: Area with rice in Europe 2012, 2020, 2030	Rice husk is approximately 20% of the processed rice, with average moisture content of 10% ((Nikolaou, 2002)). It is assumed that all rice produced in the S2BIOM countries is locally processed	None
Pressed grapes residues (pressing residues & stalks)	CAPRI & national statistics: Area with vineyards in Europe 2012, 2020, 2030	Of the processed grapes 4.6% consists of dregs and 1.5% of stalks (FABbiogas (2015)- Italian country report)	None
Cereal bran	CAPRI total estimate of tons processed cereals per EU country	In wheat processing 20% to 25% wheat offals (Kent et al., 1994). Wheat bran represents roughly 50% of wheat offals and about 10 to 19% of the kernel, depending on the variety and milling process (WMC, 2008; Prikhodko et al., 2009; Hassan et al., 2008). . So the residue to yield factor used is 10% of cereals processed domestically.	None

For the calculation of the olive stones, rice husk and pressed grapes dregs we assumed that all domestic production would also be processed locally and that is no further processing of imported olives, rice and grapes. This implied that the residues would be available locally and that the regional distribution of the processing residues is a direct outcome of the cropping area distribution over regions in every country.

For cereal bran it is more logical to assume that the basis should be the total amount of cereals processed in every country. This implies that cereal bran needs to be calculated for a total net domestic cereal production and imports:

$$Domestic\ production_{cereals} - export_{cereals} + import_{cereals}$$

The data on total domestic production, exports and imports levels were available from CAPRI for 2010 (extrapolated to 2012), 2020 and 2030 for all S2BIOM countries except for Ukraine.

To come to a regional distribution of the cereal bran potentials in every S2BIOM country 2 assumptions were made:

1) The bran based on the net domestic production (=domestic production – exports) is distributed regionally according to cereal production area share.
2) The cereal bran based on processing of imported biomass is distributed over largest (port) cities per country as it is expected that processing industries are there where imports enter the country and where population is concentrated. The residues were spatially distributed to regions with the large and medium sized cities (>100,000 inh.), every city was equally weighted.

Method used to estimate secondary forest biomass produced in the forest processing industry

The EU-Wood study (Mantau, 2010) projects the demand for material use without considering competition with other sectors in order to explore if the increasing demand for energy will lead to a strong competitive situation where the demand substantially exceeds the supply. The EU-Wood project (Mantau, 2010) has aligned the prediction of the future demand to the real GDP (Gross domestic product) and thus the prediction that utilises the IPCC B2 scenario assumptions shows a strong increase (see figure below).

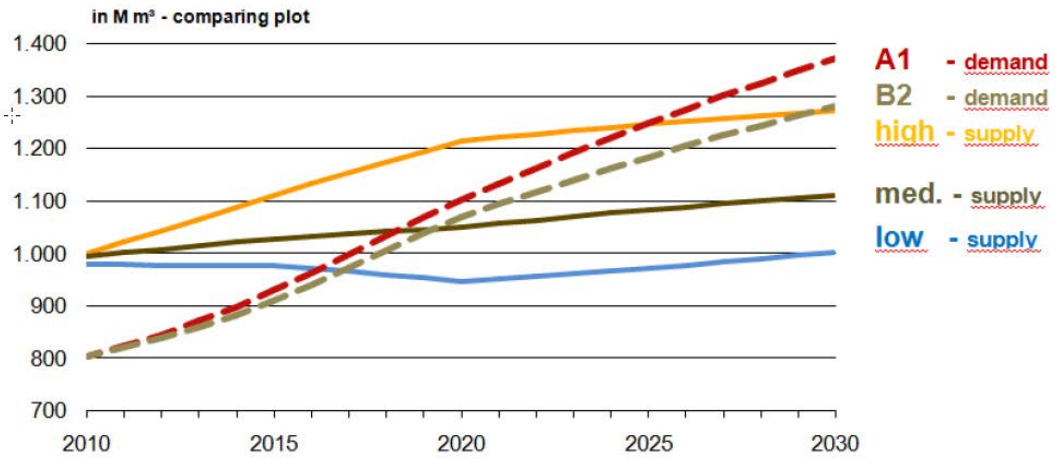


Figure 1-4: Development woody biomass potential demand and potential supply

Source: EUwood 2010

Figure A2.1: Future development of demand and supply as projected by the EU-Wood project for different scenarios (Mantau, 2010).

Thus, to constrain the potentials by such demand projection would constrain the potential with strong preference to material use. The recent trends of the forest products consumption index indicate that the production has changed its relation to the GDP (see figure below).

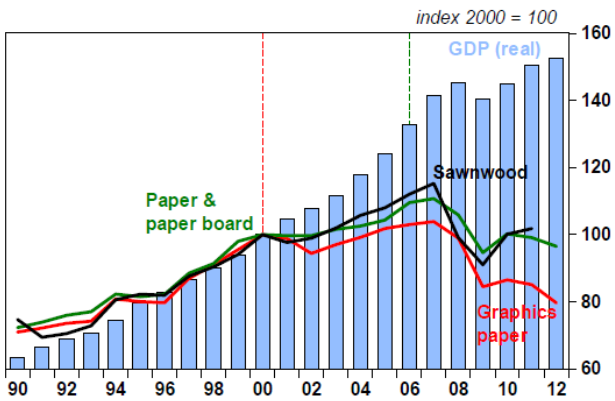


Figure 2.1.2. EU GDP (real) and forest products consumption index over the period 1990-2012 (2000 = 100). (Forest products data from FAO; GDP data from IMF, Gross domestic product based on purchasing-power-parity (PPP) valuation of country GDP).

Figure A2.2 EU GDP and forest products consumption index[14]

[14] Source: Birger Solberg, Lauri Hetemäki, A. Maarit I. Kallio, Alexander Moiseyev and Hanne K. Sjølie (2015) Impacts of forest bioenergy and policies on the forest sector markets in Europe – what do we know?

An alternative to use predict the future industry production results from modelling that considers economic competition. Such estimates are available from the EFSOS II study for 2010, 2020 and 2030. The trends of the EFSOS II study are utilised by S2BIOM. Figures 3 and 4 show for sawn wood and panels that the S2BIOM data for 2012 are close to EFSOS II reference scenario projections 2010.

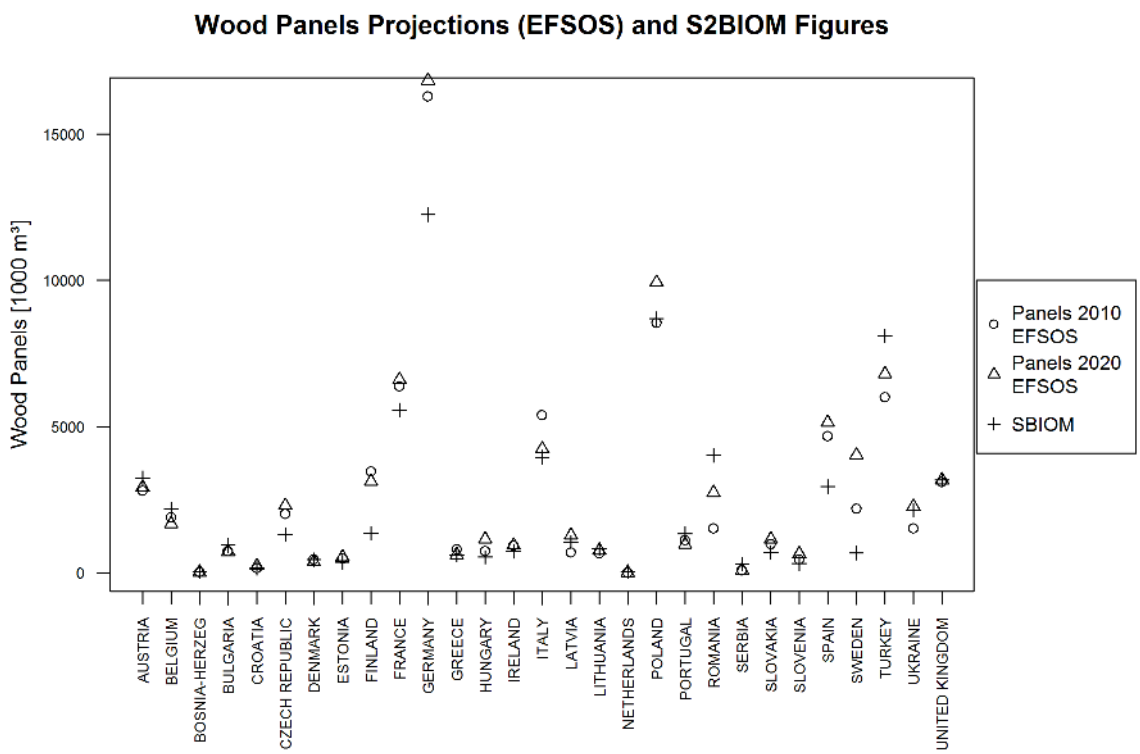


Figure A2.3 Wood panel production, EFSOS 2 reference scenario projections, and S2BIOM 2012 estimates

The S2BIOM residue and production figures of the timber industry were thus projected to the years 2020 and 2030 using the growth rates of the reference scenario of the UNECE European Forest Sector Outlook Study II (EFSOS II) for sawnwood and wood based panel production.

For the pulp and paper sector there was a huge difference between S2BIOM 2012 quantities and the EFOS reference scenario projections.

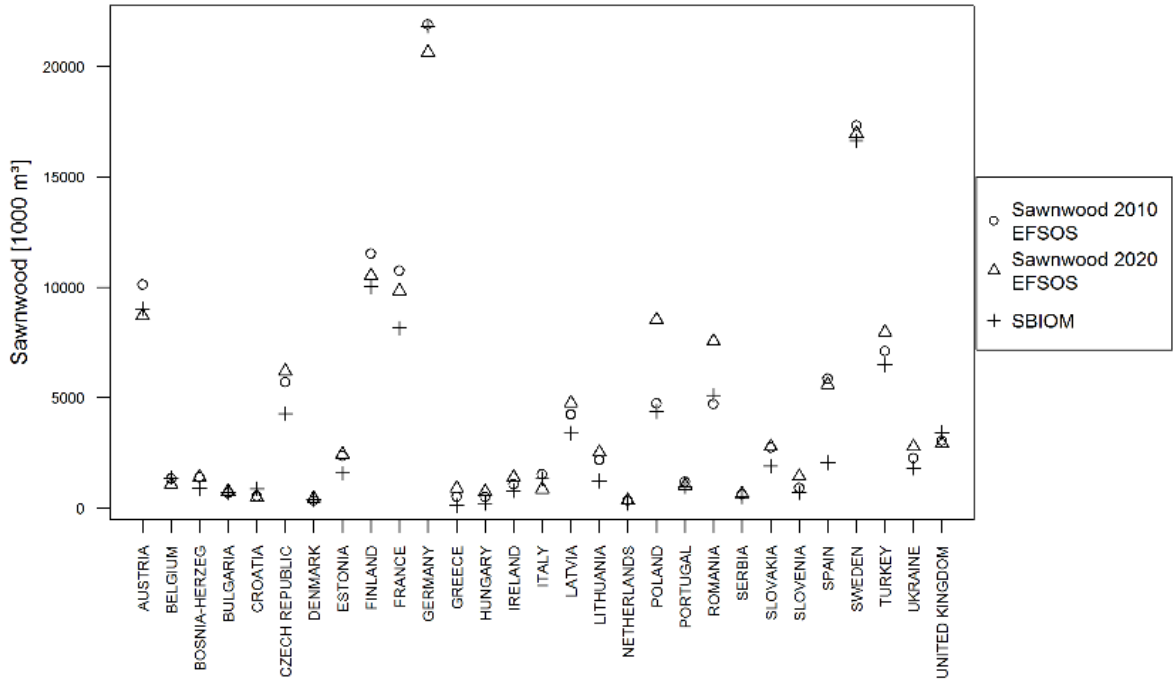


Figure A2.4 Sawnwood production, EFSOS 2 reference scenario projections and S2BIOM 2012 estimates

The visualisation of the figures from the "Historic Statistics" report of CEPI on pulp and paper production are shown in Figure 5. This figure shows the changes of pulp production for the CEPI member states which are: Austria, France, Netherlands, Romania, Sweden, Belgium, Germany, Norway, Slovak Republic United Kingdom, Czech Republic, Hungary, Poland, Slovenia, Finland, Italy, Portugal and Spain. It is for S2BIOM assumed that the changes in production after some bigger fluctuations in the past will be in 2020 and 2030 in the same dimension as in 2012. Hence the production quantities from 2012 are used for 2020 and 2030 as well.

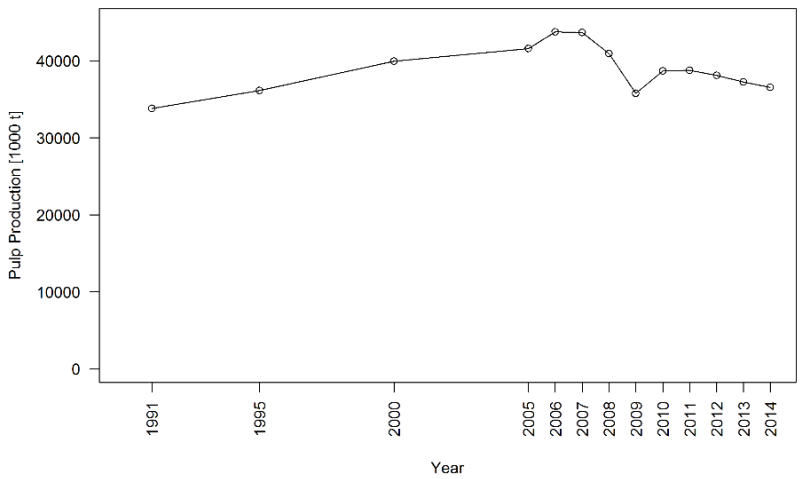


Figure A2.5 Development of Pulp production, CEPI data

The approach used is summarised by category in the table below.

Table A2.5: Approach used to estimate future production amount in the wood industry.

Sector	Approach
Saw mill residues, conifers	EFSOS II sawnwood, reference scenario
Saw mill residues, non-conifers	
Residues from industries producing semi - finished wood based panels	EFSOS II wood based panels production, reference scenario
Residues from further wood processing	EFSOS II sawnwood, reference scenario
Secondary residues from pulp and paper industry	Kept constant

Assessment of biowaste and post-consumer wood potentials

The availability of biowaste in 2012 on NUTS3 level was established as:

MSW generated per capita (kg/capita) x
biowaste fraction (%) x
population of the NUTS3 area (persons).

A further distinction has been made between the separately collected biowaste and biowaste as part of mixed waste.

In Arcadis and Eunomia (2010) projections have been provided of the shares of biowaste going to the different treatment options like landfill, incineration, MBT, composting, backyard composting, anaerobic digestion and others have been made for the years 2008-2020. It has been assumed that all countries meet the requirement of the landfill directive, e.g. that maximally 35% of the amount of biodegradable waste generated in base year 1995 is landfilled in 2020, even if current developments show that diversion from landfill has not been successful yet. Furthermore, the projections are based on policy views and current changes in treatment of biowaste in the member state concerned. For instance, some countries have a strong preference for MBT, others for incineration with energy recovery. For the year 2030 the same shares between treatment options are used as in the year 2020. Currently no policies are known that influence the production of biowaste after 2030, therefore it is assumed that the projected status quo in 2020 will be maintained in 2030.

Projections on the development of the total quantity of biowaste are assumed to be proportional to population growth. The main scenario on population development from Eurostat has been used to predict the population in 2020.

The calculation of the post-consumer wood potential is calculated according to the following formula:

$PCW_{technical\ potential} = PCW_{material} + PCW_{energy} + PCW_{disposed}$
$PCW_{base\ potential} = PCW_{energy} + PCW_{disposed}$

in which:

- $PCW_{recovered}$ = PCW used for materials like panels and chipboards
- PCW_{energy} = PCW used for energy production
- $PCW_{disposed}$ = landfilled and/or incinerated with MSW

Eurostat gives data on "wood waste", but this includes not only post-consumer wood but processing wastes from agriculture forestry and fishing sectors. Because of this mixture of secondary wood processing and tertiary post-consumer wood within one category, Eurostat data could not be used to determine the potential of post-consumer wood. For S2BIOM, data on recovered wood were used from a forest biomass resource assessment

done for the EUwood and EFSOS II studies (Mantau et al. 2010; UN-ECE/FAO 2011[15]). EUwood combines among others Eurostat and COST Action E31 data. The EFSOS II data on demolition wood is based on EU wood, but covers Europe as a whole instead of EU28. In order to determine the base potential PCW available for energy, it is necessary to estimate how much is used for material applications. In the Methodology report of the EUwood project[16], a table is given on the availability of *PCW recovered* [for material recycling] and *PCW energy* for 2007, page 119-120, which have been used in S2BIOM as well.

Assessment of cost levels for different biomass categories in S2BIOM

Because we are still in the early stages of a transition of fossil based feedstock towards bio-based feedstock there is hardly any information of enough quality to conduct a meaningful market analysis. In this light it is important to keep in mind that a distinction needs to be made between different types of cost and price levels specific per biomass type:

- Market prices exist for already traded biomass types (e.g. straw, wood chips and pellets based on primary and secondary forestry residues).
- Road-side-cost for biomass for which markets are (practically) not developed yet (e.g. many agricultural and forestry residues, dedicated crops for ligno-cellulosic and woody biomass and waste streams such as vegetal waste). These may cover the following cost:
    - Production cost (in case of dedicated crops, not for residues or waste)
    - Pre-treatment in field/forest (chipping, baling)
    - Collection up to road side/farm gate
- At-gate-cost which cover the cost at roadside plus transport and pre-treatment cost of biomass until the biomass reaches the conversion plant gate (e.g. bioethanol plant, power plant).

The cost assessed in S2BIOM are limited to the road-side cost. So, the cost from road side for transport and possible in-between treatment to the gate of the conversion installation or the pre-treatment installation are NOT included.

Cost assessment for agricultural biomass potentials

The overall methodology followed to gain insight in the minimum costs of production is the *Activity Based Costing* (ABC). It involves the whole production process of alternative production routes that can be divided in logical organisational units, i.e. activities. The general purpose of this model is to provide minimum cost prices for the primary production of biomass feedstock at the road side. ABC generates the costs of different components based on specific input and output associated with the choice of the means of production, varying with the local conditions and cost of inputs (e.g. labour, energy, fertilisers, lubricants etc.). Since the production of most biomass is spread over several years, often long-term cycles in which cost are incurred continuously while harvest only takes place once in so many years, the Net Present Values (NPV) of the future costs are calculated. This provides for compensating for the time preference of money. To account for the fact that the costs are declining in different periods of time in the future the Net Present Value annuity is applied. In this way annual, perennial crops and forest biomass cost are made comparable (=all expressed in present Euros).

The costs are automatically calculated for all field operations per year in a 60-year cycle in the case of agricultural biomass. The costs of wood production were not considered in this study as these costs need to be allocated to the main product, while here the focus is on the cost of the residues. Cost are presented as NPV per annum and expressed in € per ton dm or per GJ.

[15] UNECE (United Nations Economic Commission for Europe), FAO (Food and Agricultural Organization of the United Nations) 2011: The European Forest Sector Outlook Study II; Geneva

[16] EU Wood (2010) Methodology report, real potential for changes in growth and use of EU forests EUwood. Call for tenders No. TREN/D2/491-2008.

It is also important to note that the costs calculated in here are at the farm level cost. We are aware that the costs for the next link in the value chain might be higher because of rent seeking behaviour. However, in this approach we did not take account of it as we did not include a profit margin.
As explained in the former cost of agricultural biomass are calculated for *Net Present Value annuity* taking a 60-year coverage period. These 60 years are chosen to fit all possible cycles in the cost calculation as 60 is fully synchronizable to 1,3,5,10,15,20,30 and 60 years cycles. Cost differences after that period are negligible. In this way, cost for biomass from residues and from dedicated crops can be assessed with the same model and can be made comparable.

First the Net Present Values of all activities are calculated as follows:

Formula:
$NPv=Fv/(1+i)^n$
Where:

NPv = Net Present value
Fv = Future value
i = the interest rate used for discounting (set to 4%)
n = number of years to discount

Then the Net Present Value annuity is applied, assuming that the sum of NPVs cover the annual capital payments attracted against the same interest rate (4%) as the discount rate used for calculating the NPVs.

Formula:
$NPVa= \Sigma NPv*(1/((1-(1+i)^{-n})/i))$
Where:

NPVa = Net Present Value annuity
ΣNPv = sum of NPVs
n = number of years
i = the interest rate (set to 4%)

The cost also allow for national differentiation of cost according to main inputs having national specific prices levels. This organised through the **'Country inputs'** module in the ABC model. It contains detailed information concerning the prices of various resources needed as input for the production process of biomass specific per country. These are specified, either in absolute price levels or as an index related to the known price level in one or two specific countries (mostly Germany). This is necessary as prices of key production factors differ a lot at national level across Europe. National level price data (ex. VAT) included cover cost/prices for labour (skilled, unskilled and average), fuel, electricity, fertilizers (N, P2O5, K2), machinery, water, crop protection and land. Most of these data were gathered from statistical sources such as FADN (Farm Accountancy Data Network), Eurostat and OECD. Most cost levels were gathered for the year 2012.

The cost data elaboration also requires a feedstock specific approach. If costs are estimated for biomass that is specifically produced for energy or biobased products, i.e. in the case of dedicated crops the cost structure is clear and all cost can be allocated to the final product. All cost should include the fixed and variable cost of producing the biomass including land, machinery, seeds, input costs and on field harvesting costs. If the biomass is a waste, i.e. cuttings of landscape elements or grass from road side verges, the cost could be zero, as cutting and removing these cutting is part of normal management. However, bringing the biomass to the conversion installation requires some pre-treatment costs, e.g. for drying or densifying and then transport costs have to be made to bring it to the conversion installation. These costs will not be assessed here however as we concentrate on the road side cost.

Crop residues also require a separate approach as harvesting cost can usually be allocated to the main products, i.e. grain in the case of cereal straw, and not to the residue. However, the baling of the straw and the collection up to the roadside can be included in the costs.

For the elaboration of cost levels account also needs to be taken of the local circumstances and type of systems used for the production and harvesting of the biomass. This is particularly complex in the case of dedicated

crops for which cost estimates are mostly and/or only available from pilot plots and practically no commercial plantations. Costs vary strongly per type of management, soil and climate zone. Furthermore, cost need to be allocated per ton harvested mass over the whole life-time of a plantation as harvest levels are very low in the first years and increase in time.
The costs are determined for 2012, the reference year and are kept constant in the future years 2020 and 2030. The reason for keeping cost constant in time has several advantages:

1) Estimations of future changes in prices for (fossil) energy (fuel & electricity), labour, and machinery are difficult to predict. If predictions are used this implies automatically adding additional uncertainties in the cost assessment.
2) If cost levels do not alter in time the uses of the cost-supply data in other models in and outside S2BIOM (e.g. Resolve and BeWhere) deliver results that can only be explained from the internal logic of the models and not by differences in cost level increases based on a large number of uncertainties.
3) The cost levels presented in S2BIOM can still be further adapted by other users applying their own assumptions on future cost level changes. This enables them to use the S2BIOM cost-supply data consistently with their own modelling assumptions.

Cost assessment for forest biomass

The estimation of harvesting and comminution costs is following the approach presented earlier by Ranta (2002, 2005), Ilavský et al. (2007), Anttila et al. (2011) and Laitila et al. (2015). In contrast to the cost estimates for energy crops, the production costs are not considered in the cost estimates.
The data are mostly determined by the S2Biom project. A survey of cost factors related to forest harvesting operations was carried out in cooperation with INFRES project (Dees et al. 2015).
The methodology can be divided into two main components: 1) the estimation of hourly machine costs, and 2) the estimation of productivity. All the cost estimations pertain to current cost level (year 2012).

The general work flow is illustrated in the figure below.

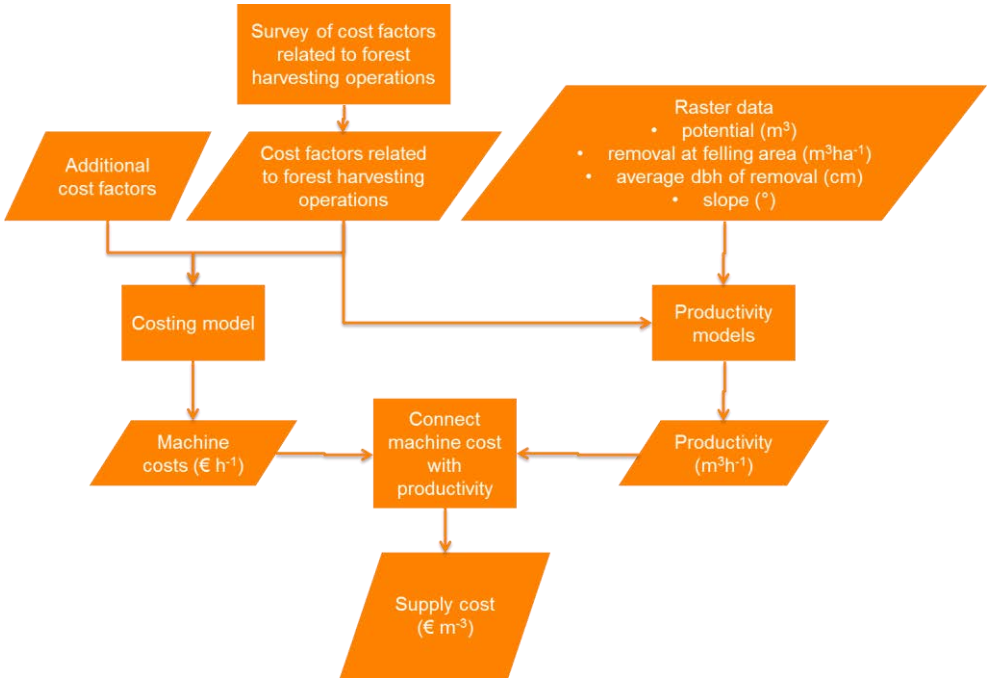


Figure A2.6 General work flow of the forest biomass cost calculations

Cost estimates for biowaste and post-consumer wood

This study follows the activity-based costing approach. In principle, the costs of harvesting collection and forwarding to the roadside need to be considered. The cost to put the biowaste in a container at roadside is assumed to be zero. The cost of further collection and processing is covered by the households and organisations that need to discard the biowaste, regardless its possible further application for energy production. Waste collection and treatment is part of the public tasks and the cost for it cannot be allocated to the processor of the waste. In case of biowaste we could define the municipal collection point as "at roadside". From this municipal collection point, the municipality can select which waste treatment option is preferred, within the framework of European and national policy, considering costs and sustainability of the treatment methods.

The cost of discarding post-consumer wood in a container at roadside is regarded zero. For instance, demolition activities are performed to make space for another building, and not with the purpose to generate wood waste. Demolition activities will follow legal instruction, i.e. put waste wood fractions in separate containers if this is required by law. For other sources of post-consumer wood such as packaging materials or household waste a similar approach can be applied. Packaging waste is of no value to organisations. Consumers bring wooden furniture to a central collection point, or put it at roadside for pick-up, not the sake of providing energy wood. Once collected and sorted, waste wood fractions have an economic value, which can be considerable if there is sufficient demand. However, as said, S2BIOM follows an activity based costing approach, considering the costs, not the economic value of the material. The roadside cost of demolition wood is therefore assumed zero.

This project received funding from the BBI JU under the EU Horizon 2020 research and innovation programme under grant agreement No.838087

Annex 3 Additional tables to biomass supply chapters

Agriculture

Crop production

Treated area with fertilizers and plant protection products

2013	Mineral (artificial) fertilizers	Organic fertilizers	Means for plant protection
ha	205,420	53,283	171,940

Number of agricultural machinery (included individual agricultural holdings and business entities)

2013	One-axle and two-axle tractors	Grain combines	Agricultural collection machines
number	92,708	1,797	19,744

Number of individual agricultural holdings with other gainful activities

2016	Processing of animal products	Processing of plant products	Forestry activities
number	11,771	7,829	1,403

Household members by agricultural activities

	Holder		Households members	
2016	Agricultural activities are major occupation	Agricultural activities are subsidiary occupation	Agricultural activities are major occupation	Agricultural activities are subsidiary occupation
number	104,489	68,528	145,060	112,941

Household members engaged at individual agricultural holdings and employees at business entities

2016	Total number	Individual agricultural holdings	Business entities
Up to 25 years (total)	42,162	41,850	41,850
Up to 25 years (women)	17,165	17,072	93
25-34 (total)	52,785	52,208	577
25-34 (women)	20,997	20,831	166
35-44 (total)	67,987	66,220	1,767
35-44 (women)	30,590	30,160	430
45 - 54 (total)	93,092	92,137	955
45 - 54 (women)	42,945	42,687	258
55 - 64 (total)	98,347	97,453	894
65 years and over (total)	41,080	40,923	157
65 years and over (women)	87,456	87,450	6

Number of seasonally employed and other workers at agricultural holdings

2016	Total	Men	Women
Total number	167,890	102,081	65,809
Individual agricultural holdings	166,309	101,184	65,125
Business entities	1,581	897	684

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Number of managers of the business entity and employees

	Manager of the business entity				Employees			
2016	Number of males	Number of females	Average age (Males)	Average age (Females)	Number of males	Number of females	Average age (Males)	Average age (Females)
number	225	55	45	43	3,405	1,106	43	42

Utilised agricultural land (included individual agricultural holdings and business entities)

2016	Arable land, gardens and kitchen gardens	Orchards	Vineyards	Meadows	Pastures	Nurseries	Olives
ha	248,269	18,899	20,612	25,561	7,068	309	20

Area of used arable land and gardens (included individual agricultural holdings and business entities)

2016	Cereals	Industrial crops	Fodder crops	Pulses	Vegetables	Potatoes	Flowers and ornamental plants	Seeds and seedlings	Fallow land
ha	161,370	23,284	32,948	2,522	15,274	3,582	62	57	7,640

Irrigated area

2016	Number of agricultural holdings that can irrigate	Number of holdings that used irrigation
ha	126,753	113,017

Production of cereals, industrial crops, vegetables, fruit and grapes

2018	tones
Wheat	241,106
Maize	187,676
Tobacco	25,547
Potato	180,424
Onion	59,030
Tomatoes	161,621
Pepper	182,872
Cherries	5,824
Sour cherries	10,538
Apricots	3,904
Apples	140,296
Pears	8,055
Plums	37,719
Peaches	13,128
Walnuts	4,826
Grape	294,497

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Area and production of crops

2018	Sown area, ha	Harvested area, ha	Total production in tones	Yield kg/ha
Wheat	73,072	70,987	241,106	3,396
Rye	3,838	3,836	9,379	2,445
Barley	44,772	42,331	130,028	3,072
Oats	3,600	3,591	7,338	2,043
Maize	36,417	36,340	187,676	5,164
Rice	3,222	3,222	19,732	6,124
Tobacco	16,582	16,582	25,547	1,541
Sunflower	2,386	2,346	3,379	1,440
Potatoes	12,406	12,403	180,424	14,547
Onion	3,635	3,627	59,030	16,275
Garlic	959	950	4,134	4,352
Beans- single maincrop	4,599	4,577	4,992	1,091
Peas-grain	1,053	1,045	2,067	1,978
Lentil	89	81	107	1,325
Cabbage	4,510	4,502	127,856	28,400
Tomatoes	5,570	5,569	161,621	29,021
Peppers	9,196	9,179	182,872	19,923
Cucumbers	1,036	1,034	54,314	52,528
Melons and watermelons	5,281	5,281	132,091	25,013
Clover	3,707	3,685	20,314	5,513
Alfalfa	19,738	19,698	115,975	5,888
Vetches hay	2,065	2,065	7,856	3,804
Fodder peas hay	1,647	1,428	4,976	3,484
Fodder maize	6,245	6,196	176,656	28,511
Fodder beet	376	376	3,481	9,257

Area and production of interfield crops

2018	Harvested area, ha	Total production in tones	Yield kg/ha
Beans-interfield	8,545	7,256	849
Potatoes-interfield	8,545	7,256	849
Cabbage-interfield	1,237	45,285	36,608

Area and production of meadows and pastures

2018	Harvested area, ha	Total production in tones	Yield kg/ha
Meadows	59,685	107,347	1,799
Pastures	744,667	512,336	688

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Number of fruit trees and production of fruit

2018	Total number of fruit trees	Number of fruit-bearing trees	Total production in tonnes	Yield kg/ha
Cherries	256,710	231,943	5,824	25
Sour cherries	1,206,349	1,017,412	10,538	10
Apricots	218,646	202,508	3,904	19
Quinces	67,252	63,868	1,573	25
Apples	4,875,902	4,724,399	140,296	30
Pears	493,346	453,775	8,055	18
Plums	1,732,823	1,670,820	37,719	23
Peaches	588,724	553,450	13,128	24
Walnuts	206,766	171,808	4,826	28
Almonds	43,227	39,394	574	15

Area and production of vineyards

	Harvested area	Total number of vines, 000	Number of bearing vines, 000	Total production in tons	Kg per hectare
2018	23,670	88,356	86,591	294,497	12,442

Organic farming

	2018		
ha	Total	In the conversion period	Fully converted (organic)
Cereal	1,078.6	503.9	574.7
Industrial crops	899.4	451.0	448.4
Fodder crops	1,134.1	409.7	724.4
Vegetables	219.7	75.1	144.6
Fruits	526.5	306.4	220.1
Vineyards	110.6	99.6	11.0

Livestock production

Number of agricultural holdings by size classes of livestock units

	2016							
LSU	More than 0 less than 1	More than 1 less than 3	More than 3 less than 5	More than 5 less than 10	More than 10 less than 20	More than 20 less than 30	More than 30 less than 50	>more than 50
Total	41,323	30,313	9,975	9,026	4,864	1,589	1,155	457
Individual agricultural holdings	41,322	30,309	9,974	9,022	4,845	1,562	1,136	400
Business entities	1	4	1	4	19	27	19	57

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Utilised agricultural area by size classes of livestock units

ha	2016							
	More than 0 less than 1	More than 1 less than 3	More than 3 less than 5	More than 5 less than 10	More than 10 less than 20	More than 20 less than 30	More than 30 less than 50	>more than 50
Total	45,883	43,784	23,642	27,460	20,448	9,291	11,389	15,727
Individual agricultural holdings	45,883	43,718	23,637	27,192	20,128	8,871	9,893	5,790
Business entities	-	66	5	268	320	420	1,497	9,937

Livestock units by size classes of utilised agricultural area

2016	LSU							
	Less than 0.5	More than 0.5 less than 1	More than 1 less than 3	More than 3 less than 5	More than 5 less than 8	More than 8 less than 10	More than 10	Less than 0.5
Total	63,158	40,474	115,539	53,612	40,419	14,628	53,532	63,158
Individual agricultural holdings	54,387	39,938	115,080	52,490	40,051	12,064	44,285	54,387
Business entities	8,771	536	459	1,122	368	2,564	9,247	8,771

The State statistical office offer various data. Here, in this report, the latest - 2018 data have been presented.

Total number of livestock, poultry and bee-hives

2018	Horses	Cattles	Pigs	Sheep	Goats	Poultry	Bee-hives
Number	10,041	256,181	195,538	726,990	117,447	1,828,287	81,197

Production of meat

2018	Beef	Pork	Mutton	Poultry
tonnes	4,381	12,929	3,446	1,499

Milk production

2018	Cow milk	Sheep milk
000 litres	404,230	36,559

Egg production

2018	Number of egg-laying hens	Average pieces per hen	Total egg production in '000 pieces
number	1,375,778	132	181,783

Production of wool

2018	Number of shorn sheep	Average wool per sheep, kg	Wool per sheep, kg
Number, kg	602,964	2	990,476

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Organic farming

2018			
Number	Total	In the conversion period	Fully converted (organic)
Cattle	6,390	2,864	3,526
Sheep	101,317	43,381	57,936
Goats	6,901	1,865	5,036
Pigs	0	0	0
Poultry	0	0	0
Rabbits	0	0	0
Beehives	8,138	2,257	5,881

Economic Accounts for Agriculture, at current prices, 2017, [69]

	In million denars at current price
Cereal	4,536
Industrial crops	4,753
Forage plants	5,758
Vegetables	26,191
Potatoes	2,359
Fruits	5,816
Wine	2,192
Crop output	51,605
Livestock	8,406
Livestock products	10,785
Livestock output	19,192
Agriculture good output	70,797
Agriculture services output	365
Agriculture output	71,162
Non -agriculture secondary activities	1,975
Output of the agricultural industry	73,137
Total intermediate consumption	34,522
Gross value added	38,615
Consumption of fixed capital	4,090
Net value added	34,525

Forestry

General overview of forestry development

	Employees in forestry	Realized investments, in 000denars	Export, in 000 denars
2018	2 162	-	66 644

Replenishment planting

2018	Replenishment planting
ha	125

Material used for afforestation and replenishment

	Seedings in ' 000 picies classic	Seedings in ' 000 picies paper pot	Seed, kg
2018	736	619	2 180

Value of services performed in forestry

2018	Total value of services	Arboriculture services	Services in forestry and felled timber, on contract basis	Non-forestry services
thousand denars	266 103	21 272	233 561	11 270

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Value of materials used for maintenance and repair

2018	Total spent	Small tools (hand-saws and similar)	Other forestry materials	Maintenance and repairs
thousand denars	85 661	16 317	43 154	26 190

Transportation, mechanisation and roads in state forests

	Trucks, number	Tractors, number	Chain saws, number	Other machines, number	Solid roads with and without substratum, km	Softroads, km
2018	60	49	133	53	1 443	7 763

Energy consumption in forestry

	LPG (liquefied petroleum gases), l	Motor spirit, l	Transport diesel, l	Heating and other gas oil, l	Lubricants, kg	Fuel wood, m3	Electricity, KWh
2018	23 626	243 578	677 718	1 000	19 869	2 020	932 611

Forest damages

	Forest fires (ha)	Damage by insects (m^3)	Natural disasters (m^3)	Illegal felling (m^3)
2018	1 525	690	-	3 450

Horizon 2020
European Union Funding
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BBI JU

Bio-based Industries
Consortium

CELEBio

D.2.2 Country report: Republic of Serbia

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Summary

The Republic of Serbia has 5.07 million hectares of agricultural land (71 % of which is intensively used (in the form of arable land, orchards and vineyards), while 29 % of agricultural land consists of natural grasslands (meadows and pastures), with 2.25 million hectares of forests, accounting for 29.1 % of the total area of the territory, with relatively small areas covering urban areas, but more than half of the population living in them. The population is slightly lower than the European average. GDP and purchasing power in the Republic of Serbia are well below the European average.

The Republic of Serbia is connected with European countries by road, rail, air and water traffic. Due to a number of geographical advantages and investments in traffic development, this connection will be even better in the future.

The contribution of agriculture to GDP (gross domestic product) in the structure of GSV (Gross Sales Value) of the economy of the Republic of Serbia is high. Agri-food products also play a significant role in the foreign trade of the Republic of Serbia, especially in exports. Traditionally, at the arable land in the Republic of Serbia production of cereals is dominant and the second largest crop group consists of oil crops. Corn and wheat dominate the cereal production followed by barley, triticale, oats and rye. The Republic of Serbia has favorable natural conditions for the development of animal husbandry, given that it has over 1.4 million hectares of high-quality permanent grasslands and significant unused cattle and sheep housing facilities. The total quantity of residues in the field is 8.5 million tonnes and the amount of residues that can be expected to be used in energy sector is 2.7 million tonnes. Since for most agricultural residues no commodity market has developed yet it is very difficult to provide figures on prices. These residues are very interesting for further utilization, as they can be used for different purposes – pellet production, direct combustion of straw bales, utilization for second generation biofuel production, gasification etc.

Serbia is considered a medium-forested country. The volume of wood mass in the forests of Serbia is about 363 million m^3, which is about 161 m^3/ha. In deciduous forests about 159 m^3/ha, while in coniferous forests the volume is about 189 m^3/ha. The annual volume growth is about 9 million m^3, which is about 4 m^3/ha. Sawmills are 3 % of the total number of wood processing companies. Particle board is the wood product with the highest demand in Serbia. This demand is generated by the market–driven growth in high–quality furniture production. The largest expansion of production capacities and new producers in the last five years was the production of wood pellets. Firewood production in Serbia is constantly increasing due to strong demand. Due to the lack of a reliable and comprehensive system for monitoring production in private forests, the largest quantities of firewood in this production segment are not statistically recorded.

Total amount of waste generated in 2018 reached about 11.6 million tonnes and municipal waste makes about 21 % of total quantity of waste and 60 % of the municipal waste represents a biodegradable fraction. Currently there are only 10 sanitary landfills complying with EC sanitary landfill standards and three regional sanitary landfills are under construction. Mixed municipal waste in Serbia is not treated and the untreated waste is disposed of in land-fills. A big part of generated municipal waste is disposed of in wild landfills, outside control of the public utility companies.

In Serbia, bio-based industries have not been significantly developed so far. Initiatives for the development of this industry are emerging, especially in the private sector.

The total planned production of primary energy from renewable energy sources in 2020 is 2 034 Mtoe. In the structure of the planned total domestic production of primary energy for 2020, renewable energy sources account for 20 % - the largest share is solid biomass 56 %, hydro potential 37 %, wind energy 5 %, while biogas, solar energy and geothermal energy account for 1 %.

In 2017, the development of the Research and Innovation Strategy for Smart Specialization (RIS3) began. The Science Fund of the Republic of Serbia is a public organization that supports scientific and research activities and the Innovation Fund has been a pioneering effort to increase the capacity of start-up s and resources available for their growth. The system of higher education in the Republic of Serbia includes 18 accredited universities with different programs related to R&D related to bio-based industry.

Serbia does not have a strategy that would encourage the development of the bio economy but there are other, sectoral strategies that to some extent cover individual sectors of the bio economy.

Serbia has continued its path toward EU membership: EU negotiation process officially started, ready for accession by 2025. Serbia has confirmed its top position holding 1st place as the top investment destination country in the world, measured by the estimated number of jobs relative to the size of the population.

Serbia has ideal natural conditions for agricultural production (one of the cleanest soils in Europe, diverse climate, a tradition of quality and healthy food production). As an important indicator of its efforts to produce quality food, Serbian law prohibits the production and import of any genetically modified foods and seeds (GMO).

Wood and furniture industry is one of the sub-sectors of the industry with the brightest future is the production of large furniture. This area offers comparative advantages such as: high-quality local raw materials, a low-priced labor force, low energy prices compared to other European countries, and a strategic geographic position that allows for fast shipment.

1 Introduction

1.1 Objectives and approach

The main objective of CELEBio is to contribute to the strengthening bioeconomy-related activities in Bulgaria, Czech Republic, Croatia, Serbia, Hungary, Slovak Republic, Slovenia and neighbouring countries. To this end, one of the key activities is to develop seven comprehensive reports for the target countries and the wider neighbouring region on the availability of sustainable biomass, logistics, costs and biomass business opportunities assessed through an analysis of the Strengths, Weaknesses Opportunities and Threats (SWOT).

This report aims to provide the necessary background information needed to evaluate the possibilities for setting up bio-based production chains in the Republic of Serbia.

The information structure and analysis presented in this report was developed by building on the method designed and applied by Van Dam et al. (2014) and was further refined through the execution of interviews with bio-based business developers and other experts. In these interviews further information was obtained on key factors that guide the choice of setting up bio-based activities in countries. Most of the experts stressed that all the identified factors are important and that a system approach is key in developing bio-based initiatives. If one link in the chain is missing, the bio-based initiative will not succeed. The identified factors are mapped in this report and will be the basis for performing a SWOT analysis for development of bio-based production chains.

In Annex 1 a further explanation is given of the approach used to set-up this country report.

1.2 Reading guide

This report is organised in 9 chapters. Chapter 1 gives an overview of the country's key characteristics. In the chapters 2, 3, and 4 the biomass production including its current uses and opportunities for what biomass can be additionally mobilised, is summarized for respectively the agricultural, forest, and waste sector. First the main traditional production and availability of biomass for food, feed, forest biomass and wood products are discussed and how this is handled in further processing industries and/or used for domestic markets and exports. Subsequently an overview is given of additional biomass potentials that are likely to be still unused or only partly used and that are a good basis for development of new bio-based activities. In Chapter 5 a description is given of the current bio-based industries and markets, advanced bio-based initiatives, and future biomass valorisation options. Chapter 6 describes the infrastructure, logistics, and energy sector. Chapter 7 focusses on the innovation potential, particularly in the context of bio-based research and development options. The research and educational infrastructure are discussed and the potential for developing bio-based start-ups and Public-Private-partnerships will be taken into a consideration. Chapter 8 gives an overview of the policy framework and describes extensively what regulations, legislation, taxes and tariffs exist of relevance for the development of bio-based production chains. Additionally, attention will be paid to situations where regulation and support measures are actually missing, and to which extend the rule of law situation influences the establishment of new bio-based activities. In Chapter 9 potential financing options related to the development of bio-based production chains are discussed.

1.3 Short characteristics of country

Republic of Serbia has a surface of 7.76 million ha. With 6.98 million inhabitants its corresponding population density is given in Table 1.3.1. The average income level is below the European mean value.

Table 1.3.1: Main population, land surface, GDP and trade characteristics of Serbia benchmarked against EU average [1, 2, 3, 4, 5]

Category	Republic of Serbia	Republic of Serbia (without Kosovo and Metohija)	EU	Unit
Population	/	6.98 [1]	512.4	million (2018)
Area (total)	8.85 [1]	7.76 [1]	447	million ha (2018)
% population in urban areas	/	60.84	44.9 %	% of total population (2018)
% territory predominantly rural	57.3 [3]	64.8 [3]	43.8 %	% of total territory (2018)
% territory predominantly urban		3.46 [4]	10.7 %	% of total territory (2018)
Agricultural Area		3.48 (2018)	173.3	million ha (2016)
Forest area		2.25	164.8	million ha (2016)
Population density		90.2	115	n°/km² (2018)
Agricultural Area per capita	0.56 (in relation to the total) 0.46 (in relation to arable)	0.50	0.34	ha/capita(2016)
Forest area per capita	0.25	0.32	0.32	ha/capita(2016)
GDP/capita	6 137	6 140	30 956	at current prices in 2018
	6 137	6 140	30 956	GDP at purchasing power in 2018
GVA by Agriculture, forestry and fishing	6.3 %		1.6 %	% of total GVA (2018)

GDP = Gross Domestic Product; PPS = Purchasing Power Standard; GVA = Gross Value Added; UAA = Utilised Agricultural Area
Source: Eurostat most recent statistical data sources (Accessed August/September 2019) (https://ec.europa.eu/eurostat/data/database) and statistical factsheets (https://ec.europa.eu/agriculture/statistics/factsheets_en)

The Republic of Serbia has 5.07 million hectares of agricultural land (about 55 % of the land calculated in relation to the total area (with KiM), 71 % of which is intensively used (in the form of arable land, orchards and vineyards), while 29 % of agricultural land consists of natural grasslands (meadows and pastures) [1, 3], with 2.25 million hectares of forests in the Republic of Serbia, accounting for 29.1 % of the total area of the territory, with relatively small areas covering urban areas, but more than half of the population living in them. The population is slightly lower than the European average. GDP and purchasing power in the Republic of Serbia are well below the European average.

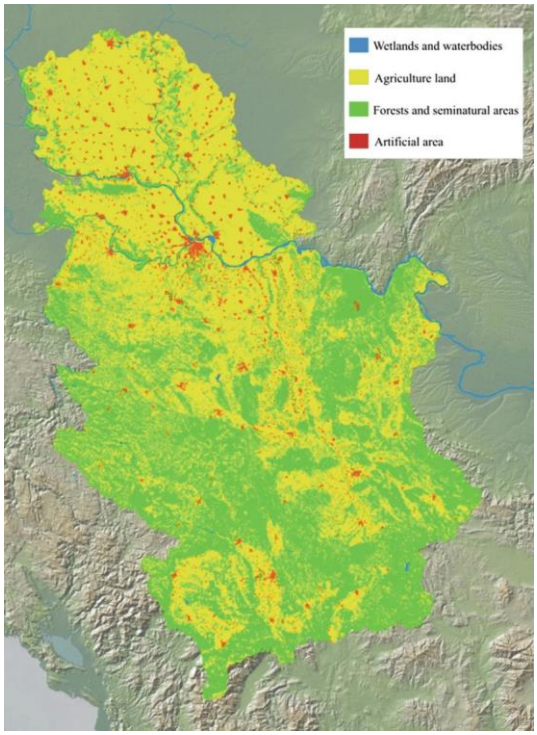

Figure 1.3.1: Main landcover distribution over Republic of Serbia.

Serbia borders with Hungary in the north, in the northeast with Romania, in the east with Bulgaria, in the south with Northern Macedonia, in the southwest with Albania and Montenegro and in the west with Bosnia and Herzegovina and Croatia (Figure 1.3.2).

Figure 1.3.2: Serbia and its bordering countries

The Republic of Serbia is connected with European countries by road, rail, air and water trafic (Figure 1.3.1). Due to a number of geographical advantages and investments in traffic development, this connection will be even better in the future. The main traffic hub is the city of Belgrade. Two pan-European traffic corridors also pass through the Republic of Serbia: the road-rail Corridor 10 (going from Austria to Greece), with its branches B (the Budapest-Belgrade branch) and C (the Niš-Sofia_Dimitrovgrad_Istanbul branch) and the river corridor 7 (the Danube Corridor connecting the Central Europe with the Black Sea) as presented on Figure 1.3.4.

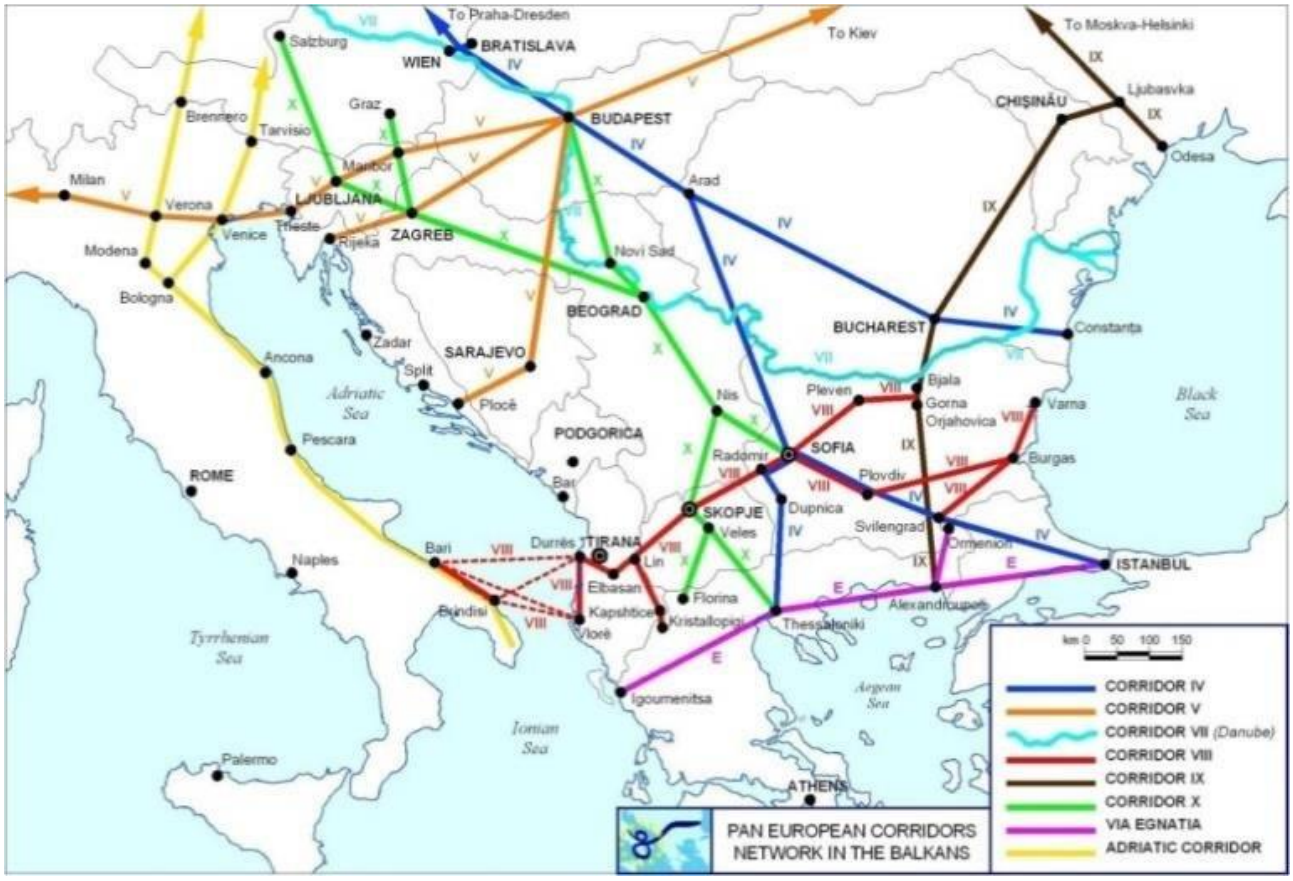

Figure 1.3.3 Position of Serbia in the Trans-European Transportation Network[1](https://www.researchgate.net/figure/Position-of-Sarajevo-at-the-Pan-European-corridor-network-in-the-Balkans-Corridor-V_fig1_336374842

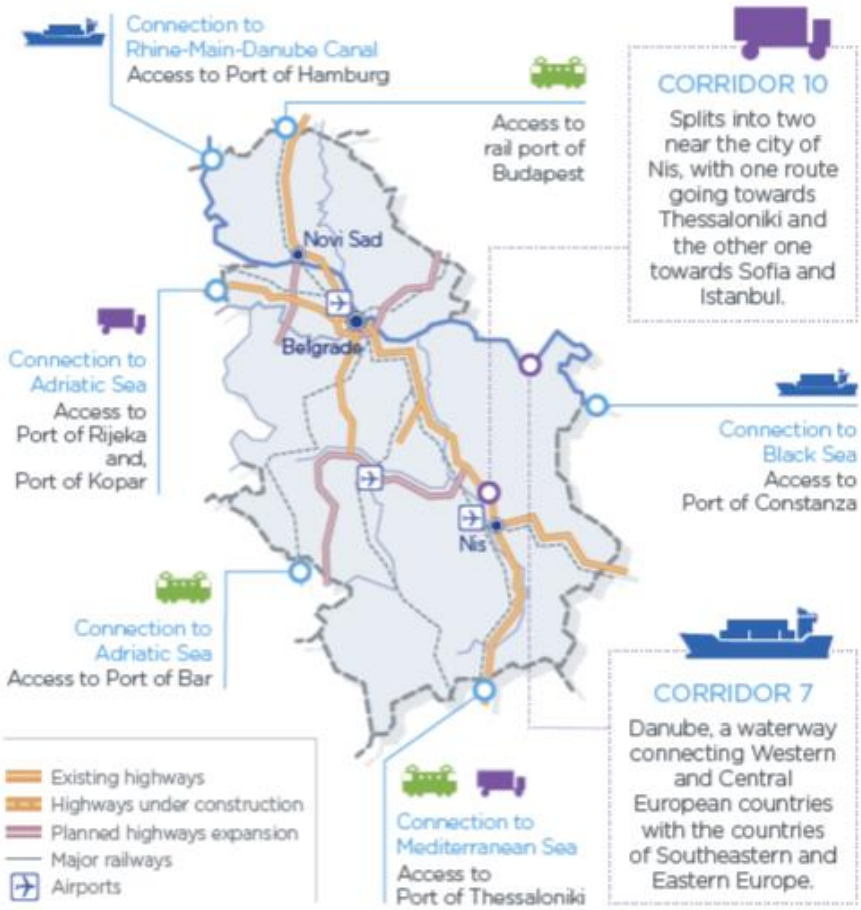

Figure 1.3.4 Transport connections of Serbia

2 Biomass supply: Agriculture

2.1 Introduction

In this chapter the agricultural biomass production and main uses is described. A distinction will be made between the main economic products produced and their main process chains and residual biomass potentials from primary production and available as by-products of food processing industries. In addition to presenting the main biomass production attention will also be paid to the importance and the structure of the agricultural sector and to the main environmental challenges associated with agriculture in Slovenia.

2.2 Characterisation of current agriculture sector

The contribution of agriculture to GDP (gross domestic product) in the structure of GSV (Gross Sales Value) of the economy of the Republic of Serbia is high, although it has declined since the beginning of this century: from 10.4 % in 2008 to 6.3 % in 2018 [3]. The high share of agriculture in the base macroeconomic aggregates of the Republic of Serbia relative to the EU countries can be attributed, on the one hand, to rich natural resources and favorable climatic conditions for agricultural production, and on the other, to a slower process of structural reformation of the rest of the economy and standstill in this process.

Although absolute employment in agriculture shows high rates of decline, the share of agriculture in total employment in the Republic of Serbia is still very high, among the highest in Europe, at over 20 %. This can be explained by the high share of employees in seasonal and occasional jobs in agriculture, who are very sensitive to fluctuations in the labor market during the crisis.

Agri-food products also play a significant role in the foreign trade of the Republic of Serbia, especially in exports. Their share in total exports has stabilized in recent years, at around 23 %. The share of agri-food products in total imports has been increasing, and has been at the level around 8 % in recent years.

Table 2.2.1: Key characteristics for the agricultural sector in 2018 [1]

Category	Republic of Serbia	EU average	Unit
Agriculture in % of total employment	5.2 [1]	3.9 %	% of total employment 2017
Agricultural area per capita	0.50	0.34	ha/capita
Cereal yield	4.6 [1]	5.2	t/ha
Irrigated utilised agricultural area	1.35	6%	% of UAA 2016
Average farm size	6.16 (2018)	16.6	ha UAA/holding (2016)
% of agr. holdings < 5 ha	71.7	62.6 %	%/total no. of holdings

HNV= High Nature Value

Figure 2.2.1: Distribution of total agricultural land in Serbia [ha] Source: S2BIOM (Dees et al., 2018)

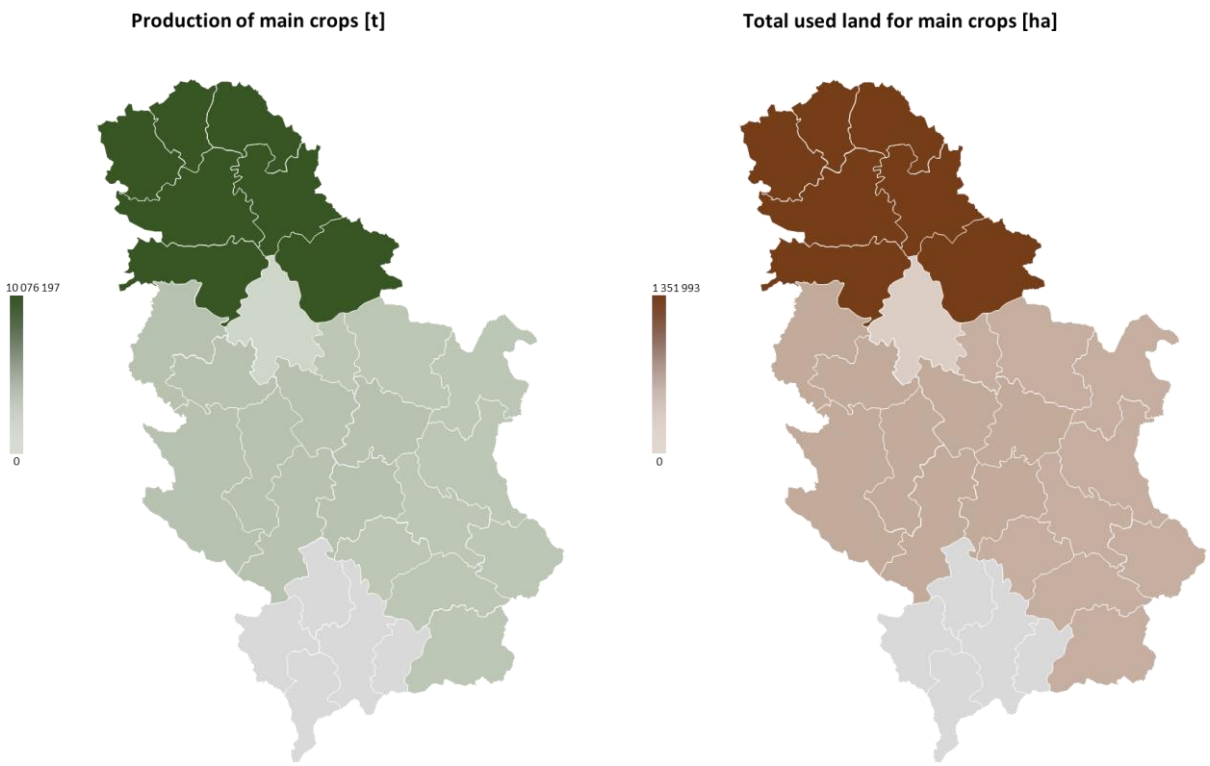

Figure 2.2.2: Production of main crops and total used land in Serbia Source: S2BIOM (Dees et al., 2018)

2.2.1 Crop production

Traditionally, at the arable land in the Republic of Serbia production of cereals is dominant and it covers 1 702 829 ha or 66.22 % of the total arable land [11]. The second largest crop group consists of oil crops (e.g. sunflower, oil seed rape, soy beans) with 493 570 ha or 19.19 % of the total arable land in Serbia.

The main agriculture products in the Republic of Serbia are cereals and oil crops. The cereal grains most frequently grown in Serbia are: corn, wheat, rye and barley. The structure of agricultural production in Serbia is such that cereal grain crops are the most important: by 63-70 % of arable land is sowed annually with a combination of these crops.

Corn and wheat dominate the cereal production followed by barley, triticale, oats and rye. A high share is produced in the north – in Vojvodina. Yields are modest with a high volatility. In Serbia, there are two groups of districts of the producers of wheat and corn:

- group of undeveloped districts (South-East Serbia) belonging to a high rank of the land capacities characteristics but achieving a low volume of wheat and corn production,
- group of relatively developed districts (Vojvodina) achieving a high level of production volume.

Maize is Serbia's single most important agricultural product, with a production of about 7 million tonnes in 2018, and a sown area of about 1 million hectares. The production of wheat is about 3 million tonnes, and the sown area is about 650 thousand hectares [1, 3]. The high share of cereals in the sowing structure, as well as the lower yields compared to the developed countries, reflect the extensive production on a large number of small farms, which do not sufficiently comply with the requirements of crop production, seed production and agrotechnics.

The production of other cereal grains in Serbia in 2018 year was:

- Barley – 439 137 t (102 125 ha)
- Oats – 81 525 t (27 175 ha)
- Rye – 12 783 t (4 408 ha).

Produced quantities of cereal grains in Serbia completely satisfy and exceed domestic food requirements. It is estimated that market surpluses of cereal grains are significant. Corn represents the agricultural crop that is most represented in domestic exports, especially due to the fact that the climatic conditions in the country are especially suitable for corn. During 2018, the export of corn in Serbia was 1 688 807 tonnes and the export of wheat was 1 107 383 tonnes [1].
The main oil crops in the Republic of Serbia are sunflower, rapeseed and soybean. The Republic of Serbia is one of the largest oil producers in Europe. The primate has sunflower, but the most significant growth is recorded in the production of soybeans and rapeseed.

In the Republic of Serbia, over 219 404 ha are sowed with sunflower, equalling about 6.30 % of arable land. The major part of this areal (94 %) is in Vojvodina. Sunflower crop is mainly grown on agricultural farms (74 %). In sunflower production, Serbia is on the tenth place in Europe, and per yield per hectare seventh in the world. The production in 2019 was about 729 079 tonnes, i.e. 3.3 t/ha, above the annual average, which is around 2 tonnes/ha. Of this amount of sunflower seeds, 283 000 tonnes up to 319 000 tonnes of oil could be produced depending of oil content in the seed, given that the annual demand of Serbia is about 80 000 t [85].

In Serbia, rapeseed production has been marginally grown, covering not more than 0.7 % of total arable land during previous decades. In 2007, the growth of rapeseed production was caused by opening a biodiesel plant in Šid (Victoria Oil). Total production of rapeseed in 2018 year was 135 422 tonnes on 44 898 ha [1, 11]. The yield of rapeseed improved significantly in recent years, thanks to new hybrids with yields of 5-7 tonnes/ha. The agro ecological conditions of some years can affect the yield, especially drought in the sowing period (which happened in 2011). The poor sowing practice, as well as the unreliability of yields and revenues, contributed to the fact that this culture in Serbia has not yet significantly increased.

The average area in Serbia sown for soybean production is 160 000-196 000 ha, with the tendency of constant growth [1]. Soybean cultivation is becoming more and more profitable, and in Serbia part of the sunflower cultivation is already substituted by soybean. The average yields range from about 2.5 to 3.5 tonnes/ha, which is higher than the world average. This soybean is mostly sown in Vojvodina.

Traditionally, the sugar industry is one of the key agro-industries in the Republic of Serbia. This position was acquired thanks to the quality of the soils and the favourable climatic conditions that are conducive to the sugar beet cultivation. The sugar beet foreign hybrids production prevails and they are used as the main raw material for sugar production in Serbia. Total production of the sugar beet is mainly dedicated for the needs of the domestic sugar industry. Also, the traditional commitment to sugar production as an important agricultural branch has contributed. The annual production of sugar beet is in the range from 2 200 000 to about 3 300 000 tonnes in the period from 2006 to 2016 and in 2018 year the total production was 2 325 303 tonnes. For production of sugar beet between 1 and 1.5 % of the total available land is used in Serbia. The cultivation of sugar beet is done mainly on arable land located on north part Serbia in region Vojvodina.

According to regular statistics, the area under the orchards is around 175 924 ha, while the vineyards are approximately 50 000 ha. Regarding the regions, most of the orchards are in the area of South and Eastern Serbia (30.51 %) and Šumadija (55.11 %), where the largest part of the area is under vineyards (53.32 % and 24.69 %, respectively) [3]. In the Republic of Serbia, fruit production accounts for 11 % of the value of agricultural production [3].

The largest orchard areas in Serbia are in western Serbia, Šumadija, the Danube region (Grocka and Smederevo) and parts of southern Serbia. The long tradition in the production of plums, apples and sour cherries is one of the reasons why these fruit species are most important for the fruit industry. Plum is the leading fruit species in Serbia, and it can even be said to be one of the symbols of Serbia. The total area under plums in 2018 was 72 224 ha, making it the first in Europe, and the total production was 430 199 tonnes [1, 6, 9]. Apples are grown on an area of 25 917 ha and production in 2018 amounted to 460 404 tonnes [1, 9]. Sour

cherry is planted in Serbia on 18 841 ha and Serbia is the fourth country in Europe regarding these areas, with total production in 2018 amounting to 128 023 tonnes [1, 6, 9].

According to the collected data from the 2012 Census, wine-growing in Serbia concerned a total area of 22 150 ha. It is assumed that today in the entire territory of the Republic of Serbia around 25 000 ha is cultivated with grapevines. Regarding to vineyard locations there are nine main wine regions in Serbia: Timok region, Nišava-South Morava region, West Morava region, Šumadija-Great Morava region, Pocerina region, Srem region, Banat region, Subotica-Horgoš region and Kosovo region [7, 8]. For period from 2006 to 2016 grape production range was from 122 489 t in 2014 up to 240 369 t in 2009, on almost the same production area. These yield fluctuations are probably caused by cultivation of domestic grape varieties which are not resistant on climate change.

In 2018, there were 20 333 ha under vineyards and grape production was 149 474 tonnes.

2.2.2 Livestock production

The Republic of Serbia has favorable natural conditions for the development of animal husbandry, given that it has over 1.4 million hectares of high-quality permanent grasslands and significant unused cattle and sheep housing facilities. In Serbia, 1.9 million LSUs were registered on 435 thousand agricultural holdings, which represents a decrease of 4.3 % in the number of LSUs and 11.1 % in the number of holdings compared to the results of the 2012 Census of Agriculture [1, 6, 10]. According to data from the annual livestock survey, the trend of LSU numbers has been declining in 2008–2018. and a linear estimate shows that it declines on average by about 24.4 thousand a year. If such dynamics continue, it is expected that around 1.7 million LSUs will be registered in the year of the next Census (2022) [10].

In the period 2003-2013 the number of livestock units per hectare of agricultural land was reduced from 0.34 to 0.27 [3]. The share of animal husbandry in the value structure of production is about 33 %, which is low considering the available land areas and their structure.

Cattle breeding is the most important branch of animal husbandry in the Republic of Serbia, primarily for small and medium-sized family farms. In the Republic of Serbia, 23 % of agricultural holdings (130 thousand) are engaged in cattle breeding, and the total number of cattle is 881.2 thousand in 2018. This represents a decrease of 26.6 % in the number of holdings and 3 % in the number of heads compared to 2012. According to data from the annual livestock survey, the number of cattle has been steadily declining between 2008 and 2018. A linear trend estimate shows that the average number of cattle is declining by about 13.5 thousand a year. There are two basic causes for this trend: decrease of interest of producers because of low prices of livestock and high prices of fodder and decrease of polulation in agriculture areas. If such dynamics continue, it is expected that about 827 thousand head of cattle will be registered in the year of the next Census of Agriculture (2022) [10]. About two thirds of the cattle head is in the Serbia - South region, while one third is in the Serbia - North region. The region with the highest number of heads is the Region of Šumadija and Western Serbia, with about 46 % of the total number of heads.

In the Republic of Serbia, 24.2 % of agricultural holdings (137.8 thousand) are involved in sheep farming, and the total number of sheep in 2018 was 1.8 million [1, 10]. This represents a decrease of 11.1 % in the number of holdings and an increase of 3.6 % in the number of heads compared to 2012. According to the annual livestock survey, the number of sheep has a growing trend from 2008 to 2018. A linear estimate shows that the number of heads is increasing by an average of about 24.3 thousand a year. There is a trend of people coming back to farming the sheep, as the interest for sheep export is increasing. If such dynamics continue, it is expected that about 1.82 million heads of sheep will be registered in the year of the next Census of Agriculture (2022). About three-quarters of the sheep heads are in the Serbia-South region, while one-third are in the Serbia-North region. The region with the highest number of heads is the Region of Šumadija and Western Serbia, with 60 % of the total number of heads. Compared to the census data, the Belgrade Region and the Vojvodina Region recorded a large increase in the number of sheep heads, 22.6 % and 19.8 % respectively, while in the Region of South and Eastern Serbia there was a decrease of 12 %. The dominant region of Šumadija and Western Serbia has growth similar to the overall result for the whole country - 3.1 %.

In the Republic of Serbia, 8 % of agricultural holdings (45.7 thousand) are involved in goat farming, and the total number of goats is 218.4 thousand [1, 10]. This represents a decrease of 27.3 % in the number of holdings and a decrease of 5.8 % in the number of heads compared to 2012. According to data from the annual livestock survey, the number of goats has a declining trend from 2008 to 2018. The linear estimation shows that the number of heads per year decreases by about 8.7 thousand a year. If such dynamics continue, it is expected that about 156 thousand of goat heads will be registered in the year of the next Census of Agriculture (2022). About 30 % of goat heads is in the Serbia-South region, while 30 % is in the Serbia-North region. The Region of Šumadija and Western Serbia and the Region of South and East Serbia have approximately the same number of goat heads, with 60 % of the total number of heads. Compared to the census data, the Region of Šumadija and Western Serbia recorded an increase of goat head of 8.2 %, while in all other regions there was a decrease [10].

In the Republic of Serbia, 56.6 % of agricultural holdings (319.5 thousand) are engaged in pig production, and the total number of pigs is 3.3 million [1, 10]. This represents a decrease of 10 % in the number of holdngs and 4.1 % in the number of pigs compared to 2012. According to data from the annual livestock survey, the number of pigs has been declining, and a linear estimate shows that it is on average declining by about 75 thousand a year. If such dynamics continue, around 2.6 million pigs are expected to be registered in the year of the next Census (2022). The number of pig heads is approximately the same in northern and southern Serbia. The region with the highest number of heads is the Region of Vojvodina, with about 44.9 % of the total number of heads. These ratios have not changed significantly since the results of the last Census of Agriculture.

In the Republic of Serbia, 59.7 % of agricultural holdings (340 thousand) are engaged in poultry farming and the total number of poultry is 23.2 million [1, 10]. This represents a decrease of 17.8 % in the number of farms and 13.2 % in the number of poultry compared to 2012. According to the annual livestock survey, poultry numbers have been steadily declining from 2009 to 2018. A linear trend estimate shows that poultry numbers are on average declining by about 626.5 thousand a year. If such dynamics continue, it is expected that in the year of the next Census of Agriculture (2022), about 12.8 million poultry heads will be registered. Poultry farming is most prevalent in the Vojvodina region and the Šumadija and Western Serbia regions, where 43.4 % and 40.7 % of the total number of poultry in the Republic of Serbia are grown. It is significantly represented in the Region of Southern and Eastern Serbia (12.6 %) and the Belgrade Region (3.3 %). In these regions, compared to the data from the Census of Agriculture, there was a large decrease in the number of poultry, 31.3 % and 37 %.

2.3 Biomass potentials from agricultural residues and unused lands

The basic production of cereal grains generates the same or higher quantity of plant residues. In some regions, secondary raw materials have taken up their functional position in the continuation of the production process, and somewhere they represent the ballast. Due to this reason, several attempts for estimation of residues from cereal grains production were made. Detailed analysis was made and presented in literature [85]. The total quantity of residues in the field is 8.5 million tonnes, with the participation of enterprises and cooperatives about 17 %, and the individual sector 83 %. The amount of residues that can be expected to be used in energy sector is 2.7 million tonnes, with the participation of enterprises and cooperatives from 33 % and the individual sector from 67 %. Additionally, the residue of the most important dominant cereal crops – wheat and corn are estimated for each region (25 of NUTS3). Due to the big differences in harvested area, total yield and yield per unit, the range of residue per unit is also wide (Table 2.3.1).

Table 2.3.1: Total yield of residues [85]

Type of residue	Residue per unit (kg/ha)	
	Range	Average value
Wheat	2 544 - 4 847	3 546
Corn stalks	5 033 - 38 483	17 616

These residues are very interesting for further utilization, as they can be used for different purposes – pellet production, direct combustion of straw bale, utilization for second generation biofuel production, gasification etc.
Distribution of agricultural residues through the regions in Republic of Serbia is presented on Figure 2.3.1.

Agricultural residues

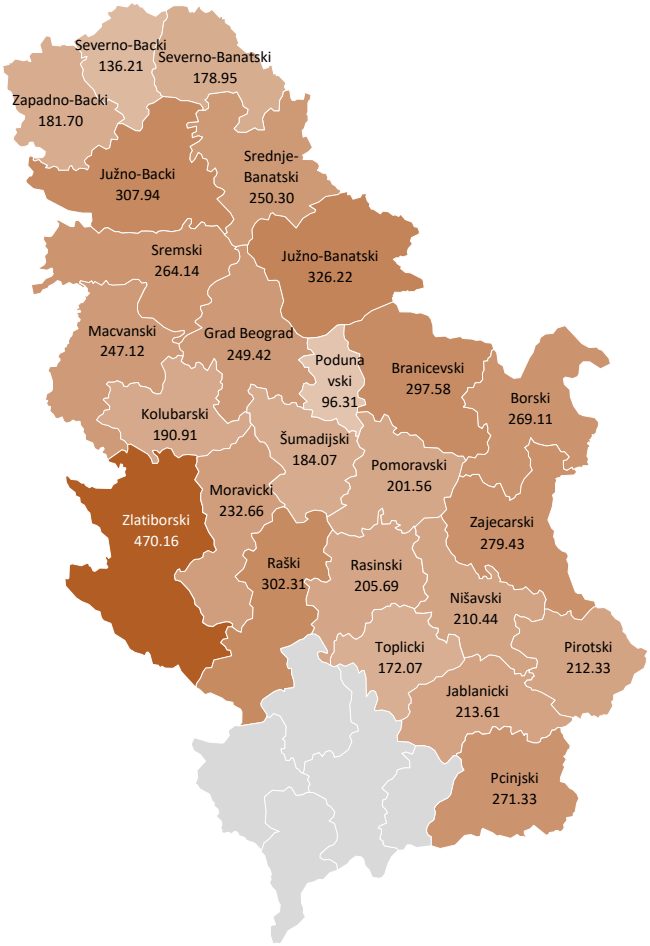

Figure 2.3.1: Agricultural residues in Serbia [kt dry mass] Source: S2BIOM (Dees et al., 2018)

Residues from the vegetable oil extraction sector, like sunflower husk or residues from oil extraction process (oil waste), are mainly used within facilities for production energy for own use. One of the companies in this sector, Victoria Logistic uses obtained residues for production of biomass pellets. The whole capacity of produced pellets is utilized in the company for the energy production and doesn't come to the market. Victoria Logistic is also engaged in the purchase of biomass – soybean, wheat and barley straw and cornstalks. The transformation of production residues into bio-energy not only ensures the energy independence of most of the Victoria Group factories, but also the reduction of harmful emissions. The company owns significant storage capacities – silos with a capacity of 200 000 tonnes, while an additional 650 000 tonnes of various types of goods are stored in external storage facilities. The total volume of transport facilitated by Victoria Logistic exceeds 2 million tonnes per year.

According to the investigation related to biomass potential in Serbia, the pruning of vine yields is from 4 up to 8 t/ha of vineyard. This data is important because of the significant area that covered with vineyards - about 22 000 ha in Serbia. On the basis of these data the total biomass residues from grape growing could be estimated at about 170 000 t, with average heating value of 12 MJ/kg the energy potential of biomass residues from grape is about 50 000 toe. The energy potential of vine pruning residues alone is about 55 000 toe.

In the Republic of Serbia, the available land is 5 178 692 ha, with the structure as follows [11]:

- Used agricultural land – 3 475 894 ha
- Unused agricultural land – 289 953 ha
- Forest land - 972 283 ha
- Other - 440 562 ha.

The regional structure of available land by categories of use in Serbia indicates dominance used agricultural land (67.12%) and a significant share of forest land (18.77%), while the share of unused agricultural land (5.60%) and other land (8.50%) [11]. The structure of used agricultural land is shown in Figure 2.3.2.

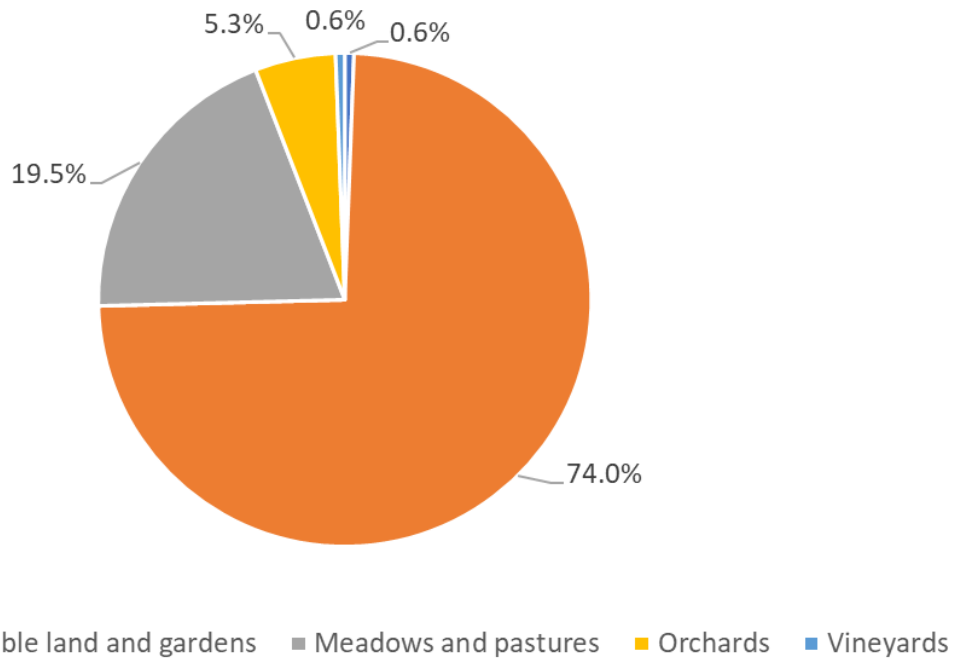

Figure 2.3.2: Agricultural residues in Serbia [kt dry mass]

Almost half (48.93 %) of the total agricultural land is arable agricultural land from the fifth to the eighth cadastral class and uncultivable agricultural land from the first to the eighth cadastral class. Namely, out of about 5.07 milion hectares of total agricultural land, 2.5 milion hectares are arable agricultural land from the fifth to the eighth cadastral class and uncultivable agricultural land (from the first to the eighth cadastral class). An analysis of the possibility of growing fast - growing plantations in the Republic of Serbia was performed, which included arable and non - arable agricultural land and land on which mineral resources were exploited [11]. Analysis of data on agricultural land for growing fast-growing energy crops was performed for cadastral classes (5 - 8) for arable agricultural land and cadastral classes (1 - 8) for uncultivated agricultural land).

Of the total agricultural land 2.5 milion hectares are arable agricultural land from the fifth to the eighth cadastral class and uncultivable agricultural land (from the first to the eighth cadastral class) which is considered for growing fast-growing energy crops [14]. Of this area, two thirds are agricultural land, and one third is uncultivated agricultural land (pastures, reeds and wetlands). A detailed soil structure that can be used to grow fast-growing plantations is shown in Figure 2.3.3.

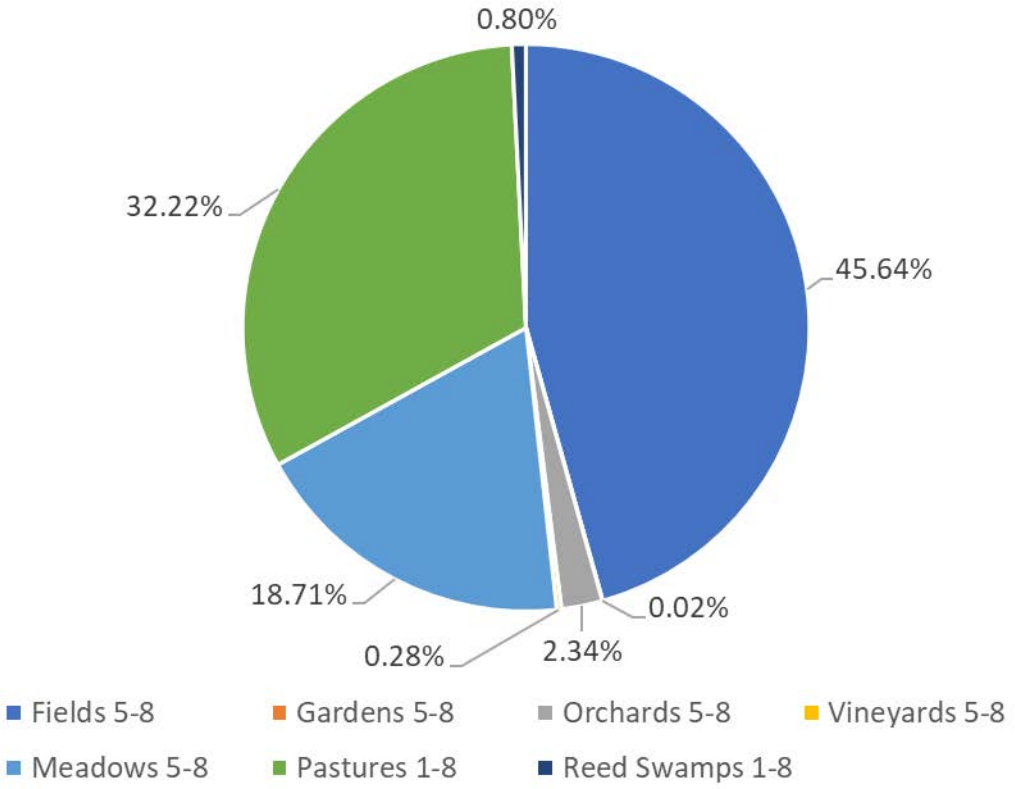

Figure 2.3.3: Soil structure suitable for growing fast-growing energy crops

Unused, abandoned and degraded lands in Serbia

On the territory of the Republic of Serbia, there is a total of 178 765 hectares of land that is under exploitation with mining activities, i.e. 2.31 % of the territory of Serbia [14]. Most of the exploitation fields are mineral raw materials, gas on an area of 29 629 hectares of land, followed by coal on an area of 27 914 hectares of land and magnesite on an area of 23.301 hectares of land. By analyzing the position of these areas, it can be seen that the largest area of land is located in the area where the Kolubara coal mine is located.

About 10 % of the total arable land is not used in Serbia. That is 424 000 ha of unused agricultural land, of which about 7 % is arable land. The most abandoned agricultural land is in the Pčinja and Pirot districts, and individually these are the local governments of Surdulica and Bosilegrad, which have more than 50 % of the land that is not used. Experts point out that there are two main reasons for this phenomenon - demographic and economic, resepectively:

- aging of the rural population;
- poor infrastructure;
- economic unprofitability;
- broken repro-chains (supply channels of repro materials).

Areas of unused lands in Serbia are presented on Figure 2.3.4.

Unused lands

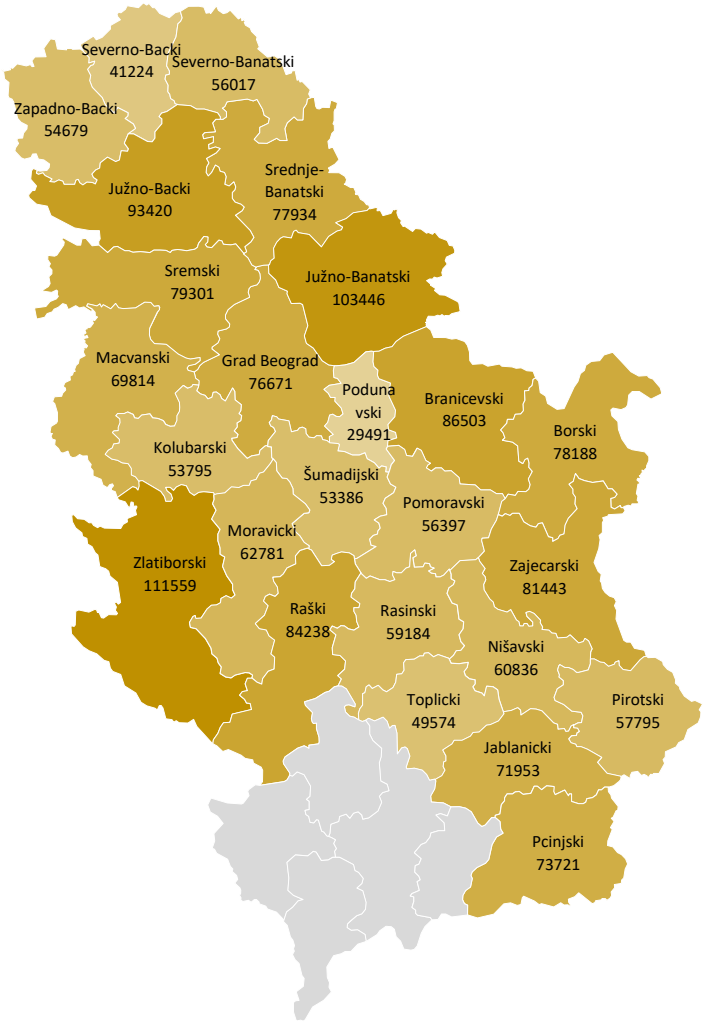

Figure 2.3.4: Total area of lands not used for agriculture production in Serbia [ha] Source: S2BIOM (Dees et al., 2018)

Most of the land that is not used is privately owned, but there is land in both state and cooperative ownership. The private owners of these areas are elderly households; the average age of the rural population is 59 years. It is economically unprofitable to use that land for the time being, because it is mostly fragmented plots, and the infrastructure is insufficient or not built at all.

The Minister in the Government of Serbia in charge of regional development and coordination of the work of public companies, Milan Krkobabić, said that at the beginning of 2020, a public call for non-refundable transfer of land to farmers younger than 40 will be announced. He said that there are more than 200 000 hectares of unused state land in Serbia. "The idea of the SANU Village Committee is to give up to 50 hectares to farmers under the age of 40 who want to engage in agriculture, according to strictly established rules of use," Krkobabić told Happy Television. He added that in two years, "trust in the association has been restored and 466 new cooperatives have been established."

2.4 Secondary agricultural residues from processing industries

Serbia has 465 registered mills, 5 755 registered processors and 3 starch factories. Cereals (mainly corn and wheat) cover 17.3 % of all Serbian agricultural exports. More than 80 % of these products are exported to the EU. Serbia applies ad valorem duties of 30 % on imports of cereals for third countries except for rice (3 %). For the EU a preferential regime with no import duties for an unlimited quantity, with the exception of some products, is in place. Preferential access is given also to CEFTA, the Russian Federation, Belarus and Kazakhstan.

The annual use of wheat for food use in Serbia is 1.2 million tonnes. About 860 000 tonnes of flour is produced which is used for the production of bread and pastry, direct consumption of population, pasta, confectionery and export. Therefore, analyzes show that Serbia needs an annual amount of 377 000 tonnes of flour and 51 000 tonnes of baked goods. For pasta, 42 000 tonnes of flour is consumed, while 54 000 tonnes of flour annually is required for the work of the confectionery industry. In 2016, the export of about 200 000 tonnes of flour was reached. So, Serbia needs about 780 000 tonnes of flour annually for normal functioning. Therefore, there is room in the balance of flour to increase its exports.

The company Delta Agrar Ltd. has been present in the agribusiness community since 1993. Its diversified operations are divided in four main organizational segments: primary production, cooperation and repurchase, agro-trade and distribution, and food processing. Production takes place in five agricultural estates, comprising 15 000 hectares. Crop production includes cultivation of all major field crops: wheat, corn, soybean, sunflower, rapeseed and sugar beet.

With a tradition dating back to 1918, Danubius Factory from Novi Sad is engaged in the production of milling products and pasta, as well as in storage, drying and transport of grain, all in compliance with strict national and international standards on food safety. Since 2006, Danubius has been operating within Delta Agrar.

Quantities of secondary residues from industy utilizing agriculutral products in Serbia are presented on Figure 2.4.1.

Secondary residues of industry utilising agricultural products

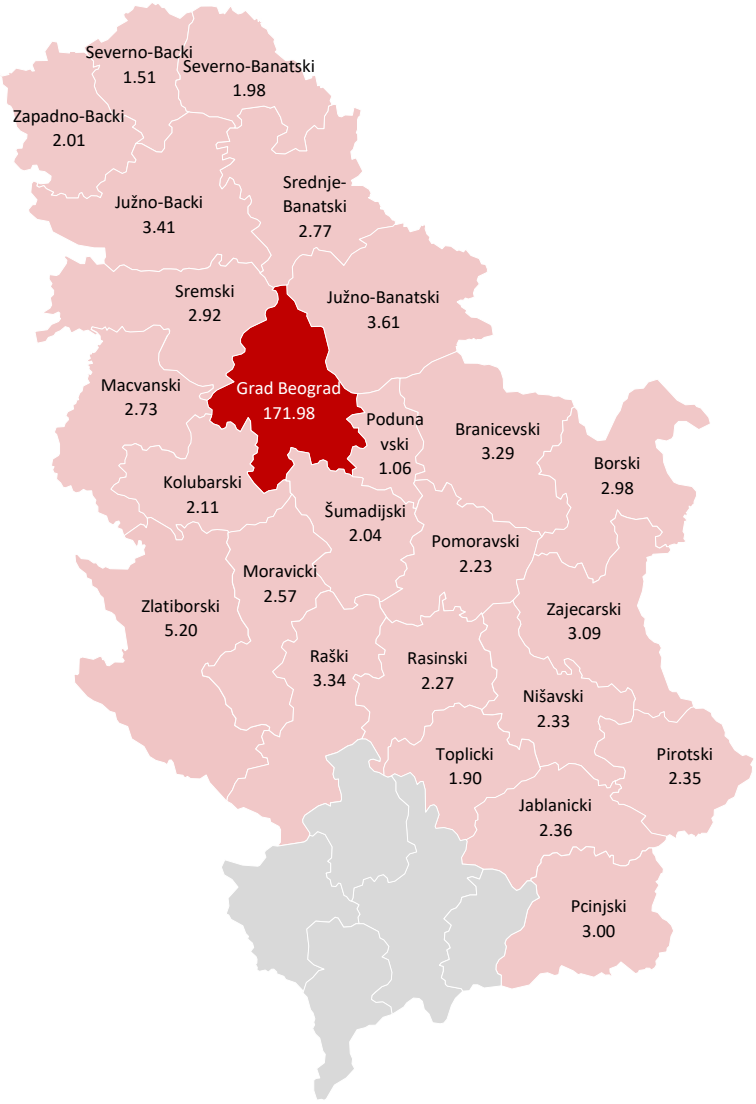

Figure 2.4.1: Secondary residues from industy utilizing agriculutral products in Serbia [kt of dry mass] Source: S2BIOM (Dees et al., 2018)

With a tradition dating back to 1918, Danubius Factory from Novi Sad is engaged in the production of milling products and pasta, as well as in storage, drying and transport of grain, all in compliance with strict national and international standards on food safety. Since 2006, Danubius has been operating within Delta Agrar.
A computer guided mill was installed in Danubius in April 2009, with the daily output of 300 tonnes of wheat processed into various kinds of flours for all purposes. Prior to leaving the mill, all finished products go through the machines that completely eliminate possible presence of larvae and insects. Danubius has the largest silo in Serbia, with a capacity of 65 000 tonnes.

Žitopromet-Ruma was founded in 1950 with headquarters in Ruma. The main activities of the company have always been based on the storage and processing of cereals. The total reconstruction of the mill with new milling technology was done at the beginning of 2014. According to the technological scheme, the capacity of the mill was raised to about 200 tonnes/24 hours. A new technology has been introduced for the transport of flour which is pneumatic, and all the control process and managing of production is largely automatic. In addition to wheat flour in basic types and packages, five types of pasta in three basic categories (short, long

and dipped pasta) are produced, so the assortment of final products is increased in comparison with the previous years.

In addition to trading activities as basic activities, three companies are engaged in cereal processing as well: Granexport, Žitobačka and Maxiprotein. Granexport, based in Pančevo, in addition to the organization of agricultural production and a significant share in the trade activities of the division, as well as the fact that due to its geo-strategic position (the Danube bank, industrial railroad track) represents the main point of the logistics chain with the possibility of loading goods directly to the vessels; with a silo of 50 000 t and a mill (capacity: 140 t per day) - also performs final finishing of corn grain. Products intended for the consumer market and industrial consumers are: corn flour, corn semolina and polenta in packages customized to the requirements of the customer. Žito-Bačka, with headquarters in Kula, in addition to the organization of agricultural production and trade in cereals - also performs processing of wheat grain, producing more types of flour in packages tailored to the requirements of the end customer (bulk packages, large packages of 25 and 50 kg, small packages intended for sale through a retail chain of distribution).

Žito Bačka's mill was founded in 1916. After a thorough reconstruction in 1975, it began to work as one of the largest and most modern facilities of that time. After privatization in 2004 the company expanded its core business and ensured its leading position in Serbia and the region.

The daily flour production is 220 tonnes. It also has a storage capacity for 3 000 t of bulk flour. The mill was reconstructed in 2013, which increased the product range. The high-tech laboratory performs daily analyzes and takes care of the quality of the flour.

With storage capacities of 155 000 tonnes, Žito-Bačka is one of the largest warehouses in Serbia. Silos in Kula have a capacity of 50 000 tonnes, of the stated capacity 30 000 tonnes used for the storage of all agrarian crops, including cereals and oilseeds, while 20 000 tonnes are used exclusively for the storage of wheat.
It should be emphasized that the storage and service capacities of Žito-Bačka doo Kula are now tripled compared to the previous period, since storage is carried out within the Silos in Kula with a capacity of 50 000 tonnes, Silos PJ in Bačka Topola with a capacity of 65 000 tonnes and Silos PJ in Belgrade capacity 40 000 tonnes.

Mirotin Group is a group of companies engaged in the production and marketing of agricultural products, as well as raw materials for primary production and food industry. The company was founded in 1992. The operations of Mirotin Group, are largely focused on the foreign markets. Over 70 % of the company's foreign trade operations stems from the export of products, primarily to the markets of the former Yugoslavian republics (Slovenia, Croatia, Macedonia, Bosnia and Herzegovina, Kosovo, Montenegro), as well as to the markets of the EU Member States: Italy, Germany and others. The main companies within Mirotin Group are Sava Kovačević AD and Mirotin Tisa.

The main products of company Sava Kovačević AD are following: agriculture and vegetables (wheat, barley, corn, sunflower, soybeen, sugarbeet), seed production (processing of wheat seeds, corn processing).
Also, within the company, Mirotin Tisa corn mill from Savino Selo operates. The processing capacity of the mill is 240 tonnes of corn grain for 24 hours. In the production program of the mill the following products are: corn edible flour, enriched animal feed corn flour, beer pie (beer semolina), corn semolina for human consumption, corn semolina for pharmaceutical use.

The basic production of cereal grains generates the same or higher quantity of plant residues. In some regions, secondary raw materials have taken up their functional position in the continuation of the production process, and somewhere they represent the ballast.

These residues are very interesting for further utilization, as they can be used for different purposes – pellet production, direct combustion of straw bale, utilization for next generation biofuel production, gasification etc. Residues from agro-food procesing industry in Serbia are presented on Figure 2.4.2.

Agro-food processing industries

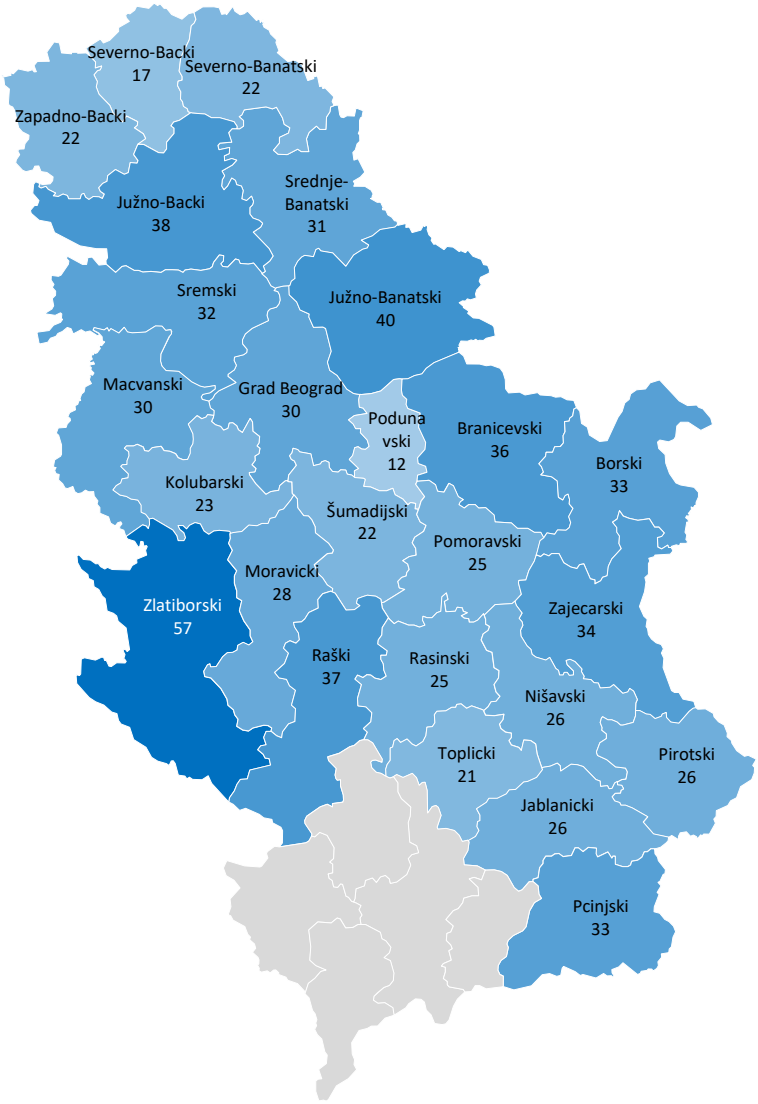

Figure 2.4.2: Residues from agro-food procesing industry in Serbia [kt of dry mass] Source: S2BIOM (Dees et al., 2018)

As one of the largest oil producers the Republic of Serbia is also the country with the largest processing capacities in the CEFTA area (CEFTA - Central European Free Trade Agreement, As of 1 July 2013, the parties of the CEFTA agreement are: Albania, Bosnia and Herzegovina, Macedonia, Moldova, Montenegro, Serbia and Kosovo (as UNMIK)). The Serbia's vegetable oil extraction industry has a capacity for the annual processing of 885 600 tonnes of sunflower seeds, 482 000 tonnes of soybeans and 247 000 tonnes of rapeseed. However, in the Republic of Serbia the average processing level of sunflower processing in the past ten years was only 40 % of the available capacities, and of soybean at 70 %.

In this sector, the most important engagement is of company "Victoria Group", which has contributed much to better sowing practice. By engaging agricultural engineers, a number of agricultural producers have been educated, which is one of the most important requirements for accepting this culture. Four years ago, it was sewed up to 20 kg of seeds per hectare, and today 2.6 kg/ha, the soil preparation was improved, seed protection from insects, and last year 99 % of surfaces did not need to be treated with pesticides. By applying

scientific achievements, new hybrid varieties have increased yields, so the pods do not open under the influence of rain and wind. Fruit harvesting machinery has also been improved.

The company Dijamant AD is the largest producer of edible oils in Serbia. With a strong distribution network of distribution centres in Belgrade, Niš, Čačak, Vrbas and Zrenjanin the company covers the entire Serbian market as leading manufacturer of margarine, vegetable fat, and mayonnaise and delicatessen products based on mayonnaise. In addition, Dijamant produces also ingredients for other food industry, especially for confectionery and bakery.

The company is also an important factor in the agricultural sector, particularly in the production of oilseeds, which includes the development of partnership relations with agricultural producers, as well as the development of logistics coverage for the purpose of purchase and a modern, safe storage of the oil crops. In cooperation with more than 400 suppliers Dijamant, for decades back, is actively involved in the organization of production of sunflower and soy in our country. Dijamant is today one of the largest single purchasers of oil plants in Serbia, with an average of purchased 250 thousand tonnes of raw materials annually.

Vital is one of the largest and oldest factories of oil and vegetable fats in the Balkans. After privatization, in October 2005, Vital became part of Invej Corporation and continues its role as an undoubtedly important actor. With the advancement of technology, the application of new ways of doing business and the development of a wide range of products intended for the most demanding consumer tastes, Vital has managed to meet the expectations of not only domestic but also foreign. Changing the way of life, new research in the field of human health and its direct connection with nutrition, are the basic guidelines that lead the development team of Vitala when creating new products.

The primary activity of the company Victoria Oil is the production of raw and refined vegetable oils, biodiesel and protein meal. Today the factory processes almost 220 000 tonnes of sunflower and over 85 000 tonnes of soybean annually, and the processing technology allows complete flexibility of the oil crop refining production process. Victoria Oil also has a cutting-edge plant for bottling and packaging edible oil with a capacity of 14 000 litres per hour.

This company's recognisable consumer brand is Iskon, which is an edible sunflower oil of the highest quality, with more than 70 million bottles produced per year. Exceptional results have not only been achieved in the local market, in which Iskon has a share of 30 %, but also through exports to Austria, Slovakia, Italy, Holland, Slovenia, Hungary, Greece, Croatia, Bosnia and Herzegovina, Montenegro, Macedonia and Albania.

Processing capacity:

- 1 200 tonnes sunflower a day
- 800 tonnes soybean a day
- 800 tonnes rapeseed a day

Production capacity of the flexible refinery plant is 300 tonnes refined oil a day.

Capacity of the filling station – edible oil bottling plant is 14 000 bottles an hour

Warehousing capacities:

- Universal silo with three kilns for storage up to 40 000 tonnes sunflower seeds or 60 000 tonnes soybean or 80 000 tonnes wheat grain
- Universal storage for all types of seeds and meal with a capacity 50 000 tonnes
- Protein meal storage with a capacity of 1 000 tonnes
- 20 000 m^3 storage for sunflower husks

The major activity of the factory Sunce Sombor includes processing of all sorts of oleaceous plants, crude edible oil production, production of packaging for own purposes, industrial herbs drying for own purposes etc. Every year, the production program is expanding, capacities are enlarging and production technology is improving.

Oil factory "Banat" AD is company for the production of vegetable oils and fats, press cake and meal. In the factory are processed sunflower seed (including high olenic type seeds), soybean, rapeseed, and pumpkin seed. The product range includes sunflower edible oil known under the brand The Cvet Banata, and assortment of cold freshly squeezed oil. The Banat AD products are oils from seeds of soybean, rapeseed and sunflower seeds high olenic Olivko type, and meal with various percentages of protein.

Residues from the vegetable oil extraction sector, like sunflower husk or residues from oil extraction process (oil waste), are mainly used within facilities for production energy for own use. As mentioned before, Victoria Logistic uses obtained residues for production of biomass pellets. The whole capacity of produced pellets is utilized in the company for the energy production and doesn't come to the market.

Victoria Logistic is also engaged in the purchase of biomass – soybean, wheat and barley straw and cornstalks. The transformation of production residues into bio-energy not only ensures the energy independence of most of the Victoria Group factories, but also the reduction of harmful emissions. The company owns significant storage capacities – silos with a capacity of 200 000 tonnes, while an additional 650 000 tonnes of various types of goods are stored in external storage facilities. The total volume of transport facilitated by Victoria Logistic exceeds 2 million tonnes per year.

There are 15 sugar factories in Serbia (in Pećinci, Vrbas, Kovačica, Bač, Crvenka, Žabalj, Senta, Sremska Mitrovica, Kovin, Zrenjanin and Nova Crnja, Šabac, Beograd, Ćuprija and Požarevac). According to the data of the Serbian Business Registers Agency, 8 of the above-mentioned factories are undergoing bankruptcy.

Approximately 180 000 to 200 000 t are exported. The export of sugar to the EU is managed by export licences. Preferential access to the EU amounts to 181 000 t/year duty free. Serbia stated that it applies ad valorem (20 %) and specific import duties for raw sugar (EUR 0.14/kg) and white sugar (EUR 0.15/kg). The specific import duties are reduced for imports from the EU, EFTA, Turkey, Belarus and Kazakhstan. Trade with CEFTA countries and the Russian Federation is completely liberalised.

The structure of companies in the sugar industry is dominated by medium and large companies representing more than 10 % of the total number of companies within the entire agro-industry branch. The equipment in the sugar industry is such that in larger plants the equipment is better. In 2016 the processing capacities of factories that were in operation, was used at 60 % capacity. The trend in the last ten years is that sugar production in Serbia is increasing. The factories are owned by two companies - "Helenik Sugar"and "Sunoko". The fact that two sugar producers operate in this market certainly opens the issue of monopoly, both at the market of raw materials, and selling final product, especially related to the high consumer prices.

Production center Pećinci is one of the state-of-the-art sugar plants in the region. During the sugar beet processing campaign, this factory has the highest processing capacity. The plant processes 8 000 tonnes of sugar beet daily and produces 1 150 tonnes of sugar. The annual capacity of sugar beet processing reaches 800 000 tonnes, which is one fifth of the annual sugar beet crop in Serbia.

Production Center Bačka was founded in 1913 and it is oldest sugar plant in Serbia. The daily capacity of sugar beet processing is around 6 000 tonnes, which gives around 900 tonnes of sugar daily. The annual capacity of processing is around 600 000 tonnes of processed sugar beet. Planned maximum annual capacities:

- 80 000 tonnes of sugar
- 22 000 tonnes of molasses
- 23 000 tonnes of dry pulp pellets.

Production Center Kovačica was founded in 1976. After the privatisation of the factory in 2002, the daily sugar beet processing capacity jumped from the former 4 000 tonnes to the current 7 000 tonnes. The annual capacity of sugar beet processing is 700 000 tonnes, whereas the daily production of sugar is 1 000 tonnes.

The Sugar Factory "Crvenka" was founded in 1912. Its optimum slicing capacity is 6 500 tonnes of sugar beet per day and 1 000 tonnes of sugar per day, as well as 350 tonnes of dried briquetted sugar beet pulp and 250 tonnes of molasses. Today, the factory is in the process of ownership transformation in order to form a stock company again. The development of the Sugar Factory, above all, implied the expansion of its capacity.

The Sugar Factory "Šajkaška" was founded in 1976 and it started operation in 1979. In the period from 1979 to 2006, the factory had 28 sugar beet campaigns and processed in total 7 015 000 tonnes of sugar beet. Capacities: 5 500 tonnes of sugar beet/day.

In the past few years, the expansion of high-quality wine varieties has started to intensify. The changes in the structure of the assortment were influenced by the adoption in 2005 of the Law on Planting Material, as a result of which the introduction and registration of new varieties and clones was made easier. In addition, subsidies from the Serbian Ministry of Agriculture for raising new vineyard plantations and other positive measures

stimulated production. The development of small private wineries and tendency of their founders to produce quality wines also had an impact on positive changes in the grapevine assortment.

Fruit and vegetable processing industry

Nectar - for two decades of doing business it has grown from a small entrepreneur venture to a leader company that has spread beyond the borders of Serbia. More than 1000 people are employed in the company. It is the only company in the region that has complete manufacturing circle: from cooperation with farmers and buying fruit, to production and final outcome – finished goods like juices, nectars, alcoholic beverages, jams. 10 000 small farms provide the best fruit for the production of final products..

Fruvita is located in the most famous fruit growing area in Serbia. The river Danube and the hills of fertile land are the reason why the fruit-growing tradition of the Smederevo-Grocka region has been around for centuries, and the quality of the fruit is widely known. Peach and apple are the most famous fruit crops, and besides them, the area is also known for the production of plums, cherries, apricots and pears. Fruvita was founded in 2003, and today it has two modern production plants, both located in the most famous fruit growing area in the country and surrounded by endless orchards. Thanks to its unique location, Fruvita always processes fresh fruit and transforms it into juices of the highest quality. In the village of Kolari, there is a state-of-the-art line for the production of Rossi & Catelli fruit purees and a unique line for squeezing fresh fruit from Flottweg. In the village of Lunjevac there is a plant for the production of finished products with the most modern KHS aseptic line for filling juices of the highest quality in PET packaging, Combibloc line for filling fruit juices in cardboard packaging and SBC line for carbonated drinks.

ITN Group was established as a family business in 1992. Formed with a vision of modernization and increase of efficiency in agriculture and food industry - ITN Group today is considered a regional leader in: Distribution of specialized machinery for agricultural producers - ITN AgroTech. Engineering, procurement, production and installation of complete equipment for the food and beverage industry - ITN FoodTech. Processing, packaging and distribution of frozen fruits - ITN Eko Povlen. ITN Eko Povlen Processing, is a regional market leader by applying the knowledge and experience of the entire ITN Group company. Taking advantage of new technologies and mastering various agribusiness spheres - in a short time, ITN Group has created a company that exports 10,000 tons of frozen fruit per year. Shock-IQF freezing technology at -40 ° C completely retains the taste and quality of the fruit without further chemical treatment. The richness of flavors, textures and vitamins is completely preserved, making this method of processing fruits the most favored and most lucrative on the market. Complete quality control - Highest standards from production to product itself. ITN Eko Povlen fosters cooperation with its agricultural producers through expert support and clearly defined rules. The highest standards of hygiene, quality, type and quantity of treatment products are respected. This approach creates premium quality fruits.

„Swisslion "company was founded in 1997, and now it represents one of the leading multinational companies in Balkan region, containing manufacturing business units in Serbia, Macedonia, Bosnia and Herzegovina, trading branches in Montenegro, Bulgaria, Romania, Slovenia and Switzerland and with over 7000 employees. Portfolio of the Swisslion Takovo business system contains production of confectionary products, baby food, alcohol and non-alcoholic drinks, soups, pastas, ice-creams and processed meat products.

The company GMP Jarmenovci is located on the slopes of the mountain Rudnik, known for the best orchards in Serbia. The company deals with the purchase and processing of the highest quality fruits and vegetables, by modern technologies. All products are produced on 100 % natural basis, without preservatives, artificial colors and additives. The company GMP Jarmenovci factory in Jarmenovci successfully operates on the domestic and foreign markets. Product quality is confirmed by exports to many countries around the world such as Germany, Austria, Switzerland, the Netherlands, the United States and countries in the region.

Sirogojno Co. is a family owned company, founded in 1991. in the village of Sirogojno, in the Mount Zlatibor region of Western Serbia. Over last two decades the company has been nurturing the cooperation with the population of Zlatibor region and it has been putting continuous effort into improvements of working and living conditions within the region. Sirogojno Co. is one of the largest exporters of frozen and dried fruit from Serbia (raspberry, strawberry, blackberry, wild blueberry, black and red currant, plum, sour cherry). As part of our ongoing commitment to continuous improvement, Sirogojno Co. has recently expanded its product offer by

introducing frozen vegetables (peper, swiss chard, green&yellow beans, sweet corn, carrot, broccoli and spinach).

The development of the "Bakina Tajna" brand began in 2003. In the spirit of the traditional cuisine of our grandmothers, "Bakina Tajna" products are prepared in a home-made, natural way, trying to preserve the best from the fruits of nature. Fruits and vegetables are picked by hand, and the secret of preparation is in simmering, that is, slow cooking at low temperatures, which preserves the nutritional properties of the fruit. Only natural ingredients are used, without the addition of preservatives, artificial colors and flavors, and the result is delicious, tasty and healthy products of "Bakina Tajna" that have won consumers in over 20 countries. During more than a decade of work within the brand "Bakina Tajna", a wide range of top products has been developed, which are divided into several categories: "Ajvari", Homemade jams and sweets.

"Voćar-Palanka" from Smederevska Palanka, a fruit and vegetable processing factory, dates back to 1959. The main activity of the factory was the processing of cherries into pasteurized cherries. For the past ten years, the program has been constantly supplemented with new products. "Voćar-Palanka" currently has 70 employees. The annual production capacity is 4 000 tons. The factory has a line for hot processing of fruits and vegetables, it covers an area of three hectares.

Cold processing - there are no precise data on the number of cold storages in the Republic of Serbia. According to the data of the Ministry of Agriculture, Forestry and Food of 2011, there were 363 cold storages in the Republic of Serbia for freezing and storage of fruits, vegetables and mushrooms, whose total capacity is about 550 000 tonnes. Capacity utilization is about 75% [3].

Warm processing - In the Republic of Serbia, 85 enterprises are engaged in the warm processing and drying of fruits and vegetables, as well as the production of juices, whose total installed capacity is about 565 000 tonnes. Capacity utilization is about 50 %. A significant part of processing capacities relates to the production of fruit and vegetable juices. The capacity of fruit juice production annually is around 240 million liters, which places the Republic of Serbia in the serious producers in the region.

In Serbia, with production of wines placed on the market, according to the number of producers enrolled in the Wine Register (January 1, 2015), 235 producers are dealing who are exclusively market oriented [85]. Participation of Serbia in the total world production of wine increased from 0.46 % to 0.80 % from 2006 to 2013. Serbia achieved the largest share in 2010 (0.90 %). In the reporting period, Serbia has recorded a growth of wine production at an average annual rate of 8.63 %.

According to the data from the Wine Register (January 1, 2014), the number of large winery in Serbia with more than 250 employees is small, i.e. only two wineries, and in a group of wineries with 50 to 250 employees there is only one winery, although measured by their share in the total volume of produced wine they have a large share in production. In Serbia there are 23 medium wineries, with 10 to 49 employees. Small wineries, with less than 10 employees, make up for the largest group of wine producers in Serbia (191).
There are three types of wineries in Serbia:

- Industrial/corporate producers (Vršac vineyards with about 1 700 hectares of plantation, Navip from Belgrade and Rubin from Krusevac have about 700-800 hectares of vineyards) - operate on a large scale with large vineyards, processing facilities, and storage rooms - these are the privatized former state enterprises, which were focused on quantity and price only. Quality was low. Most of these processors are still struggling with this inheritance, suffering from bureaucratic management, operational inefficiencies, and quality issues. Modern technologies and marketing strategies are largely absent. These wineries also produce about 8 million liters per year of cognac distillate,
- Medium-sized wineries that produce wines in the high-end and premium segments - all of them are family managed, but with some hired employees. There is some heterogeneity in this group. Their intentions are to grow to around 500 000 liters per year and then stay at this level, which they consider as the limit of a winery managed as a family business. Rather than increase scale, they would focus on increasing quality. This group probably has the potential to grow from the current 3 million liters to about 5 million liters over the next five years. Although they currently only represent less than 10 percent of the market in volume terms, they represent an estimated 20 percent of the market in value terms.

- Third are small wineries, each producing a volume of 10 000 to 80 000 liter per year. Their combined output is estimated at around 1 million liters annually. These wineries are 100 percent family run (no hired employees), quality focused, and just getting into commercial production and sales. A significant part of their production is of a slightly lower quality wine sold in bulk from the winery to customers in the region.

The very beginning of production at Carnex in 1958 also marked the expansion into foreign markets, primarily the English. From cured meat products, boiled sausages, smoked products, sterilized canned dishes, pasteurized meat in pieces to carefully prepared products intended for lovers of chicken products.

Matijevic company was founded in 1994. Today the company employs 1 670, of whom more than 1 000 are employed in 130 retail outlets all over Serbia, from Niš to Subotica. Matijević Meat Industry currently produces 180 tonnes of finished goods and all types of fresh meat daily, of which 90 % is sold in its modern retail outlets, 5 % is sold wholesale to other customers and 5 % is exported to Bosnia and Herzegovina and Montenegro. The production lines have all been built in the last couple of years and occupy an area of 35 000 m^2. Especially worth noting are: the modern slaughter line, with capacity for: 300 pigs/hr, 30 cattle/hr, 4 500 chickens/hr, cutting line matching the capacity of the slaughter line, machine processing with filling line for finished products, capacity 120 tonnes/day, non-perishable foods line, capacity 300 tonnes/month and deep-freeze chambers, capacity up to 3000 tonnes.

As a leading company in our region in the field of dry meat production, Zlatiborac relies on a long tradition of the Stojanović family and the unique natural conditions of village Mačkat, situated on the Zlatibor Mountain. Since its establishment in 1992, Zlatiborac stands on solid foundations – high-quality products that are made at the crossroad of tradition, nature and innovation. Today, yhe manufacturing facilities are spread over 40 000 square meters, on the same place where the first family-owned drying chamber is standing, for more than 130 years. The factory in Mačkat and four regional business centers in Serbia employ more than 850 people, while the products are available in thousands of retail stores across Serbia.

2.5 Cost of main biomass source

Since for most agricultural residues no commodity market has developed yet it is very difficult to provide figures on prices. Instead cost estimates can be presented building on the S2BIOM methodology and assessment. The cost refers to *Roadside cost* and these cover all biomass production collection and pre-treatment cost up to the road where the biomass is located. The roadside cost is only a fraction of the total 'at-gate-cost.' The road side costs are presented in Table 2.5.1 below; for further details on the cost calculation in S2BIOM see Annex 2.

Table 2.5.1: Road side cost levels (€/ton d.m.) for agricultural biomass sources based on S2BIOM cost calculations

Road side cost for agricultural biomass	**Average (€** ton dm) (2020 cost level)
Maize stover	10.02
Cereal straw	16.25
Sunflower straw	12.35
Oil seed rape straw	13.14
Residues from vineyards	133.15
Residues from fruit tree plantations (apples, pears and soft fruit)	133.15
SRC unused lands	23.77
Dedicated crops on unused lands	23.77

2.6 Summary and conclusions in relation to SWOT elements

Strengths	Weaknesses
• *Resources* Wealth of land resources, favorable ratio of available land per capita and employed in agriculture; The richness of biodiversity; Good quality and structure of agricultural land; Favorable climatic conditions for agricultural production; Sufficient quantities of quality animal feed (bulky and concentrated); Low labor cost; • *Food production* Existence of a domestic variety of cereals, industrial plants and certain types of vegetables; Recovery of some branches of animal husbandry; The growing organic production sector; Availability of foreign markets and export growth potential; • *Production chain* Significant capacity for accommodation and storage facilities; Large processing capacity; Significantly improved technology in some subsectors (mill industry, oil factories, facilities for processing milk, meat, freezing and processing of fruits, grapes and vegetables); Availability of raw materials from domestic production; The privatization process is largely complete; Existence of horizontal structures of association (Cooperative union, various associations, chambers, etc.); • *Technological development and the environment* A large number of scientific and educational institutions that can be involved in the system of knowledge creation and transfer; Interest in adopting new technologies (large farms); Relatively low environmental pollution from agriculture in most of the country; The richness of biodiversity and the existence of genetic resources; Large biomass production, the possibility of producing energy crops on unused lands (low ILUC) and utilisation of renewable energy sources; • *Rural development* Preservation of traditional knowledge and technologies; Solid state of infrastructure in some rural areas;	• *Resources* Lack of agricultural infrastructure (field roads, irrigation, drainage, windbreaks); Land degradation, disorder of watercourses and canals; Small size of farms and small parcels; Small percentage of irrigated areas; Plant depreciation; Insufficiently improved breeds structure of livestock; Small number of livestock; Unsatisfactory condition of equipment and machinery; Unfavorable age and educational structure of the agricultural workforce; Unresolved social status of agricultural employees; Poor rainfall schedule throughout the year; • *Food production* Low level of technology and agrotechnics; Low quality inputs (planting material, fertilizers, etc.); Small production of fruits and vegetables in a protected area; Insufficient application of modern knowledge and technologies; Insufficiently innovated range of processed products; Unsuitable and underdeveloped insurance system; • *Production chain* Outdated technology for drying and storage of cereals, packaging and refrigerating facilities for vegetables; Low utilization of processing capacities; Low level of hortisontal and vertical organization; Low level of professionalization and lack of enterprising management staff; Low impact and bargaining power of producer associations; • *Technological development and the environment* Poor quality of research equipment and technical conditions; Lack of development institutions and demonstration facilities; Organized knowledge transfer reaches a relatively small number of users; Degradation of habitat and biodiversity, especially in areas with limited economic conditions in agriculture; Inadequate waste management system; Inadequate water management system; • *Rural development* Adverse demographic trends; Inactive labor market; Adverse social structure; Unused farm income diversification opportunities; Low infrastructure; unclear land rights on unused lands

Opportunities	Threats
• *Resources* Improvement of the management system of agricultural land and other natural resources; Possibility of increase of areas under organic production; Possibility of growth of livestock numbers and revitalization of cattle and livestock production; Investors' interest in raising new plantations with intensive production technology; Involvement of larger areas in the support system; • *Food production* Growing investor interest in investing in the sector and related activities; Possibility of growth of integral and organic production; Possibility of growth of production of products with geographical origin, medicinal, aromatic and spicy herbs; Export growth potential; Alignment of domestic legislation with EU standards and regulations (Acquis communitaire); Introduction of quality system / scheme; • *Production chain* Existence and use of native assortment and breeds; Opportunities for investing in distribution systems; High export potential based on foreign trade agreements; • *Technological development and the environment* Existence of capacity for creation and transfer of knowledge; Existence of unused opportunities for private-public partnerships in creation and transfer of knowledge and technologies; The growing need for different types of consulting services; Possibility for production of bioenergy crops; Better utilization of thermal waters in greenhouse production; Better use of wind and sun energy; • *Rural development* Possibility to create new products and services; Possibilities for private-public partnerships; Possibilities of intensifying regional cross-border cooperation; Utilisation of the pre-accession period to increase competitiveness, application of standards with the use of EU funds (IPARD);.	• *Resources* Incomplete restitution process; Inadequate response to the effects of climate change - lack of systemic solutions; Inefficiency of land, forest and water potential management systems; Lack of financial capital and difficult investment opportunities in the improvement of equipment, facilities and machinery; Neglect of areas with aggravated working conditions in agriculture by agricultural policy; • *Food production* Lack of financial capital; Insufficiently recognized interest of manufacturers and processors in business cooperation; Increasing competition from countries with highly subsidized production; Lack of adequate response to climate change; Political and economic instability in the country, region and globally; Further decline of standard of life and purchasing power in the country, region and globaly; Unpreparedness of the agro-industrial sector to trade liberalization processes; • *Production chain* Insufficient recognition/"branding" of the products, insufficiently innovated range; The presence of the gray economy and monopoly on the side of processing and trade; Lack of specific banking products and bundles; • *Technological development and the environment* High costs of creating and transferring knowledge; Lack of coordination of activities of line ministries; Insufficient innovative potential of scientific and research staff. Disinterest, non-motivation of producers to accept new knowledge and technologies; Insufficient and poorly diversified offer of educational modules, practical trainings; Absence of systemic response to climate change; • *Rural development* Insufficient recognition of rural specificities in local and national policies (there is no understanding at the high level of decision makers about the the rural specifities of various regions of Serbia); Low investor interest; Insufficient visibility of the specificities of small holdings in national policies, including agricultural policy; Standstill in EU integration process.

3 Biomass supply: Forestry

3.1 Introduction

Serbia is considered a medium-forested country. Total area of forests in Serbia is 2 237 511 ha, and the percentage of forest cover is 26.7 %, which is somewhat lower than the average percentage of forest cover in Europe [1, 12, 13]. The area of state-owned forests managed by the State Enterprises amounts to 963 458 ha, which is 43 % of the area of forests and other wooded land in Serbia [1, 12,13]. The remaining forest area is managed by private owners, other social enterprises and National Parks.

In Table 3.1.1. the main characteristics of Serbian forests are presented.

Table 3.1.1: Serbian forests in numbers, 2018[17]

Forrest area	2 237 511 ha (2 252 400 ha in 2007)
Forestation	26.7 %
Growing stock	362 487 417*m^3 or 161 m^3/ha
Annual increment	9 079 773* m^3
Possible cut	3 268 857 m^3
Coniferous trees	422 397 m^3
Deciduous trees	2 845 460 m^3
Length of forest roads	24 931 km
Length of forest borders	-

*data for 2007

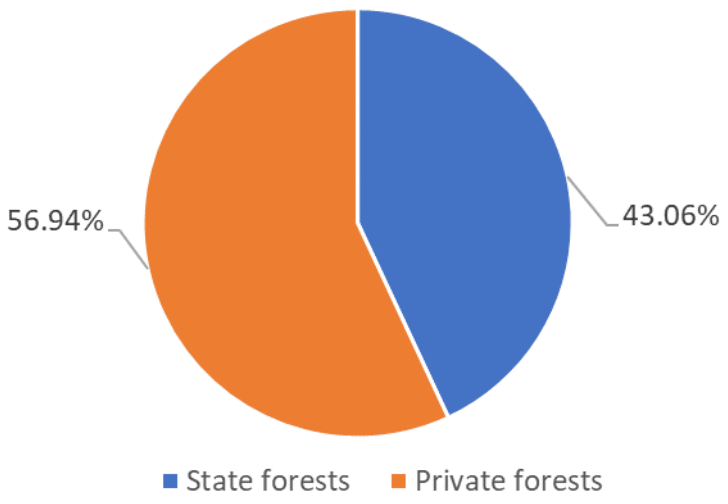

Figure 3.1.1: Ownership in Serbian forests

3.2 Primary biomass resources from forestry

The volume of wood mass in the forests of Serbia is about 363 million m^3, which is about 161 m^3/ha [16]. In deciduous forests about 159 m^3/ha, while in coniferous forests the volume is about 189 m^3/ha. The annual volume growth is about 9 million m^3, which is about 4 m^3/ha. In deciduous forests about 3.7 m^3/ha, while in coniferous forests the volume growth is about 7.5 m^3/ha. Depending on the productivity of the species, the age structure and the mixture of species, as well as the ownership structure, the annual growth is very different.

The most important indicator of forestry as an economic sector, but at the same time an indicator of anthropogenic pressure, is deforestation. During 2013, about 2 700 000 m^3 of wood was felled in the forests of

Serbia [16], and in 2018 it amounted to 3 221 000 m^3 [1]. Compared to 2008 and 2009, felling is increasing by about 100 000 m^3 per year. Analysis of the trend of deforestation in the last 30 years shows that deforestation in the last ten years, according to the Republic Bureau of Statistics, ranges from 2 500 000 to 2 800 000 m^3, which is less than in the seventies and eighties of the last century. Unofficial expert estimates are slightly higher than official data and range in average around 3 000 000 m^3 per year [16]. The presented trend is caused by lack of the land reforestation after forest cutting.

It is very important to emphasize that the extent of felling is about one third of the annual volume growth of the wood volume of forests.

The ratio of annual volume growth (about 9 million m^3) and annual felling (2 600 000 m^3) is less than 3:1. This ratio of growth and felling can be considered satisfactory, both from the aspect of wood volume that remains for the future, and from the aspect of the quality of forest ecosystems.

Average forest density in Serbia is 939 trees per ha: it is 596 trees·ha^{-1} in natural high forests, 1 090 trees·ha^{-1} in coppice forests, and 896 trees·ha^{-1} in artificially established stands [17]. Average forest volume is 161 $m^3 \cdot ha^{-1}$, 254 $m^3 \cdot ha^{-1}$ in high forests, 124 $m^3 \cdot ha^{-1}$ in coppice forests, and 136 $m^3 \cdot ha^{-1}$ in artificially established stands (plantations). Average volume in the inventory area in 1979 was 115 $m^3 \cdot ha^{-1}$.
Primary and secondary biomass potential from forests in Serbia in 2020 based on data obtained during the S2Biom project is presented on Figures 3.2.1. and 3.2.2.
The assessment of the roundwood and primary residue potentials in S2BIOM was made by using the EFISCEN model and using national forestry inventory data as an input. The secondary forestry residues from saw mills and wood processing industries build on the potentials assessed in EUWood and S2BIOM in combination with some updated data from national sources.

Primary biomass potential from forests in Serbia in 2020 is presented on Figure 3.2.1.

Production from forests + Primary residues from forests

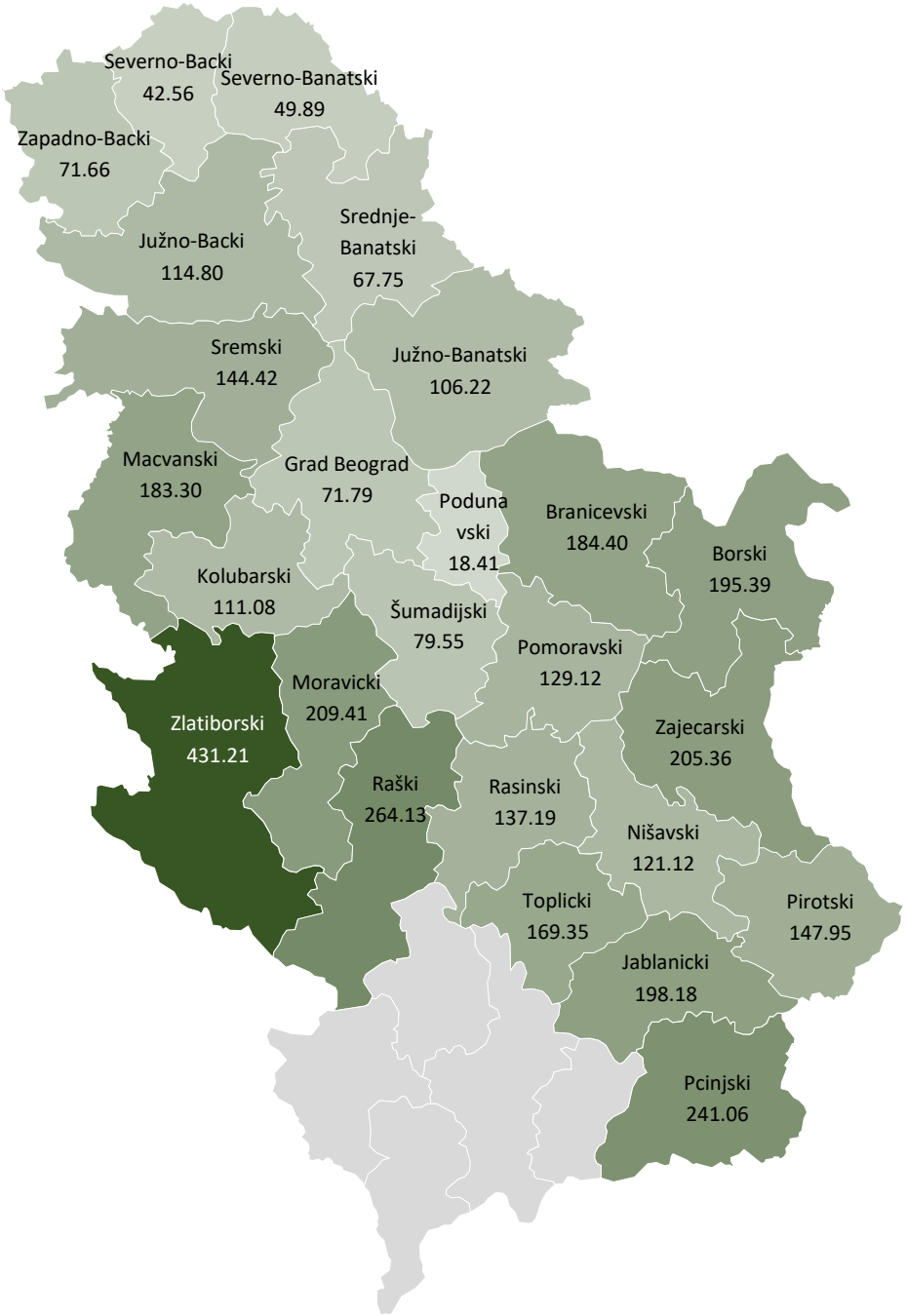

Figure 3.2.1: Primary biomass potential from forests in Serbia in 2020 [kt of dry mass] Source: S2BIOM (Dees et al., 2018)

Secondary residues from wood industries

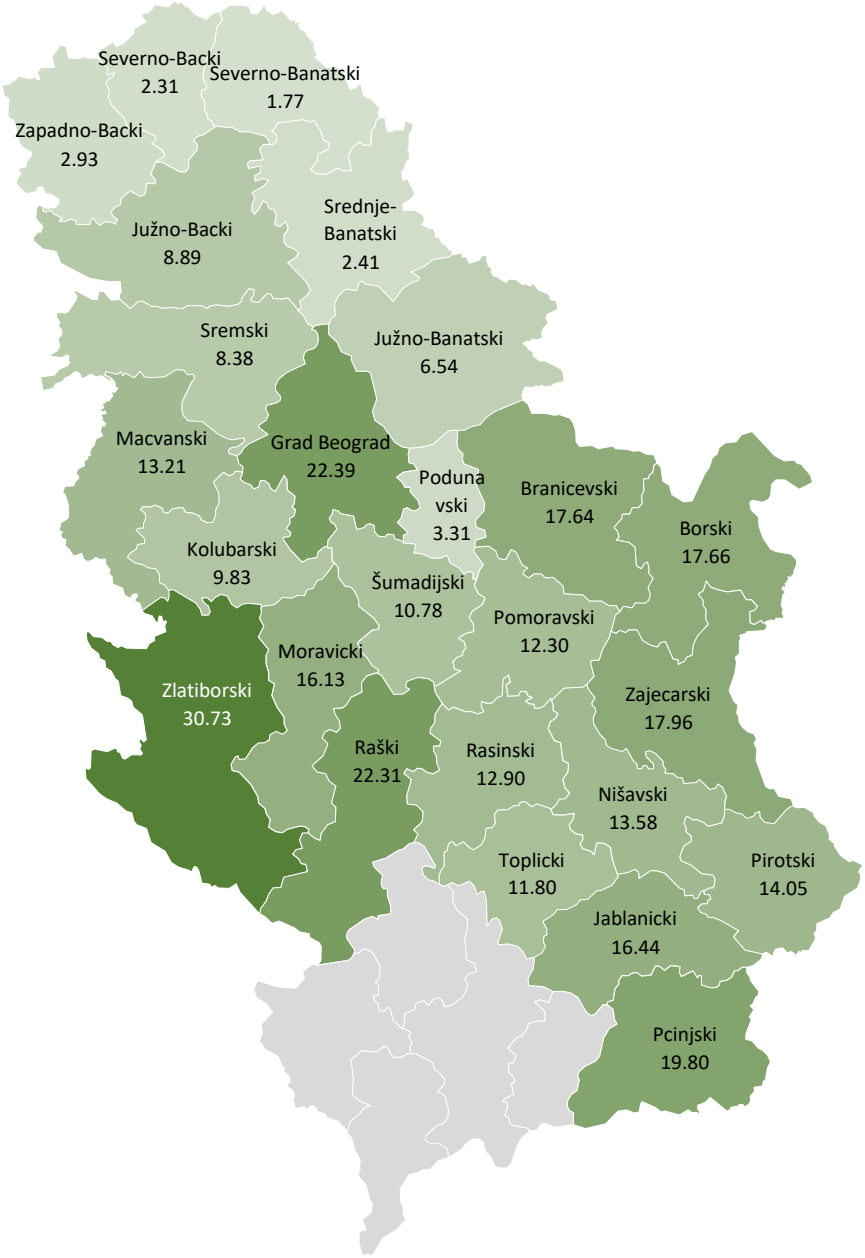

Figure 3.2.2: Secondary biomass potential from forests in Serbia in 2020 [kt of dry mass] Source: S2BIOM (Dees et al., 2018)

3.3 Secondary biomass resources from wood processing industries

Forest - based industries in Serbia have always played an important role in the country's economic development.

Serbia's logging is managed by public enterprises Srbijašume and Vojvodinašume. These enterprises determine the quantity of wood required from domestic sources and make allocations to companies/individuals engaged in logging. Allocations are revised and adjusted depending on market requirements, availability and accessibility of timber. At the end of each year, companies may conclude an annual contract with Srbijašume and Vojvodinašume to ensure the supply for the coming year. The annual volume of timber felled in 2016, for commercial purposes in Serbia there was more than 3.1 million m^3, 76 % were produced in state-owned forests by the public enterprises, while the largest part of this wood volume (50 %), is used as firewood. Conifers represent a relatively small share of the total amount supplied and cut while hardwood is the most available wood with annual supply of 2.7 million m^3 [18].

Table 3.3.1: Forest base industry at a glance [18]

Number of companies		3 445
Number of workers		34 512
Structure (%)	Producing furniture	24.4
	Producing timber	75.6
Export ($)		1 391*
Export structure (%)	Furniture export	40.48
Impact on GDP		1.4
Export structure (%)	Upholstery	29
	Solid wood furniture	24
	Livin and dining furniture	12
Export destination (%)	EU	51
	Russion Federation and Belarus	21
	Region	26

*in 2018

Sawmill tradition in Serbia dates back to the beginning of the 19th century. Even today, Serbia is the 2nd largest producer of sawn beech wood and the 3rd largest producer of sawn hardwood in the Balkans. Sawnwood, besides furniture, is the most significant forest product of the woodprocessing industry in Serbia.

Sawmills are 3 % of the total number of wood processing companies. At the same time, sawn wood accounts for 37.2 % of exports in this sector [18]. Most sawmills are small, located in rural areas and operate only during the warm season. Large sawmills, with annual capacities of 3 000 – 5 000 m^3, hold 55 % of the installed capacity for sawn wood production. The existing raw material base drives sawmill production and most sawmills produce sawn hardwood. Annual production of sawn hardwood in Serbia exceeds 300 000 m^3, and 70 % of this is sawn beech wood.

Particle board is the wood product with the highest demand in Serbia. This demand is generated by the market–driven growth in high–quality furniture production. Serbian producers make more than 200 000 000 m^3 in particle board. Although Austrian company Kronospan invested in a particleboard factory in Lapovo in 2009 and Italian company Fantoni has privatized Serbian company SPIK Ivanjica, the demand for particle boards is still very high. An increase in domestic production was not enough to satisfy the market needs which resulted with import of 170 000 m^3 in 2015, presenting 54 % particle board consumption of local market [18].

In terms of volume, plywood is the main product in Serbia. The production of plywood has fluctuated significantly in the past. After a drastic decline of 61 % in 1999, production began to increase in 2000 and has been on the rise since. Although plywood is produced solely at SIMPO-ŠIK in Southern Serbia, with the capacity of over 40 000 m^3 annually, 28 000 m^3 was produced in 2015 and was mainly exported to Greece and Turkey

Even though raw hardboard dominates the domestic construction and furniture industry, the import is still necessary. In 2015, 26 000 m³ were imported from Hungary and Germany.

Over the past 15 years, veneer production slowly declined for two reasons. Firstly, veneer was produced by stateowned companies, which are now being privatized. Secondly, "veneer quality" logs have generally been exported, rather than processed locally and then exported as a higher–value product. Currently, peeled veneer makes about 90 % of total veneer production with Poplar veneer being the leading product, while remainder is mainly Beech. Other significant veneers currently produced in Serbia are Oak, Ash and Walnut. Poplar and Beech are primarily used in the manufacturing of plywood boards, which are mainly utilized in furniture and packaging production. Even so, plywood production in 2015 was 16 000 m³ and export 8 000m³ plywood demands on domestic market are present with import in amount of 13 000 m³.

There has been a significant increase in the production of solid laminated wood board. Produced mainly from Beech, these products are ranked with A/B quality. Edge–glued panels for stairs, tables and furniture parts are predominantly produced. The expansion of small, privately owned companies, especially in Central Serbia, has generated a substantial increase in the export of solid wood boards. Main export markets are Germany and Italy.

Production of solid wood joinery has a long tradition in Serbia. A large number of companies produce high quality windows and doors and significant quantities have been directly exported. Door production is dominated by solid Oak and Beech. However, Spruce and Fir are also commonly used. Domestic companies use high-quality metal accessories for joinery along with ecological coatings and can comply with any other consumer request.

Serbia's furniture market is a demanding, versatile market which generates many possibilities for furniture producers. All categories of furniture and furnishings are produced. Although most of the production is carried out by large and medium companies, micro and small enterprises have an important part in the furniture industry, when it comes to the development of small quantities and designed furniture. These family-owned companies have been successfully exporting products to the EU market for years, and are often aligned with construction companies to provide furniture and furnishings for buildings throughout Serbia, Russia, Middle East and other markets. Furniture is generally produced from laminated particle board. The demand for high-quality solid wood furniture is ever present locally, as well as on foreign markets. Only 30% of all furniture in Serbia is produced from solid wood and a great potential for investment lies in this relatively unexplored sector, particularly considering the segment's demand growth internationally.

For the past few years, the export of wooden hangers, cutting boards, crates and other solid wood items has been on constant increase. The main export markets, besides Italy and Germany, are Finland, the Netherlands and Switzerland.

Today, there are around 800 producers of paper and paper products in Serbia. Of the overall volume produced, cardboard, paper and cardboard containers are the most dominant products. The annual production of paper and paper products is about 506 000 tonnes [19]. Serbia continues to import significant amounts of paper and wood pulp, while domestic production is mostly concentrated on paper-processing industry. Over the past years, pulp and paper-based industry continue to register growth in production and exports. In 2018, the annual production of paper and paper products is about 510 666 tonnes: paper and cardboard – 228 275 tonnes, corrugated paper and cardboard – 57 886 tonnes and paper and cardboard containers – 224 505 tonnes [1].

At the beginning of 2017, 14 companies were engaged in the production of wood chips, and the production of wood briquettes was represented in 37 companies [19].

The largest expansion of production capacities and new producers in the last five years was the production of wood pellets, which is currently active in 54 factories/plants. In 2016, seven producers stopped production and are currently in the process of bankruptcy, of which three producers are from the group of large producers. In Serbia, hardwood pellets are mainly produced from beech, where spruce is also added. Pellets also contain bark, which no producer in Serbia currently removes, with the exception of main producers. Pellets are

produced from raw wood or from by-products of the wood industry [20]. At the end of 2015, the total installed capacity for the production of wood pellets in Serbia reached 550 000 tonnes, and the realized production was 229 000 tonnes, which gives a utilization of 41.6 % [19]. The closure of factories/plants reduced capacity to 463 000 tonnes.

The largest quantities of wood pellets in Serbia are produced from rough log, firewood and sawmill bark residues, which is completely opposite in relation to the countries of the European Union where wood pellets are mostly produced from wood residues such as sawdust. The total consumption of biomass for the production of wood pellets in Serbia in 2016 amounted to 464 000 m^3, and in 2017 it is expected that consumption will exceed 0.5 million m^3 [19].

The Serbian pellet market has been developing since 2006, but intensive production of pellets began in 2008. In Serbia, pellets are produced from hardwood, predominantly from Beech with a small portion of Spruce. Today, a major part of production is sold on domestic market, while 27 % of production was exported, mainly to Italy, Greece and Germany.

Wood briquettes are most often produced from beech residues without additives and impurities, although some producers add corn starch during the production process to achieve greater compactness of the briquettes [19]. Most use sawdust as a raw material. Due to the sharp increase in the popularity and price of wood pellets, some of the manufacturers of wood briquettes have installed additional lines for the production of pellets. This led to the diversion of raw materials to the production of pellets, instead of briquettes.

In Serbia, the largest quantities of wood chips are produced from conifers and soft hardwoods, and to a lesser extent from hardwoods such as beech. In 2016, the production of wood chips decreased by 12.5 % to the level of 99 000 tonnes (114 000 tonnes in 2015) [19]. One of the main reasons for this decline was the decision of the largest producer of wood chips to increase its production of wood pellets during 2015 and 2016. Accordingly, wood chips were mostly used for the production of pellets instead of being placed on the market. In the period 2013-2016 demand for wood chips in the domestic market was volatile, leading to the largest producers exporting stocks that could not be sold on the domestic market.

Charcoal production is mostly carried out in rural areas that are rich in forests in over 1500 charcoal kilns and one industrial plant [19]. The annual production of charcoal in Serbia is 30 000-34 000 tonnes, depending on the demand on the domestic market and the main export markets.

Firewood production in Serbia is constantly increasing due to strong demand. Due to the lack of a reliable and comprehensive system for monitoring production in private forests, the largest quantities of firewood in this production segment are not statistically recorded, which is the main reason why statistically recorded production of firewood is almost five times lower than real production. This conclusion was reached on the basis of the results of the FAO project implemented in Serbia in the period 2009-2011, which showed that the actual production of firewood in 2010 amounted to 7.05 million m^3, while in the same year it was statistically recorded only 1.45 million m^3 [19]. In recent years, data collection on the consumption of firewood for energy purposes has significantly improved, which is shown in the statistical yearbook and energy balance. Deforestation is result of negligence of forest management, especially for privately owned forests

This project received funding from the BBI JU under the EU Horizon 2020 research and innovation programme under grant agreement No.838087

3.4 Summary and conclusions in relation to SWOT elements

Table 3.4.1 summarises SWOT elements in relation to biomass supply from forestry.

Table 3.4.1: SWOT elements in relation to biomass supply from forestry

Strengths	Weaknesses
• There is enough forest cover to meets domestic needs for wood raw materials. • Principle of sustainability and multifunctionality in forest management is respected • Favorable ownership structure, satisfactory proportion of forest ownership. • Continuity in the supply of the wood market, with slight growth. • Long-term opportunities to increase the raw material potential for wood processing. • The privatization process in the wood processing sector is completed. • A large number of companies and entrepreneurs. • Skilled workforce (tradition, experience, knowledge). Developed network of educational institutions. • Increase in exports of wood products. • Employment of the population from rural and underdeveloped areas. • Significant number of self-employed and indirectly employed persons. • A significant sector for the production of energy from renewable sources. • System of certification of forests and a chain of supervision (COC) in state-owned forests is applied in a significant number of wood processing companies.	• Unsatisfactory condition of forests, which in relation to the wood market is characterized by insufficient participation of valuable technical roundwood. • Insufficiently known condition of forests and extent of felling in private forests. • Low representation of technical roundwood in the total sales of wood assortments. • Use of forests that rely on a large number of small contractors, without technical capacity and a permanently employed workforce. • Fragmentation of production, a large number of small businesses and entrepreneurs. • Too many customers of technical roundwood, whose total capacity does not provide adequate quality utilization of raw materials. • Unrecorded employment in certain activities. • Inadequate spatial distribution of wood processing plants in which the largest number of companies are located in districts that are not rich enough in forest resources. • Low share of products with a higher degree of finalization in exports. • Total capacities for primary processing are oversized, which increases the overall demand for rough log. • Low values of average earnings. • Private forest owners' associations are not present on the market. • Insufficient control of wood flows by state authorities. • Lack of strict forest management. • Reported lower official values in GDP than real ones. • Insufficient allocation from the budget for strategic development of the wood sector. • Insufficient number of employed specialized staff in the sector.

This project received funding from the BBI JU under the EU Horizon 2020 research and innovation programme under grant agreement No.838087

Opportunities	Threats
• Forest richness and pronounced biodiversity • Increasing forest cover and production potentials of forests. • Development of domestic wood industry and increased demand for wood as a resource • Development of the biomass and bioenergy sector. • Potential of non-wood forest products • The potential of the ecological effects of the forest up to the reduction of the greenhouse effect • Increasing the level of finalization and development of areas that have an export perspective. • Increasing the number of employees through job diversification (contracting). • Potential of hunting tourism activities • Sustainable forest biomass production • Organizing private forest owners for a joint appearance on the wood market. • Certification of private forests. • Increased budget allocations (and/or channeling of own funds) to improve the condition of forests. • Establishment and development of new partnerships within the sector. • Strengthening competitiveness in the international market. • Change of the existing spatial distribution of production in the direction of establishing the optimal production of certain product categories, in accordance with the characteristics and forest potentials of the region. • Changes and adjustments of the personnel education system in accordance with the needs of companies and the conditions of their business.	• The trend of decreasing the share of technical roundwood and the increase of firewood production. • Decrease in the value of total income from forest use. • The impact of the economic crisis on business. • Increase in undeclared employment. • Inadequate qualitative structure of employees • Large number of employees with minimum wages • Insufficient cross-sectoral cooperation • Lack of an integrated information system • Due to inadequate monitoring of the official share of the wood sector in GDP, economic policy measures are not adjusted to its more dynamic development. • Impossibility of processing rough log in some regions due to the lack of local processing capacities. • Strengthening competition from neighboring countries in common export markets. • Insufficient effects of budget support for work on improving the condition of forests due to reduced benefits. • Due to the production fragmentation of wood processing companies, their position in the regional and EU markets is very weak, as a result of which they most often represent suppliers of large distribution systems.

4 Biomass supply: Waste

4.1 Introduction

In the Republic of Serbia, data on waste generation are mainly based on the following sources [23]:

- Serbian Environment Protection Agency (SEPA) data base – data related to waste generation are produced from the mandatory yearly reports in accordance with the "Rulebook on the form of daily records and annual report on waste ("Official Gazette of the Republic of Serbia", No. 95/2010, 88/2015);
- Statistical Office of the Republic of Serbia (SORS) - data on waste generation are based on a statistical survey that has been carried out according to the standards and rules of the Regulation (EC) 2150/2002 on waste statistics.

Due to the different way of data collection (and incomplete reporting by stakeholders as well as incomplete data delivery to surveys) some differences may appear. Furthermore, the statistical survey partly reflects materials that are not covered by the Law on Waste Management - LWM (e.g. waste disposed at the used mines).

According to the data submitted to SEPA[1], the total amount of generated waste is presented on the Figure 4.1.1. Total amount of waste generated in 2018 reached about 11.6 million tonnes and the quantities were slightly increased compared to 2017, when they had increased compared to the previous ones due to the increase in number of reporting plants and the increased amount of waste generated by thermal power plants and a company activity of which the production covers pig iron, steel and ferroalloys.

The total generation of waste in Serbia in 2016 was 9.2 million tonnes, out of which 74 000 tonnes were classified as hazardous waste.

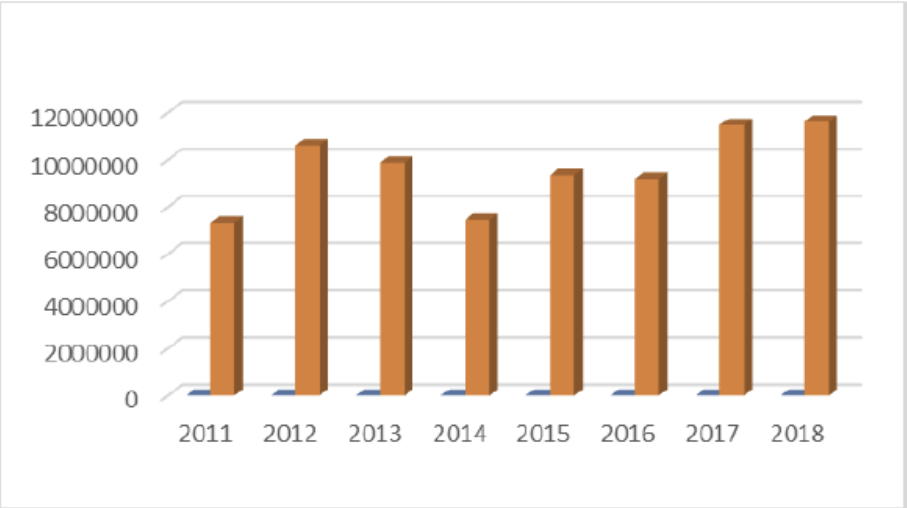

Figure 4.1.1: Total quantities of generated waste (t) Source: [25]

[1] Every waste generator, except for households, shall maintain and keep daily records on waste and shall submit regular annual report to SEPA, including the types and quantities of waste generated. The reporting takes place under the Rulebook on methodology for development of national and local register of pollution sources, as well as the methodology for the types, methods and cut-off data for data collection ("Official Gazette of the Republic of Serbia", No.RS, No. 91/10 and 10/13) and under the Rulebook on the daily record on waste and annual waste report forms and instructions for their completion ("Official Gazette of the Republic of Serbia", No.RS, No. 95/2010).

Total amount of waste obtained from the records of the Waste Catalogue by waste category shows that the highest amount of waste generated during those activities (Figure 4.1.2 [24]. The largest waste generators are thermal power plants, which in the course of their operation generated 7.45 million tonnes of coal fly ash during 2018. They are followed by solidified waste from the waste treatment plants, scrap iron-containing metals and metalwork waste, and mixed construction and demolition waste. The total amount of municipal waste in 2018 amounted to 2.3 million tonnes, or 20% of the total amount of all waste categories.

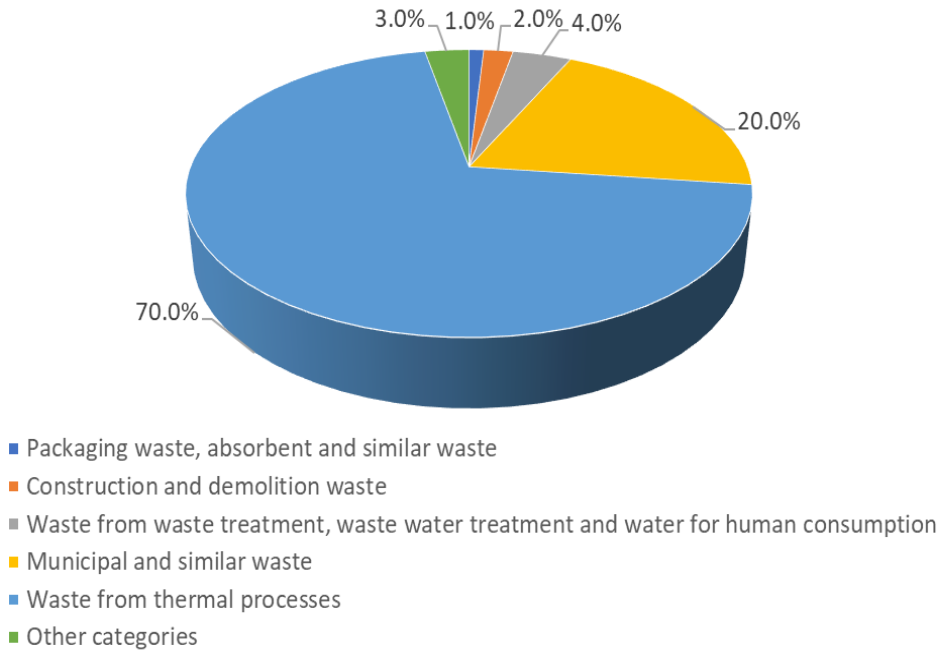

Figure 4.1.2: Total amount of waste per category from the Waste Catalogue in 2018

Based on quantities of generated hazardous waste as per waste groups from the Waste Catalogue, it can be concluded that the largest amount of hazardous waste belongs to the category "Waste from thermal processes", having a share of 34% of the total amount (Figure 4.1.3 [24]).

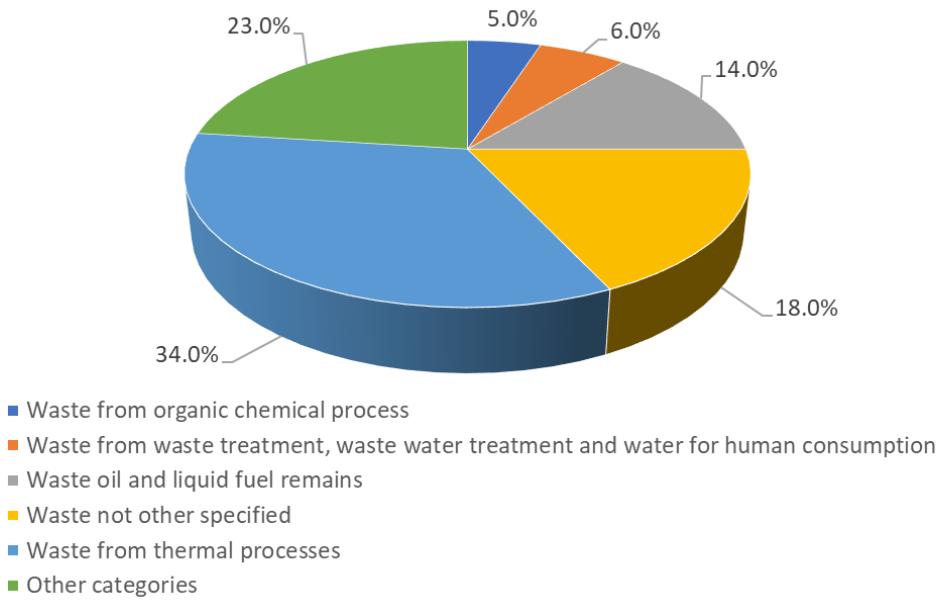

Figure 4.1.3: Total quantity of hazardous waste per waste category from the Waste Catalogue in 2018

Table 4.1.1 shows the quantities of waste generated in Serbia in 2017 broken down by the 2-digit chapter codes of the List of Waste. The data covers quantities reported by companies which submit to the SEPA annual reports on the types and quantities of waste generated [23].

Table 4.1.1: Quantities of waste generated in Serbia in 2017 (in tonnes) broken down by the 2-digit chapter codes of the List-of-Waste (Source: Waste management in the Republic of Serbia for the period 2011-2017; SEPA, 2018)

Chapter	Waste	Quantity
01	Waste resulting from exploration, mining, quarrying, physical and chemical treatment of minerals	/
02	Waste from agriculture, horticulture, aquaculture, forestry, hunting and fishing, food preparation and processing	36 219
03	Waste from wood processing and the production of panels and furniture, pulp, paper and cardboard	33 238
04	Waste from the leather, fur and textile industries	7 830
05	Waste from petroleum refining, natural gas purification and pyrolytic treatment of coal	5 442
06	Waste from inorganic chemical processes	1 077
07	Waste from organic chemical processes	8 645
08	Waste from the manufacture, formulation, supply and use (MFSU) of coatings (paints, varnishes and vitreous enamels), adhesives, sealants and printing inks	3 612
09	Waste from the photographic industry	241
10	Waste from thermal processes	8 249 653
11	Waste from chemical surface treatment and coating of metals and other materials; non-ferrous hydro- metallurgy	1 828
12	Waste from shaping and physical and mechanical surface treatment of metals and plastics	70 454
13	Oil waste and waste of liquid fuels (except edible oils, 05 and 12)	10 212
14	Waste organic solvents, refrigerants and propellants (except 07 and 08)	27
15	Waste packaging; absorbents, wiping cloths, filter materials and protective clothing not otherwise specified	118 013
16	Waste not otherwise specified in the list	55 319
17	Construction and demolition waste (including excavated soil from contaminated sites)	230 535
18	Waste from human or animal health care and/or related research (except kitchen and restaurant waste not arising from immediate health care)	2 964
19	Waste from waste management facilities, off-site waste water treatment plants and the preparation of water intended for human consumption and water for industrial use	404 873
20	Municipal waste (household waste and similar commercial, industrial and institutional waste) including separately collected fractions	2 237 432
TOTAL		11 477 614

The statistics of SORS provide quite different picture of the waste generation on Serbia (Figure 4.1.4 [1, 23]). According to SORS, approximately 48.9 million tonnes of waste were generated in Serbia in 2017. Approximately 64.7 % of the generated quantity was non-hazardous and 35,3% hazardous waste. The main reason for the differences of the figures of SORS and SEPA is, that the statistics of SORS include approximately 38.4 million tonnes of waste from mining and quarrying, which are not covered by the statistic of SEPA, since these wastes

are not covered by the Waste Framework Directive (2008/98/EC) but are covered by the Directive 2006/21/EC on the management of the waste from extractive industries and amending Directive 2004/35/EC [23]. However an analysis of specific material streams shows a better match of data based on the same definition (e.g. in case of waste from construction sector according to SORS, 537 900 t of waste were generated, including 325 000 t backfilled (i.e. 212 900 t disposed off site as waste) vs. 230 535 t waste from chapter 17-Construction and demolition waste (including excavated soil from contaminated sites) disposed off-site as waste as presented on Figure 4.1.4.

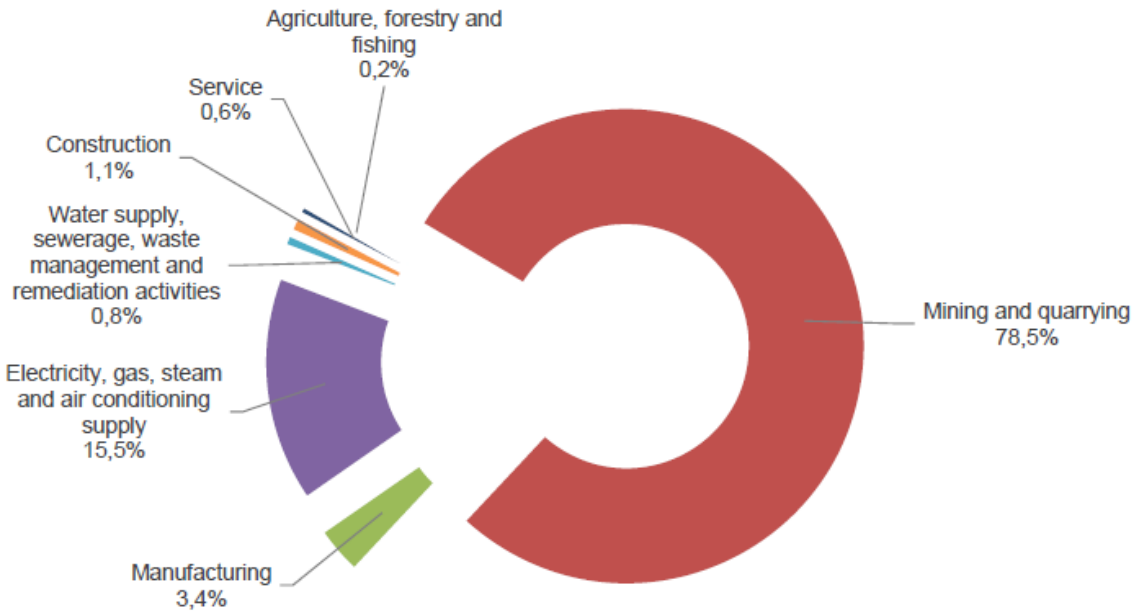

Figure 4.1.4: Share of generated waste in the Republic of Serbia by sectors in 2017 (Source: SORS, Statistical Release ZS60)

4.2 Waste from biological resources

According to the LWM municipal waste means "household waste, as well as other waste which is similar to household waste due to its nature or composition". To a large extent, municipal waste consists of the waste generated by households but may also include similar waste generated by small businesses and public institutions and collected by or on behalf of municipalities or directly by private operators. Municipal waste including separately collected fractions (except packaging waste, which are listed in Chapter 15, Sub-Chapter 15 01) are classified in Chapter 20 of the list of waste:

- 20 01 – separately collected fractions (except 15 01– packaging waste);
- 20 02 – garden and park waste (including cemetery waste);
- 20 03 – other municipal waste (including mixed solid municipal waste and separate collected fractions).

The vast majority of municipal waste is mixed municipal waste (waste code 20 03 01).

In accordance with the Rulebook on methodology for collection of data on composition and quantities of waste on the territory of Local Self-Government Unit ("Official Gazette of the Republic of Serbia", No. 61/2010) local self-governments have an obligation to analyse quantities and composition of municipal waste on its territory four times a year. The amount of waste generated in Chapter 20 of the waste list is shown in Table 4.2.1 [23].

Table 4.2.1: Quantity of waste from category 20 of the Waste list in tonnes/year (Source: Waste management in the Republic of Serbia for the period 2011-2017; SEPA, 2018)

	Year						
	2011	2012	2013	2014	2015	2016	2017
Chapter 20 - municipal waste [tonnes]	2 733 825	2 658 549	2 454 520	2 186 297	1 936 309	1 963 776	2 237 432
TOTAL - quantity of waste [tonnes]	7 337 333	10 601 454	9 881 313	7 451 105	9 354 680	9 197 100	11 477 614

As indicated in Table 4.2.1, in Serbia, municipal waste makes about 21 % of total quantity of waste. According to latest data from SEPA, in 2016, the total quantity of waste was 9.2 million tonnes. Although the data is not provided by all companies which should report data, according to official statistics it is estimated that average daily quantity of municipal waste in 2016 was 0. 73 kg per inhabitant, and average annual quantity was 270 kg, while the EU average in 2016 was 483 kg.

Error! Reference source not found. 4.2.2 presents basic indicators that show the quantities of produced municipal waste (mainly consists of mixed municipal waste). The indicators are prepared based on annual data on waste quantities reported by Public Utility Companies (PUCs) in local self-governments in accordance with the Rulebook on form daily waste records and annual waste report ("Official Gazette of the Republic of Serbia", No 95/10).

Table 4.2.2: Quantities of municipal waste (Source: Waste management in the Republic of Serbia for the period 2011-2017; SEPA, 2018)

	2011	2012	2013	2014	2015[2]	2016	2017
Total quantity of generated waste (million tonnes)	2.71	2.62	2.41	2.13	1.84	1.89	2.15
Quantity of waste collected and deposited by municipality PUCs (million tonnes)	2.09	1.83	1.92	1.67	1.36	1.49	1.80
Average scope of waste collection (%)	77	~ 70	80	~80	82	~82	83.7
Average daily quantity of municipal waste per inhabitant (kg)	1.01	0.99	0.92	0.81	0.71	0.73	0.84
Average annual quantity per inhabitant (t)	0.37	0.36	0.34	0.30	0.26	0.27	0.30

According to information from the SEPA, very small number of public utility companies (PUC) performed measurements and submitted the reliable information about municipal waste characteristics. In most municipalities, a lack of weighbridges represents one of the major problems for collecting good quality data about waste generation. In most cases, this kind of practice results in data on the quantities of generated and landfilled municipal solid waste which is based on estimations. Reasons therefor are mainly lack of understanding the importance of this type of analysis, difficult economic conditions in companies, lack of equipment and lack of professional (skilled) people who could adequately carry out the analysis in terms of taking representative samples and separation of waste fractions according the catalogue.

Based on available information and research on the composition of mixed municipal waste, which was made in 2008, it can be concluded that about 60% of the municipal waste represents a biodegradable fraction consisting of garden and food waste and other biodegradable material like paper and cardboard (Figure

[2] Note: The data for 2014/2016 differ from the data used in chapter 4 based on the study on waste generation and composition for the period 2014 to 2030 (Municipal Solid Waste Information Republic of Serbia 2014 Bojan Batinić). Since this study also includes data on waste composition, chapter 4 to 8 rely on these data primarily.

4.2.1 [23]). Relevant recyclable fractions are plastics (about 15%), paper and cardboard (about 15%), glass (5, 26%) and metals (2%).

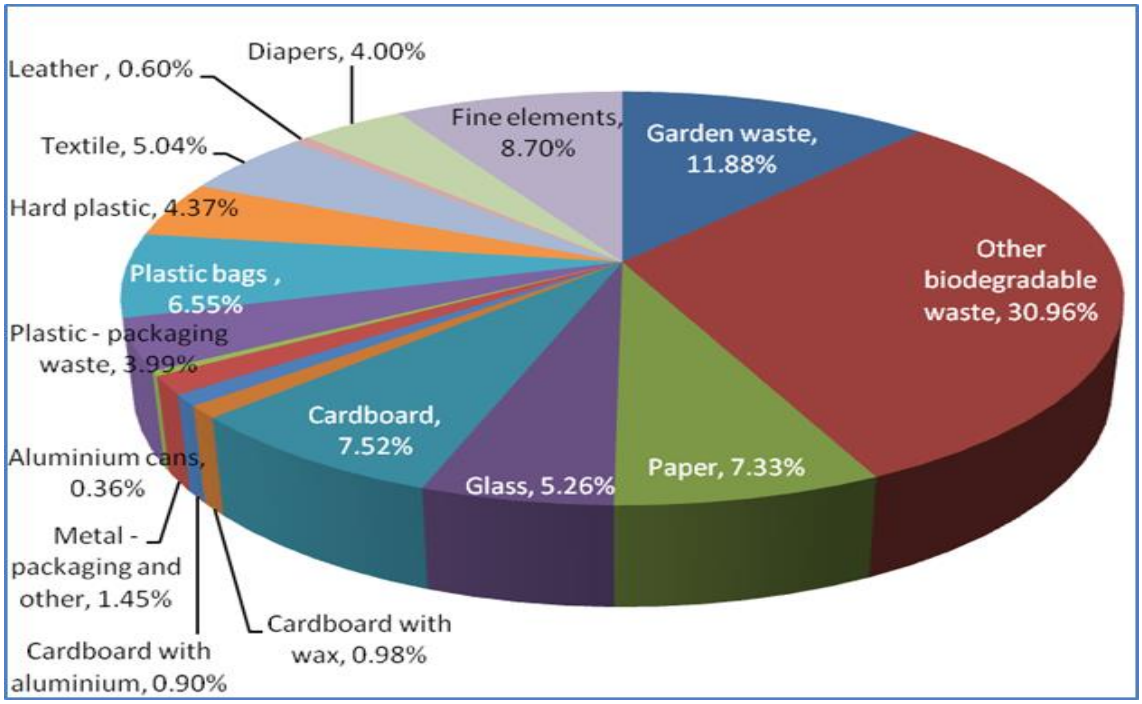

Figure 4.2.1: Average morphological composition of mixed municipal waste in Serbia Source: Batinic 2014, Report on Municipal Solid Waste Information, reference year 2008)

Vegetal waste, animal by-products in 2016 livestock in Serbia amounted to around 0.89 million cattles, 3 million pigs, 1.7 million sheep and 0.2 million goats (Source: Statistical Yearbook of Serbia 2017; SORS). Based on that data the amount of manure produced can be estimated in the range of 1 million tonnes DM per year.
Thus, the amount registered as manure and vegetal waste in the survey of SORS accounts only for 77 794 t of manure and 12 558 t vegetal waste.

4.3 Current waste treatment and unused potentials estimates

Local self-government units are responsible for organizing of the municipal waste management systems, thus ensuring their functionality. Local self-government units are also responsible for the management of waste whose owner cannot be determined or does not exist, and for the administration of the provision of municipal waste management services.

Waste management issues are not equally and evenly present in all municipality units, and the activities regarding the introduction of an integrated system are not conducted with the same intensity, but they primarily depend on the capacities of a municipality. Such an incoherent system cannot function adequately and the change of such condition in the direction of applying the modern sanitary and safe ways for handling with waste cannot be expected without significant assets. The only economically feasible solution would be the establishment of regional waste management centres where the waste collected from several municipalities (including separately collected waste fractions) will be treated at the plants for separation of recyclable waste, and the rest of it will be disposed of at the regional landfills, as was defined in the 2003 National Waste Management Strategy. These regions will implement the principles of integrated waste management system for a longer period (Table 4.3.1]23]).

Table 4.3.1: Waste management regions (Source: Investment Planning Tool (Solid Waste Man-agement in Serbia) and Implementation plan for Council Directive 1999/31/EC on the landfill of waste)

REGION	OWNERSHIP[3]	MUNICIPALITIES
Sremska Mitrovica	Public	Bogatić, Šabac, Sremska Mitrovica.
Pančevo	Public	Opovo, Pančevo.
Inđija	Public	Inđija, Irig, Pećinci, Ruma, Šid, Sremski Karlovci, Stara Pazova.
Užice	Public	Arilje, Bajina Bašta, Čačak, Čajetina, Ivanjica, Kosjerić, Ljubovija, Lučani, Požega, Užice.
Pirot	Public	Babušnica, Bela Palanka, Dimitrovgrad, Pirot.
Kikinda	Majority private	Ada, Bečej, Kikinda, Nova Crnja, Novi Bečej.
Lapovo	Majority private	Batočina, Despotovac, Lapovo, Rača, Svilajnac.
Jagodina	Majority private	Ćuprija, Jagodina, Paraćin, Smederevska Palanka, Velika Plana.
Leskovac	Majority private	Bojnik, Crna Trava, Lebane, Leskovac, Medveđa, Prokuplje, Vladičin Han, Vlasotince, Žitorađa.
Subotica	Public	Bačka Topola, Čoka, Kanjiža, Mali Iđoš, Novi Kneževac, Senta, Subotica.
Valjevo	Public	Barajevo, Koceljeva, Lajkovac, Lazarevac, Ljig, Mionica, Obrenovac, Osečina, Ub, Valjevo, Vladimirci.
Zrenjanin	IMCA	Kovačica, Sečanj, Titel, Žitište, Zrenjanin.
Nova Varoš	IMCA	Nova Varoš, Priboj, Prijepolje, Sjenica.
Vranje	IMCA	Bosilegrad, Bujanovac, Preševo, Surdulica, Trgovište, Vranje.
Beograd	Public	Čukarica, Grocka, Mladenovac, Novi Beograd, Palilula, Rakovica, Savski venac, Sopot, Stari Grad, Surčin, Voždovac, Vračar, Zemun, Zvezdara.
Novi Sad	IMCA	Bačka Palanka, Bački Petrovac, Beočin, Novi Sad, Srbobran, Temerin, Vrbas, Žabalj.
Niš	IMCA	Aleksinac, Doljevac, Gadžin Han, Merošina, Niš, Ražanj, Sokobanja, Svrljig.
Sombor	IMCA	Apatin, Bač, Kula, Odžaci, Sombor.
Vršac	IMCA	Alibunar, Bela Crkva, Plandište, Vršac.
Zaječar	IMCA	Boljevac, Bor, Kladovo, Knjaževac, Majdanpek, Negotin, Zaječar.
Smederevo	IMCA	Golubac, Kovin, Smederevo, Veliko Gradište.
Kragujevac	IMCA	Aranđelovac, Gornji Milanovac, Knić, Kragujevac, Topola
Kraljevo	IMCA	Kraljevo, Novi Pazar, Raška, Tutin, Vrnjačka Banja.
Kruševac	IMCA	Aleksandrovac, Brus, Ćićevac, Kruševac, Rekovac, Trstenik, Varvarin.
Petrovac	IMCA	Kučevo, Malo Crniće, Petrovac, Požarevac, Žabari, Žagubica.
Loznica	IMCA	Krupanj, Loznica, Mali Zvornik.
Undefined[4]		Blace, Kuršumlija.

Waste management regions are formed through the voluntary cooperation of local self-government units. In the previous waste management strategy on landfill it was foreseen to be a maximum of 27 regions (based on application of an Investment Planning Tool).

[3] Public: Ownership in the form of a Public Utility Company or Publicly owned limited liability company.
Majority Private: Where the main assets or services are provided either by private companies or joint ventures with majority private ownership.
IMCA: Inter-municipal agreement exists but regional company not in place yet.

[4] Prokuplje region ceased to exist. Two municipalities, former members of the region joined Leskovac region, and two remaining Kuršumlija and Blace, have not yet decided which region to join.

Waste collection service is not available to a large part of the population. Collection is organized primarily in urban areas, whereas rural areas are significantly less covered. Thus, the service ranges from only 25% to 100% in some municipalities. It has been estimated that collection rate of organized municipal waste collection amounts to ~82% in the Republic of Serbia as indicated in Table 4.3.2 [23].

Currently there are only 10 sanitary landfills complying with EC sanitary landfill standards and three regional sanitary landfills are under construction (2017). According to latest data from SEPA in 2017, 460 488 tonnes of waste was landfilled into compliant sanitary landfills. The three largest cities in Serbia (Belgrade, Novi Sad and Niš) do not have a sanitary landfill. Furthermore, there are 123 controlled not-compliant municipal landfill sites in Serbia and about 3 450 dumpsites. Due to the poor service coverage in rural areas it is likely that large amounts of waste fall into non-compliant landfills or dumpsites. Thus about 20 % of generated municipal waste in Serbia is disposed in wild landfills, outside control of the public utility companies.

Table 4.3.2: Quantity of waste disposed on sanitary landfills in tonnes per year (Source: Waste management in the Republic of Serbia for the period 2011-2017; SEPA, 2018)

Landfill	2011	2012	2013	2014	2015	2016	2017
RSL "Duboko" Uzice	3 566	34 135	65 955	72 757	72 051	77 930	75 295
RSL "Vrbak" Lapovo	14 924	25 660	27 873	24 344	35 580	49 749	41 266
RSL Kikinda	20 497	25 212	23 298	41 018	54 008	50 903	50 411
RSL "Gigos" Jagodina	50 011	58 975	69 704	57 667	62 760	74 113	62 893
RSL "Zeljkovac -D2" Leskovac	/	/	58 938	62 332	64 269	63 380	69 255
RSL "Muntina padina" Pirot	/	/	40 537	41 976	36 956	31 685	29 987
RSL "Jarak" Sremska Mitrovica	/	/	/	17 808	44 545	48 126	66 526
RSL Pancevo	/	/	56 666	63 533	54 098	64 305	49 450
SL "Meteris" Vranje	/	/	2 723.9	2 593.9	178.8	199.3	202
SL "Vujan" Gornji Milanovac	/	/	11 479	12 731	14 879	13 628	15 203
TOTAL [t]	88 998	143 982	357 174	396 760	439 325	474 018	460 488

Mixed municipal waste in Serbia is not treated and the untreated waste is disposed of in land-fills. A big part of generated municipal waste is disposed of in wild landfills, outside control of the public utility companies. In most cases, wild landfills are located in villages and are primarily the result, of the lack of funds for expansion of waste collection system and poor organization of waste management on local level.

There is no systematically organized separate collection, sorting and recycling of municipal waste in the Republic of Serbia. Although the primary waste selection in Serbia has been set forth under the law which envisages which separation of paper, glass and metal in specially labelled containers, recycling is not functioning in practice even low amounts of recyclables are collected.

Hazardous waste from households is not collected separately from the mixed municipal waste stream.

Serbia does not have the necessary infrastructure to reduce the disposal of biodegradable waste. Currently, composting sites exist only in Subotica and partially in Sremska Mitrovica re-gions. The biodegradable waste generated by households in full falls into a mixed municipal waste stream and is not further treated before disposal. Given the fact that in Serbia most of these waste flows are not collected separately, the absence of separate collection will not allow to achieve environmentally, economically as well as financially beneficial treatment of this waste in the context of targets of biodegradable waste disposal and recycling.

4.4 Summary and conclusions in relation to SWOT elements

Main challenges in municipal waste management in Serbia remain related to ensuring good coverage and capacities for providing basic services, such as collection, transport and sanitary waste disposal. The main issues in municipal waste management are:

- Most of the municipal waste goes to landfills untreated, as well as a significant proportion of municipal waste is still being disposed of in non-sanitary landfills because it is the cheapest way to handle waste (not addressing the future cost for later sanitation of polluted areas);
- These low disposal costs jeopardise the goal of waste prevention and recycling since separate collection, sorting, re-use and recycling of secondary raw material and biode-gradable waste therefore is not economical attractive;
- Not all municipalities have guaranteed the conditions for the use of public waste management services by waste holders located in their territory. Currently the coverage of waste collection in Serbia is about 82%;
- Separate collection of recyclables and bio-waste is not yet implemented adequately. Recycling targets for Municipal waste are not yet achieved. Currently the recycling rate for Municipal waste based on reported waste data is about 3%;
- Hazardous waste from households is not collected separately from the mixed municipal waste stream;
- Cooperation between municipalities and producer and importer organizations is not en-sured, a large part of secondary raw materials is collected by the informal sector;
- There is no common and clear mechanism for assessing the achievement of targets for municipal waste treatment;
- There are no centres of competence that would help the municipality to implement the strategic objectives on a regional basis;
- There is no accurate and reliable record-keeping on generation and management of municipal waste, which may lead to the adoption of unjustified strategic decisions on the selection of waste management methods.

The overall goal is to develop a sustainable waste management system in order to reduce environmental pollution and spatial degradation.

The integrated network of treatment installations should be in operation until 2024 obligatory for the waste management regions of Subotica; Vranje; Kruševac; Užice; Pančevo; Pirot; Sremska Mitrovica; Nova Varoš; Novi Sad; Kragujevac; Zrenjanin; Valjevo; Belgrade and voluntary of all other waste management regions and shall cover:

- Source separation at household level should be organised via bin/bag-system (including vehicles) at least for following waste streams:
    - recyclables including specific special waste streams such as packaging waste (metals, plastics, glass, paper and cardboard, wood);
    - bio-degradable waste (food and garden green waste);
    - non-hazardous residual mixed municipal solid waste.
- Public amenity sites to be established at municipality level (covering waste streams such as bulky waste, green park waste (e.g. from cuttings in gardens), packaging waste (including waste from special waste streams such as: metals, glass plastics, pa-per and cardboard, wood), hazardous waste from households (including waste from special waste streams such as WEEE, used batteries and accumulators, waste oil, medical and pharmaceutical waste), asbestos containing waste (small scale storage possibility);
- Home-composting in rural areas at household level (covering waste streams such as biodegradable-waste including green waste);
- Composting facilities at municipal level (covering waste streams such as biodegradable-waste including green waste);
- Transfer stations / storage areas for interim storage at regional level (covering waste streams such as C&D waste, hazardous waste, municipal waste);
- Secondary separation and mechanical sorting of recyclables (at least eight facilities in the dedicated regions);

- Mechanical-biological treatment of mixed municipal solid waste (at least one facility in the indicated regions);
- Mobile treatment facilities for mineral construction and demolition waste at regional lev-el;
- Incinerator dedicated for thermal waste treatment of municipal waste (at least one facili-ty in Serbia);
- Incinerator dedicated for organic industrial and medical waste (at least one facility in Serbia);
- Physical-chemical treatment for hazardous waste (at least one facility in Central Serbia).
- Regional sanitary landfills for residues and pre-treated municipal waste at regional level (also covering selected hazardous waste such as asbestos containing waste).

Short term objectives among others are:

- Increase the recycling rate of waste from households to overall 25 % by weight by 2025;
- Increase the level of diversion as percentage of totally generated paper and cardboard in Serbia to 25% by 2025

Long term objectives are:

- By end of 2030, the recycling rate of waste from households will be increased to overall 35 % by weight; respectively 45 % by end of 2035 and finally 65 % by 2054;
- By end of 2029, increase the level of diversion as percentage of totally generated paper and cardboard in Serbia to 35 %; respectively 50 % by end of 2034;
- By end of 2029, increase the level of diversion as percentage of totally generated bio-waste in Serbia should to 40 %; respectively 60 % by end of 2034;
- By end of 2028, reduce the biodegradable waste going to landfills to 75 % of the total amount of biodegradable waste generated in 2008 (maximum amount to be landfilled); respectively 50 % by end of 2032 and 35 % by end of 2039;

Table 4.4.1 summarises SWOT elements of waste sector in the Republic of Serbia.

Table 4.4.1: SWOT analysis in relation to waste sector in Serbia

Strengths	Weaknesses
• Existence of national waste management strategy; • Adopted key laws on waste management harmonised with EU Directives; • Started construction of several regional sanitary landfills – regional centres for waste management; • Unused potential for waste recycling • Possibility of waste incineration in cement plants, thermal power plants	• Lack of infrastructure for treatment and disposal of waste (regional landfills – regional centres for waste management, facilities for recycling, composting etc.); • Absence of facilities for treatment of hazardous waste; • Absence of central storage for hazardous waste; • Pollution of waters, soil and air due to poor waste management practice; • Degraded areas due to inadequate waste disposal and numerous dumps and wild landfills; • Absence of organized collection and disposal of waste in rural areas; • Lack of accurate data on quantity of waste that disappears; • Lack of public awareness/willingness of how to handle waste sustainably
Opportunities	**Threats**
• Introduction of the EU waste management standards; • Integration process and use of the EU and other funds • Rehabilitation of unregulated dumps and remediation of contaminated soil; • Reduction of industrial waste generation; • Contribution to employment and opening of new jobs; • Charging by quantity of generated municipal waste	• Lack of investment for development of waste management infrastructure; • Areas burdened by uncontrolled and unhygienic landfills – dumps; • Insufficiently developed public awareness of necessity to treat waste properly; • "Not in my backyard" principle; • Inability of citizens to pay the real, economic price for municipal services

5 Bio-based industries, products and markets

Industrial production has been growing steadily since 2015, with its slowdown in 2018, when the growth rate of total industrial production (excluding construction) was 1.3 %, while the growth rate of production in the manufacturing industry was 1.9 % [26]. A detailed analysis of the sector of the economy included the identification of sectors that possess the resources and capabilities necessary for strong, dynamic, diversified and sustainable development and exports [27]. The most successful ten sectors with the best performance are: crude oil and natural gas exploitation, property renting and leasing services, real estate, postal and courier services, computer programming, consulting and related activities, gas production and distribution, motor vehicle production, health activities, exploitation of metal ores and collection, purification and distribution of water. Based on the analysis, a performance and competitiveness matrix was developed that provides a comparative overview of sectors based on their characteristics and the structure of international competitiveness and performance as a whole. Figure 5.1 shows the distribution of 53 sectors engaged in the production of tradable goods based on performance as a whole, shown on the x-axis, and export competitiveness, shown on the vertical y-axis. Each sector is represented by a circle, and the size of the circle indicates the number of firms operating in that sector: the larger such firms, the larger the circle [27].

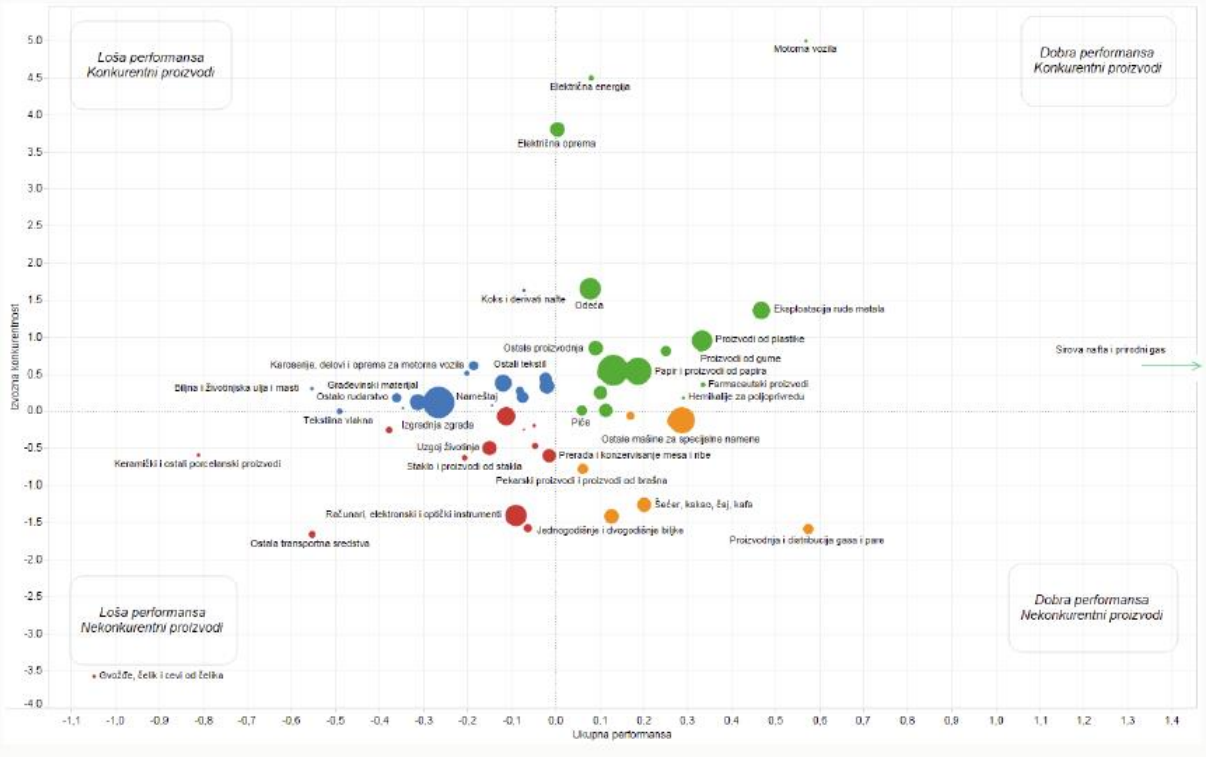

Figure 5.1: Comparative overview of the sector

The analysis of the economy was performed on the basis of the development potentials index. The Development Potential Index seeks to identify sectors with a healthy corporate base, but also to focus on those that can contribute to broader economic and social priorities [39]. By grouping sectors by related branches, it was found that development potentials between groups vary, i.e. that they are not evenly distributed. This unevenness is shown in Figure 5.2 - the sectors are distributed according to economic branches, and each sector is colored in accordance with the development group to which it belongs (dark green is the highest development group, and dark red is the lowest).

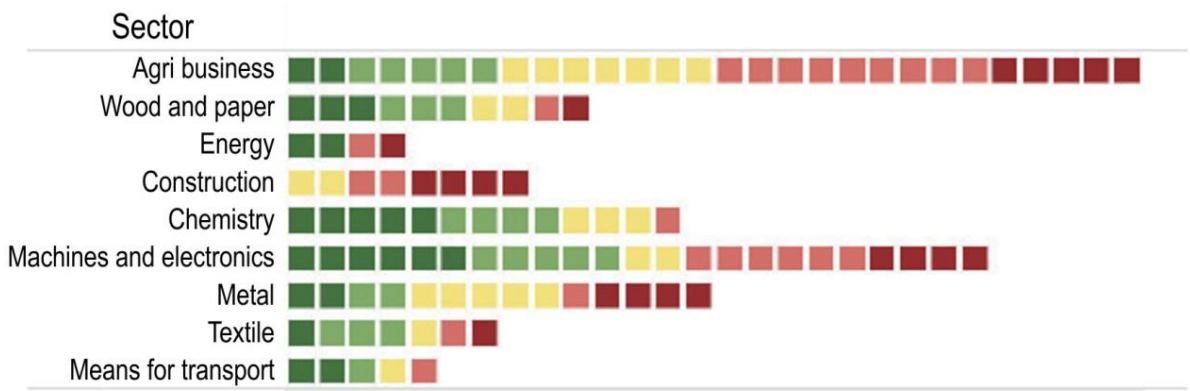

Figure 5.2: Overview of economic branches according to development potentials

The Government of the Republic of Serbia has identified four priority areas within the manufacturing sector namely [28]:

- Food industry
- Wood and furniture industry
- Rubber and plastics industry
- Mechanical and equipment industry.

5.1 Chemical industry

The Chemical Industry is a globally one of the most important and most linked branches with the overall economy of a country. The product range of the Chemical Industry can be divided into three basic groups of sectors – chemicals and chemical products, basic pharmaceutical products and rubber and plastics products. Based on the chemical composition, they are divided into the inorganic and organic products. The largest part of the chemical Industry belongs to the organic chemistry - carbon-based, which means that the basic raw materials are crude oil or natural gas. These products include pharmaceutical products, rubber and plastics, agrochemistry products, paints, detergents, household cleaning products, etc. A smaller group of products belong to the products of inorganic chemistry, which are not based on carbon. The structure of Chemical Industry in Serbia is defined in following way:

1. Base chemicals and chemical products (base chemicals, fertilizers, plastic granulates, industrial gases, bases for colors and varnishes, basic non-organic chemicals, synthetic rubber); Pesticides and agriculture chemicals; Paints, varnishes, dyes, printing colors and fillers; Detergents, soaps and cleaning products; Other chemical products (glues, ether oils..)
2. Rubber and plastic products (rubber tires, other rubber products); plastic profiles; plastic packaging; plastics products for construction purposes, other..)
3. Non-metal mineral products (glass products, fireproof products, ceramics, porcelain, grinding products and agents)
4. Pharmaceutical products.

Chemical Industry in Serbia consists of 1 507 companies [35]. Production volume of the Chemical industry is on the rise. By far, petrochemical Industry is the strongest performer in the group, followed by pharmaceutical and rubber and tires Industry (Figure 5.3 [35]).

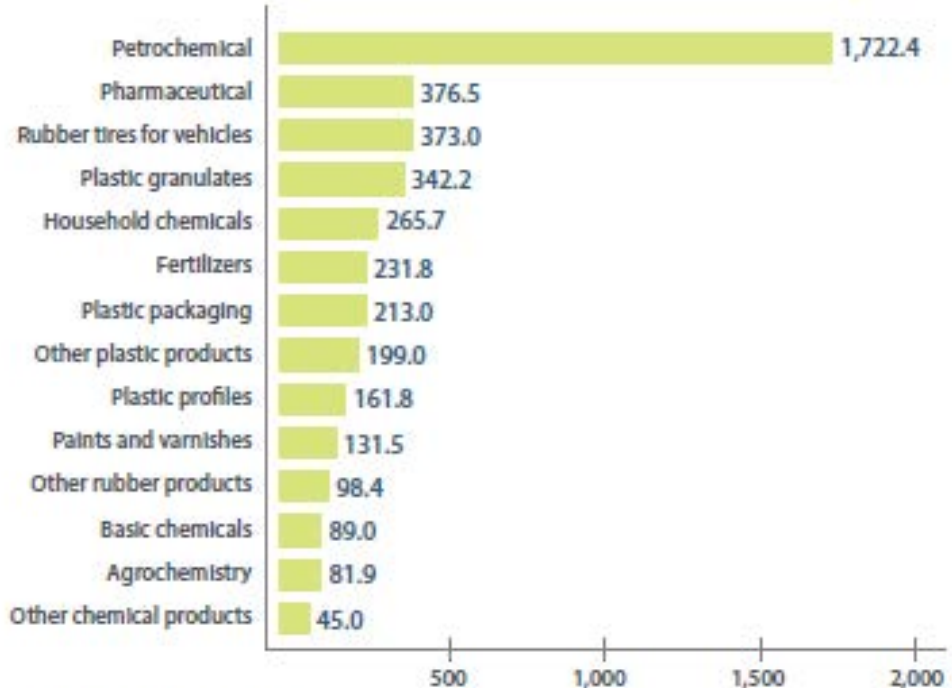

Figure 5.1: Turnover chemical industry sector 2015, million EUR

Petrochemical industry joint stock company majority owned by "Gazprom Neft". Russian company owns 56.15 % of the share capital of NIS, while 29.87 % of NIS shares are held by the Republic of Serbia. In Serbia, NIS owns a refining compound, with two units, one in Pancevo and the other in Novi Sad (not in operation), which produce a wide range of petroleum products – from motor fuel and diesel fuel, through aviation fuel, to industrial lubricants and feedstock for petrochemical industry.

NIS operates the Pančevo Oil Refinery, one ofthe most modern in the Balkans Refinery's maximum annual installed capacity is 4.8 million tonnes [36]. The Refinery's current key investment project is the construction of the Delayed Coking Unit: an investment worth €300 million [36]. In Serbia andother countries in the region (Bosnia and Herzegovina, Bulgaria and Romania), NIS operates a network of more than 400 petrol stations and over 20 %of the retail chain is located outside Serbia. As its separate business segments, NIS is developingjet fuelsales, bunkering services and lubricant and bitumen sales and distribution. NIS exports: energy and motor fuels, gas, lubricants, aromatics.

NIS engages in generationofheat and electricityusingconventional and renewable sources, production and sales of compressed natural gas, sales of natural gas, electricity trade, development and implementationof strategic energy projects, development and implementationof energy efficiency improvementprojectsIn Serbia's oil and gas fields, NIS owns 14 small heat and electricity generating power plants, withthemaximum capacity of14.5 MW. Key development projects under way [36]:

- Combined-cycle heat and power plant (CCPP) Pančevo – installed capacity: 196 MW
- Wind Farm Plandište – installed capacity: 102 MW

Another investment cycle has been launched, envisaging investments worth €2 bilion in the period between 2017 and 2025.

JSC "HIP-Petrohemija" Pancevo (HIPP) is the largest petrochemical company in Serbia and organized as a joint stock company majority owned by the state of Serbia with its institutions and state-owned companies (76%), oil companies NISa.d. NoviSad (21%) and Lukoil Srbijaa.d.Beograd (3%) [35].

It's designed to produce around 650 000 tpy of petrochemical products: Ethylene as excess to needs of captive polyethylene production, Propylene, 1,3-butadiene as excess to SBR (styrene–butadiene rubber) needs, MTBE (methyl tertbutylether), HDPE (high-density polyethylene), LDPE (low-density polyethylene), and

around 100 000–200 000 tpy of by-products (pyrolysis gasoline, pyrolysis fuel oil, raffinate II) at production sites in Pancevo (southern Vojvodina), and Elemir.

HIPP also operates two plants to produce HDPE pipes and fittings at location Luka Dunav, and HDPE granules near town of Crepaja. The production program includes: Polyethylene pipes (telecommunication, gas, water); Fabricated fittings (Equal Tees, Reducing Tees, Reducer Couplers, Elbows, Cross branches, End Caps, Stub Flanges); Corrugated Electro-Insulating Pipes. In July 2010 HIP-Petrohemija and NIS signed an agreement regarding strategic cooperation in long-term naphtha supply (Figure 5.4 [37]).

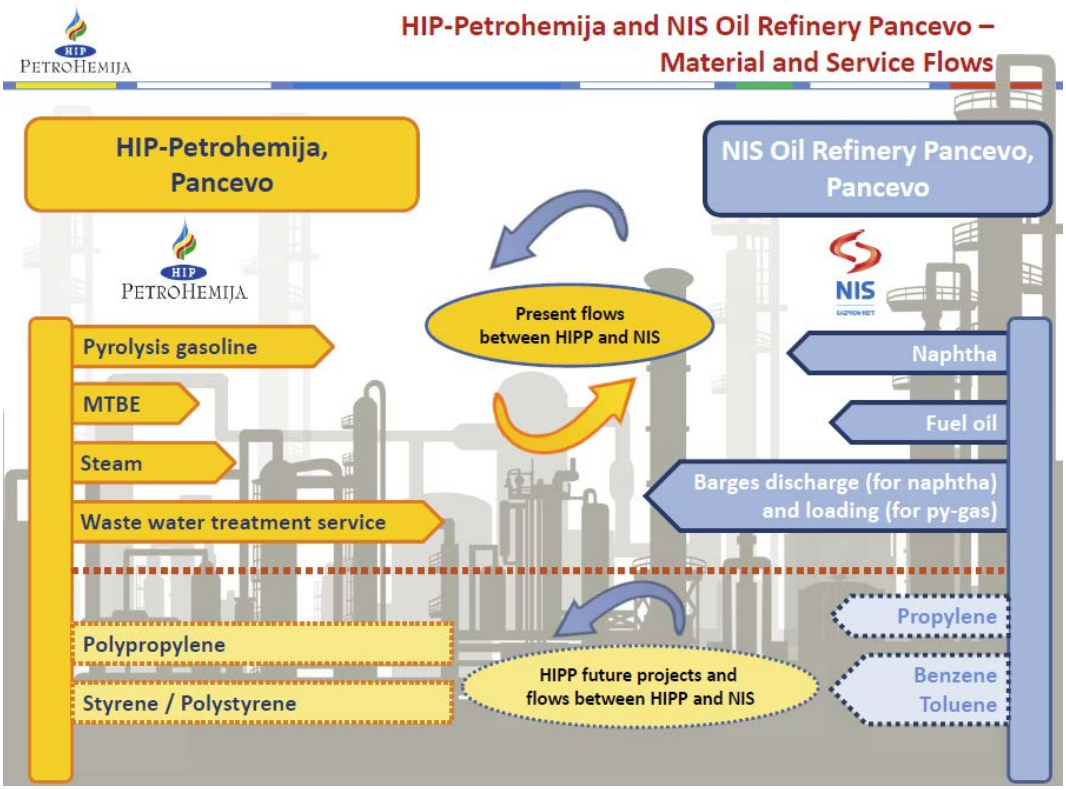

Figure 5.2: Cooperation between HIPP and NIS

In the period 2017-2020 the realization of projects fully financed by own resources will be completed, in total amount of EUR 23.5 million [37]. Capital projects are carried out in:

- Ethylene Plant - Operational and energy efficiency improvement - Gasoline tank reconstruction, compressors retrofit, reinstrumentation - Total EUR 7 million
- HDPE Plant - Capacity increase - new catalyst activator, new extrusion and packaging trains - Total EUR 11.1 million
- LDPE Plant - Operational efficiency improvement - Hyper compressor reconstruction, new packaging train - Total EUR 3 mill.
- SBR Plant - Operational efficiency improvement - New air purification unit - Total EUR 1.2 million
- Utility Plant - Energy efficiency improvement - Cooling towers reconstruction - Total EUR 1.2 milion.

JSC "Hipol" Odžaci, a joint stock company majority owned by the state of Serbia. It is located on production site near town of Odžaci, western Vojvodina. It has capacity to produce 35 000 tpy polypropylene, 300–400 tpy atactic polypropylene (APP) and 20 000–30 000 tpy propylene – "polymer grade" (as excess to polypropylene plant's needs) [35]. Company also operates two distillation columns to process light naphtha (C3–C6 fraction) and produce 50 000 tpy LPG and C5–C6 residue for its partner.

JSC "Methanol–Acetic Acid Complex" (MSK) is a joint stock company majority owned by the Public Company "Srbijagas". It has capacity to produce 200 000 tpy of methanol, 100 000 tpy of acetic acid (glacial), and 220 000 tpy oxygen. Basic products in MSK production programme are Methanol (Technical and purssimum) and

Acetic Acid (Technical, Pharmaceutical and Acetic Acid for Food Industry), Nitrogen, Liquid oxygen and Demineralized water [35]. MSK follows intensively the global trade flows at the world market while considering the possible future products and technologies based on Methanol and Acetic Acid, in order to expand the product range of its offer, both in the region and in wider context. The most important MSK development directions are: development of Acetate chemistry, Methanol energy valorization and increase of energy efficiency.

Serbian Pharmaceutical market is one of larger markets in Central and Eastern European region. Serbian Drug and Medicaments Agency is responsible for regulation of Serbian pharmaceutical market: issuances of the licenses and placing of drugs on the list, licenses for clinical testing of drugs and medicaments; monitors undesired reaction to drugs; approves advertising of drugs and medicaments; exercises quality control of drugs and medicaments and engages in other task and assignments specified by the law. The drug production includes the complete drug production process or certain parts of the production process, active substance production, raw material procurement, drug quality control and market release of drug batch, drug storage and distribution. More than 30 pharmaceutical companies perform their business activities in Serbia [35].

The chemical industry shows the most dynamic export performance. In addition to the rubber and plastics sectors, the following sectors also have high development potential: production of basic chemicals; agrochemistry; paints and varnishes; as well as household chemicals and personal hygiene products. Other chemical and pharmaceutical products have shown solid development potential [39].

5.2 Wood and furniture industry

Over the past decade, Serbia's wood has been one of the most attractive sectors for foreign investors [18, 38]. Companies such as French Tarkett, Italian Ditre and Gruppo Fantoni, Austrian Kronospan have built factories in Serbia to supply not only the local market, but also the EU and the ever-growing Russian market.

However, despite the relatively good performance, the potential and space for their improvement still exist. They are located in the segment of more efficient use of wood raw materials as well as in its focus on products with high added value. The production of furniture and other products with a high degree of finalization represent the main development potentials of this industry. At the same time, the adequate allocation of wood resources to producers of high value-added wood export products will enable the creation of thousands of new jobs in mostly underdeveloped areas rich in forests.

At the end of 2015, there were 2 598 companies active in the wood and furniture industry of Serbia, of which 1,806 were engaged in wood processing, and 792 companies were engaged in furniture production (Figure 5.5 [38]). To this number of companies, it is necessary to add 1 961 active entrepreneurs, so that the total number of active companies in the wood and furniture industry of Serbia at the end of 2015 was 4 559. The average annual growth rate of the number of companies in this sector was 4.4 % for the period 2007-2015. The largest number of companies in the wood processing segment is engaged in the production of sawn timber (649), followed by companies engaged in the production of construction joinery (433) and other wood products (446). The largest number of companies in the segment of furniture production is engaged in the production of other furniture (441), followed by companies engaged in the production of office furniture (219) and kitchen furniture (103) [38]. Observed by size, the most represented category of companies in this sector are micro and small companies. The share of medium and large companies is very small, in the wood industry 0.5 %, and in furniture production 1.8 %. This structure of companies is relatively unfavorable from the point of view of export competitiveness and their positions in the main export markets.

The largest number of registered companies is located in the regions with the lowest forest cover (Figure 5.6 [38]). In some regions, above all Bačka and the city of Belgrade, installed capacities for which it is necessary to provide a high percentage of raw materials by bringing them from the side with a distance of over 300 km. In other regions, such as Bor, Zajecar and Pirot districts, the number of companies engaged in the processing of technical roundwood is extremely small.

Figure 5.1: Number of active companies in the wood industry of Serbia in the period 2007-2015

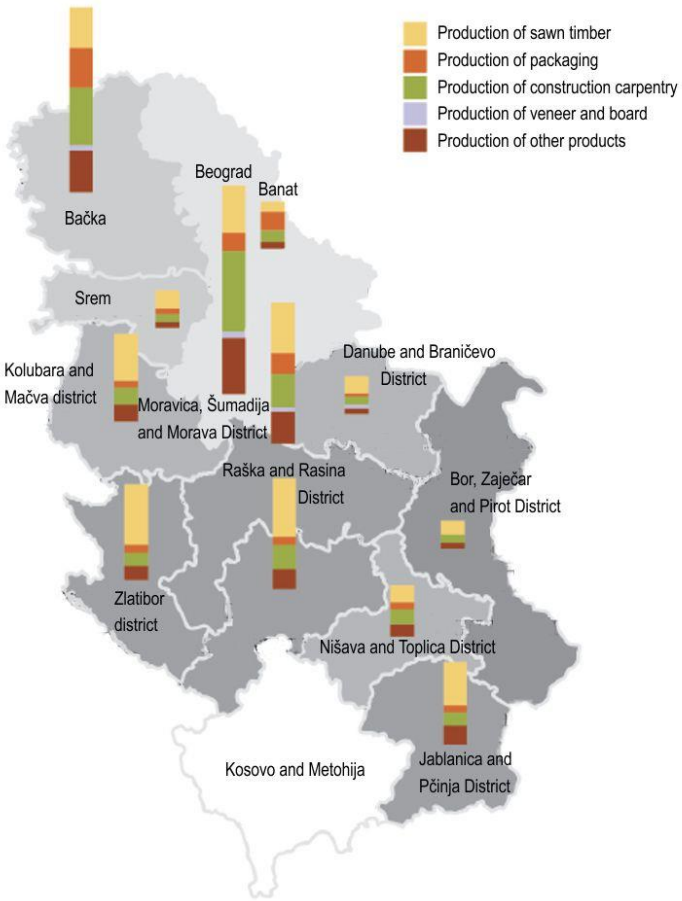

Figure 5.2: Territorial distribution of wood processing companies in Serbia

According to the business results of all subsectors in the period 2010-2015, it was found that furniture and wood flooring production make the greatest contribution to the growth of the sector as a whole because they represent the two most successful subsectors despite the fact that wood flooring had a negative growth rate in the observed period. The worst results are achieved by the subsectors of veneer production and wood-based panels, as well as the subsector of construction joinery and elements. There is a significant number of successful companies in all subsectors, and their total number at the level of the entire sector in 2015 was 588, which represented 22.6 % of the total number of companies. These 588 successful companies generated 62 % of the total operating revenues in the sector in 2015 [38].

The process of production and marketing of certified wood products today is fully completed and consists of 3 segments (Figure 5.7 [38]).

Figure 5.3: Chain of forest certification, production and sale of wood products

The analysis of the current state of the wood and furniture industry shows that they represent the branches that can generate the largest number of new jobs in Serbia in the shortest possible time (estimates between 10 and 12 thousand in the next five years). On the other hand, insufficient use of the available potentials of the sector requires fast and efficient institutional support, which would create the conditions for dynamic growth of production and reaching exports of over 700 million USD annually.

The wood industry represents a great untapped potential - the utilization of raw materials is not complete, it is used in an inefficient way, and without employment in their best use. Reasons for this range from problems related to the ownership structure, inaccessibility of certain areas, to inefficient forest management and illegal logging and timber trade. On the other hand, the used part of the forest raw material is not employed in the production of those products that create the greatest added value. The chance of the wood industry is reflected in the exploitation of potential along the entire value chain - from the raw material itself, through the products of primary and secondary processing, all the way to the final products that can find their placement in foreign markets. In the process, space is opened for a large number of companies: from warehouses and saw mills, through those that will produce panels and plywood, construction beams, to final products such as wooden barrels, wooden packaging, windows and doors, furniture, etc. As the whole industry is labor intensive, by employing all the links of the value chain, wide effects can be achieved for the burning problems of the whole economy [39].

In Serbia, wood can be interesting for the production of viscose, but it does not exist in Serbia. Given the modern technologies of viscose production and the possibility of meeting all requirements in terms of environmental protection, this production may be interesting for Serbia in the coming period.

Textile industry

Textile industry in Serbia has a long-standing tradition and for many years have been one of the main export industries. Production of textiles, garments, leather and leather items is performed by about 2 000 companies [36]. The exports of this sector recorded the value exceeding USD 1 billion. Admirable tradition, high-quality products at competitive price, together with skilled workforce are the main reasons for attracting the clients and importers to work with the Serbian companies.

Furthermore, over the last 10 years, the Serbian fashion industry has evolved from a domestic, manufacturing-based industry into a design-led sector operating in the global marketplace. Many Serbian design students go on to work in global fashion houses which promote the Serbian fashion industry abroad. Serbia has also managed to develop the successful Serbian fashion brands operating on the domestic and foreign market.

Sector Highlights are:

- High quality goods and "fashion sense"
- Flexible, reliable and quick delivery tailored to customer needs
- Serbia has also own fashion brands
- Short delivery time and reasonable transportation costs
- Long tradition in providing services to global industry leaders

FTAs with EU, Russia, USA, CEFTA, EFTA, Turkey, Belarus and Kazakhstan, enabling efficient access to various markets.

5.3 Current bio-based industries

In Serbia, this type of industry has not been significantly developed so far. Initiatives for the development of this industry are emerging, especially in the private sector. Below are some of the examples that are already in business or in the start-up phase.

Fill company manufactures paper sippers. Production of biodegradable paper sippers is completed, which are made of food materials, i.e. materials that are healthy, enabling premium quality. The materials are certified by the FDA, as well as by the Republic of Serbia. Sippers are exported to Austria and Slovenia. The production program includes different diameter of sippers: 6, 8, 10 and 12 mm with standard length of 210 mm, but other dimensions are made as needed.

Polimer Commerce was founded in 2008, and it started selling Polystyrene (PS) and Polyethylene-Terephthalate (PET) foils, and soon the production of confectionery packaging, from the above-mentioned foils, began.

For 6 years of existence, Polimer Commerce works for leading companies in the confectionery, dairy, ice cream and frozen food industries (Bambi AD Požarevac, Imlek AD Belgrade, Mlekara AD Subotica, Frikom AD Belgrade, Niška Mlekara AD, Kuč Company. Doo, Mlekoprodukt Zrenjanin, Meggle Doo Serbia...) In 2012, Polimer Commerce completed a new business facility and a hall that follows all world standards of quality and environment. All machines are thermoformers, so this form of plastic processing is represented in Polimer Commerc.

The products are made of PS, PET and PVC foils, depending on the customer's needs, and currently in its range the company makes more than 30 different shapes of dishes and lids for various customers. All products have accompanying documentation and health certificates. The products can be divided into two categories: confectionery industry and dairy industry and ice cream industry.

About a third of Polimer komerc's products are exported to six countries. In addition to Serbian, they also supply the markets of Croatia, Macedonia, Romania, Bulgaria and Austria, and a certain amount has already gone to Germany. Since the production of packaging for the cosmetics industry has begun, some of the products will be found in America and Vietnam. It is planned to start exporting to the United Arab Emirates next year.

The company Polimer komerc from the municipality of Plandište was the first in Serbia to start making bio-based packaging. For now, they are experimentally using granules made from corn starch in order to start supplying products made of biodegradable material to the market.

As a company focused on environmental protection, a new packaging has been developed - glass Eco Friendly boxes. The glass container for cosmetics is made of a mixture of plastic and wood flakes, which reduces the length of decomposition of plastic.

In particular, producers who produce their natural preparations from traditionally grown aromatic and medicinal plants originating from Serbia can be highlighted. These producers are engaged in the production of dietary products, natural cosmetics, phytopreparations, essential oils, hydrolates and plant extracts. All these manufacturers actively participate in various innovative projects that enable the development of technologically original processes and products of plant origin for the needs of the pharmaceutical and cosmetic industries. All Nut company produces plum stone flour and apricot kernel flour, i.e. hazelnut flour used in the diet. These types of flour are ground defatted oil cake that is obtained as a residue when squeezing plum/apricot kernel oil, or defatted oil cake that is obtained as a residue when squeezing hazelnut oil.

The main manufacturers of these products are shown in Table 5.1.1.

Table 5.3.1: Manufacturers

Company name	Location	Company name	Location
Hemel http://www.hemelshop.rs/	Jagodina	All Nut www.allnut.rs	Beograd
Bioss https://www.bioss.rs	Beograd	Marigold https://www.marigoldlab.com/	Apatin
Lala ulje http://lalaulje.com	Crepaja	Herba http://www.herba.co.rs	Beograd
Golden Oil http://www.goldenoil.co.rs	Backo Petrovo Selo	SabiHandmade https://www.sabihandmade.com/	

Ethanol production in Serbia is based on molasses and cereals. Table 5.1.2 shows the existing industrial plants for bioethanol production, their capacities and raw materials used for production.

Table 5.3.2: Bioethanol production in Serbia

Company name	Location	Raw material	Annual capacity	Quality
Alpis http://www.alpis.rs	Kovin	Molasses obtained from the sugar production process.	10 000 000 l	Refined ethyl alcohol with a concentration of 96 % *v/v*. BUCKAU WALTHER technology in a semi-continuous process.
REAHEM D.O.O. http://www.reahem.rs	Novi Sad	Molasses and corn, and raw materials of starch origin from the food industry		Refined ethyl alcohol 96 % Ethyl alcohol 70 %
Etanol Lab D.o.o. http://etanollab.rs	Šabac	Raw materials of grain origin	2 500 000 l	Refined and absolute (dry) ethanol 96 and 99 %
Panon	Crvenka	Molasses	30 000 l per day	Refined ethyl alcohol 96 % Ethyl alcohol 70 %

5.4 Food and feed ingredients industries

SRIP HRANA[33] is a long-term Strategic Research and Innovation partnership for Sustainable Food Production. It has developed into a dynamic community of agriculture holdings, companies, cooperatives, research institutions, investors and other interested parties, whose main interests are focused on improvement of research and development activities in the companies for the purpose of agri-food sector development. As it is coordinated by the Chamber of Commerce and Industry of Slovenia, it includes all leading stakeholders.

The food and beverage sector is by far the largest export sector in Serbia (EUR 1 665 million, 11.7 % of total exports) after means of transport and equipment [29]. The fruit and vegetable processing subsector is by far the most competitive subsector (total exports amount to EUR 430 million, and including the agricultural segment, over EUR 700 million), with Serbia being among the largest European producers of raspberries, plums, quinces and peppers. Nevertheless, there is much room for increasing competitiveness through diversification, increased commercialization, and the extension of all value chains. The competitiveness of the sector is largely based on extremely favorable soil and climatic conditions in Serbia. A large part of the land is uncultivated (11 % in total and 9 % south of Vojvodina), average yields per hectare of cultivated land are low (37 % lower than the EU average for the same portfolio of primary products) and the product range is relatively low-value and/or short value chain.

Trade balance of agricultural products is in constant surplus. In 2018, Serbia had high surplus that amounted 1.1 billion EUR, with increase of export for 1.1% compared to 2017 (Figure 5.1.1 [30]). Serbia is the biggest exporter of foodstuff among CEFTA countries and the only net exporter. The structure of the export in 2018 is shown in Table 5.1.3 [30].

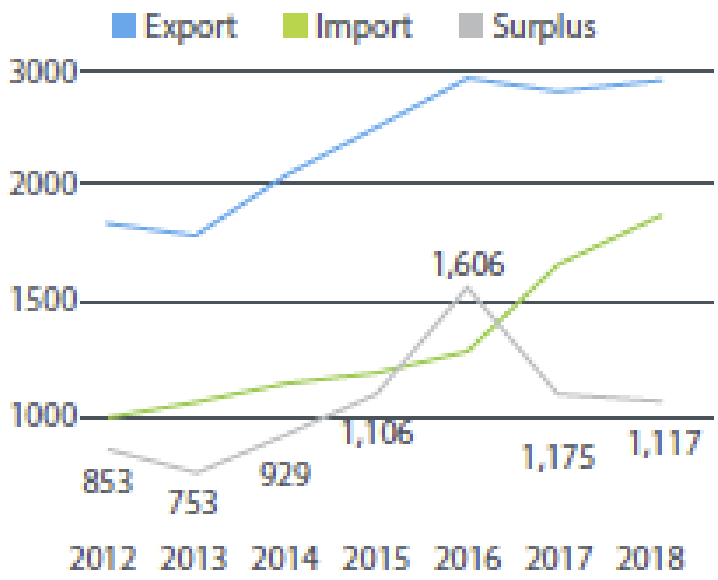

Figure 5.4.1: Trade balance in agricultural products (EUR million)

Table 5.4.1: Main export products in 2018

Product	EUR mil	Product	EUR mil
Raspberries, blackbarries, currants frozen	220.2	Food preparations for animals	60.8
Corn, other than seeds	196.5	Non-achocolic beverages, other than fruit juices	58.6

Wheat	163.0	Sunflower seeds	56.1
Apples, fresh	85.1	Sunflower oil	54.0
Other fruits, not fresh	82.7		

Fruit production is one of the key sub-sectors of Serbia's economic development and therefore given a strategic treatment by the Government of Serbia. In 2018 export of Serbian fruits amounted 520.5 millions of EUR [30]. Serbia is in the top 3 largest providers of frozen fruit to Austria, Russian Federation and Germany in 2018. In 2018 Serbia's export of frozen raspberries, blackberries, mulberries, etc, represents 29% of world exports placing Serbia No.1 exporter of this group of products in the world. With around 135 000 tonnes exported with total value of more than 221.1 EUR million, Serbia was largest exporter of frozen raspberries, blackberries, mulberries, etc, in 2018 globally. Around 90-95% of raspberry production is intended for export, mainly frozen in bulk. This constitutes a huge potential for investors who are thinking to start a production of final products with all kinds of different berries such as: spreads, jams, toppings, ingredients for ice-cream industry, fruit cubes for yoghurt production, etc.

Besides berries, another fruit production has an important role in agricultural system of the country. In 2018, Serbia was, measured by value of apples, the first exporter from Europe to Russian Federation. Serbia exports around 100 million EUR of apples annually [30]. Massive apple orchards are expanding all across Serbia, especially in Vojvodina with premium melioration systems, trendy varieties and expensive anti-hail nets.

Ideal climate for vegetable production makes Serbia the main vegetable exporter and supplier of the South Eastern Europe. The most popular vegetables produced in Serbia are: paprika (pepper), cabbage, tomato and potato. Vegetable production in 2018 is shown in Table 5.1.4 [30].

Pepper production is oriented towards pasteurized pepper in different forms: shredded, cooked and roasted. Due to dry matter in it, majority of red pepper is used for production of aromatic spices, but also for preparing a traditional Serbian winter dish - "Ajvar" spread. Ajvar is prepared using a special recipe, with red peppers and eggplants, and could nowadays easily be found on every continent. Serbia has two very famous markets and pepper production centers: Leskovac area for production of dry and fresh pepper and northern Serbia for production of mild, hot, and crushed pepper for industrial spices. Cabbage production is second important in Serbia and it is traditional winter dish. Serbian sauerkraut is considered delicacy and local consumption during the winter is enormous. In the last few years, production of green peas and sweet corn is in constant rise due to the increased consumption of frozen, ready-toeat, meals worldwide.

Table 5.4.2: Vegetable production in 2018

Product	Quantity (tonnes)
Potato	487 909
Cabbage	209 353
Melon and watermelon	199 419
Paprika	135 072
Tomato	131 869
Cucumber	42 539
Peas	29 261
Onion	27 967

Livestock farming and meat processing in Serbia have a long tradition. The most popular meat products are fresh or smoked pork and beef, as well as poultry. At the same time, products such as pate, dry sausage of different types, hot dogs and smoked beef and pork are widely spread through all chains of supermarkets in the Balkan region. Serbian slaughterhouses and meat processing houses have a strong position on the CEFTA

market. However, Serbia's livestock has decreased over the last decade by 15 % on average, with lack of investments being one of the main reasons behind [30]. That creates additional investment opportunities to match production capacities with the plenty of opportunity for further development of international placement.

Free Trade Agreement define new quotas for duty free export from Serbia to Turkey, pertaining to beef, sunflower oil, sunflower seeds, soybeans, animal feed and pet food, and the quotas for export of peas, beans, green peas, sweet corn and prunes have been increased. Serbia would be able to export, free of duty, 5 000 tonnes of fresh, chilled or frozen beef thanks to Free trade agreement with a Turkey [30].

Besides "kajmak", a creamy dairy spread originally made in Serbia, Serbia has various dairy products to offer internationally. Sour yoghurt, paprika in sour cream and white soft and hard cheeses are among the most popular ones. Fresh and pasteurized milk of the highest quality is mainly used for meeting high local consumption, but also easily finds export markets in the neighbouring Montenegro and Bosnia and Herzegovina [30]. However, after stabilisation of the domestic dairy market, Serbian export companies began to think more about conquering new markets, primarily Russia and Turkey. So far, White salad cheese, sour cream spread, hard cheese and goat cheese have already found their customers on the demanding Russian market.

On more than 15 000 hectares of agricultural land, Serbian organic production mostly consists of fruits and field crops, with constant growth of cereals and oilseeds production. Most of these products are exported to the EU (Germany, Netherlands) and US market, but also there is high demand on the domestic market [30]. Demand for organically grown producers exists in many countries, and Serbia with 2 000 produces of organic food, has excellent ecoclimatic and technical conditions to cultivated, in addition to berries and fruits that are traditionally grown, also organic cereals and oilseeds (Table 5.1.5 [31]).

Table 5.4.3: Areas by plant srtructure in 2015

Category	Areas in conversion (ha)	Areas in organic status (ha)	Total (ha)
Cereals	2 069	2 183	4 252
Industrial plants	1 216	1 458	2 674
Vegetables	45.6	124.9	170.5
Fooder	397.6	1 042	1 440
Fruit	1 291	1 604	2 895
Medicinal and aromatic plants	2.7	68.3	71
Other	1 845	50.4	1 895
Total arable land	6 867	6 531	13 398
Pastures/meadows	803	1 097	1 900
TOTAL	7 669.5	7 628.5	15 298

Main Serbian organic products are:

- Grain and industrial plant: wheat, maize, barley, triticale, oat, rye, potato, flax, oilseed rape, sugar beet, sunflower, soy;
- Fruit: raspberry, cherry, blackberry, blueberry, apple, plum, peach, pear, quince, grape, aronia;
- Vegetable: paprika, cabbage, zucchini, onion, carrot, cauliflower, broccoli, pumpkin, melon, watermelon;
- Livestock products;
- Honey, propolis;
- Fattened carp;
- Spice and medicinal herbs, wild as well as collected in natural conditions.

During 2015 in animal husbandry was noted growth in number of heads of animals in comparison to the previous year (Table 5.1.6 [31]).

Table 5.4.4: Organic animal production in 2015

Animal	Number of heads/unts Conversion period	Number of heads/units Organic status	Total
Sheep	1 616	3 232	4 848
Pigs	132	100	232
Cattle	153	2 593	2 746
Goats	569	1 117	1 686
Poultry	301	1 079	1 380
Donkeys	4	16	20
Horse	128	90	218
Beehives	2 033	471	2 504

Of relevance for the organic sector are companies operating in the fruit and vegetable sectors. Cold storages dominate in organic sector due to common opinion that certicate for cold storage can be obtained easier than for whole technology line. More then 40 food processing companies also process organic products, virtually all of them processing conventional produce while operating an organic line additionally. Some of the primary producers also process their own produce, still majority cooperates with bigger processors. Few processors are dealing only with processing of organic raw material. According to data of Serbian Chamber of Commerce and Industry 520 processing facilities have been registered with the exploitation rate of 80%.

Post-harvest operations and processing of organic raspberry and blackberry is done by the companies that purchase fruits and have cold storages or processing lines. In Serbia with secondary processing - drying of fruits and vegetables, and juice production deals 85 entities with the total capacity of 565 000 tonnes [31, 32]. Capacity exploitation rate is around 50%. Significant part of processing capacities refers to production of fruit and vegetables juices. Annually production capacity of fruit juices is around 240 million litres showing that Serbia is a serious producer in the region.

The structure of processed organic products in 2017 is shown in Table 5.1.7 [33].

Table 5.4.5: Processed organic products in 2017

Product type	Quantity	Product type	Quantity
Mill products (flour, cereals)	713 103 kg	Honey Bee products	5 965 kg 3 670.40 kg
Bakery products (bread and pastries), pasta and biscuits	165 011.32 kg	Soy products	500 000 kg
Milk (raw, pasteurized) Dairy products (cheese, yogurt, sour cream, sour milk)	9 038 998.01 l 1 121 500 kg	Baby food	15 500 kg
Meat Beef fat	28 500 kg 1 500	Dried mushrooms Other mushroom products	61 100 kg 120 000 kg
Frozen fruit, dried fruit, fruit products (jam, juice and spread) and other fruit products	25 694 585.13 kg (juice 5 340 109 l Jam122 160 kg Spreads 3 500 kg Other products 3 003 971.86 kg)	Tea	9 088.20 kg
Frozen vegetables, dried vegetables and other vegetable products	129 390 kg (27 075 kg ostali proizvodi)	Eggs	190 040 pieces
Vegetable oils (edible and essential) Oilseed spread	263 165.06 l 494 485.80 kg	Other products	1 251 721.80 kg

Serbia Organica is a national association for the development of organic production (https://serbiaorganica.info). It is an independent, non-government and non-profit organization which serves as a one-stop-information-shop for investors, advising on potential investment opportunities and partners. Mission of the Union is to establish organic production as reliable and competitive agribusiness industry on domestic as well as on foreign market, but also to put 20% of agricultural land (1 million ha) under organic production over the next 10 years [31].

Since livestock production occupies an important place in agricultural production in Serbia, the feed and fodder sector is relevant in the country rural economy. Dominant fodder crops which cultivated for use in this sector for feed are maize for forage, clover and alfalfa (lucerne). There are approximately 100 producers of animal feed in Republic of Serbia and the most important are liseted in Table 5.1.1.6 [1, 34]. The majority of the producers are with small production potentials and they have been operating only for couple of years. However, regarding the amount of the fodder crops production, all installed production capacities for animal feed could be used. Market trends and price fluctuations affect the viability of the animal feed production. For small producers with relatively low storage and production capacities it is most difficult to survive in this market.

Table 5.4.6: Production of the most important products in feed and fooder sector in 2019.

Product	Area (ha)	Production (t)	Yields (t/ha)
Maize	37 401	763 354	20.4
Clover for animal feed	61 725	283 503	4.6
Alfalfa (lucerne)	106 095	594 981	5.6

Production facilities in the feed and fodder sector of Serbia are relatively well distributed in the country regions. Although Vojvodina and Belgrade region are declared with the largest number of manufacturers for animal feed production. This is because of higher population density in that regions and higher raw materials and fodder crops availability. The main companies which deal with production of animal feed in Serbia are shown in Table 5.1.9 [34].

Table 5.4.7: The main producers of animal feed in Serbia

Company name	Location	Company name	Location
FSH Sto	Belgrade	AGROPRODUKT d.o.o.	Kragujevac
DOO "Gebi"	Čantavir	TONNEJA	Kraljevo
AGRO MIL	Pojate	PP "POMAK"	Kraljevo
FSH"DE HEUS" d.o.o	Šabac	STR "AGROPLUS"	Kragujevac
HRANA PRODUKT	Sremska Mitrovica	DOO BRANA "MM-KOMERC"	Varvarin
VETERINARSKI ZAVOD "SUBOTICA"	Subotica	NUSCIENCE PREMIX INTERNATIONAL	Velika Plana
PANTELIC d.o.o	Kraljevo	FSH INTERFOOD	Valjevo
FSH JABUKA	Pančevo	DOO DREN	Novi Sad
Konzul- PJ FSH "BAFI"	Novi Sad	FARMER d.o.o	Čačak
FSH Nutriko	Vranje	"MELBAT" ŠAJKAŠKA	Novi Sad
DEM KUPLIN	Kulpin	INBERG	Boljevci
AGROSMESA	Surčin, Belgarde	DOLINA GRUŽE	Kraljevo

The entire technological process of animal feed production in all factories is automated: by introducing computer technology, precise control and management of the production process has been achieved, and every possibility of error has practically been eliminated. In some of the production process the technologists, with the help of the most modern program for the optimization of mixtures and the latest knowledge in the field of nutrition of domestic animals, creates mixtures that meet the most stringent requirements of customers and prescribed standards. Some companies have established close cooperation with many faculties, mainly department for livestock breeding whose experts regularly monitor and control the quality of the products.

For the purpose of efficiency of production, the factories have modernized their production in order to meet the needs of their customers by investing in machinery and equipment, as well as by building a larger production and warehouse space. For example, company "NUTRIKO" has its own laboratory, equipped with state-of-the-art equipment for quality control of raw materials and finished products.

The business plans of companies from this sector have shown the intention for increase the production and export to other markets. For further market development different incentives have been recognized and planed for implementation in the future:

- Incentives for machinery purchasing for the preparation and distribution of animal feed.

Support through different financial mechanism of construction of fodder storage facilities.

5.5 Summary and conclusions in relation to SWOT elements

The main SWOT analysis findings considering the bio-based industries, products and markets are summarised in table 5.2.1.

Table 5.5.1: SWOT analysis of bio-based industries, products and markets in Serbia.

Strengths	**Weaknesses**
• Available domestic raw material resources (biomass). • Relatively high skilled workforce. • Significant number of employees in the manufacturing industry. • Growing participation of Serbian sectors in European and global value chains. • Existence of European and globally recognized manufacturers and brands in several industries. • High investment attractiveness. • Benefits for enlarging production and creating strong companies that can become regional leaders in production. • Business according to international quality standards (ISO, HACCP, etc.). • Existence of free trade exchange with the Russian Federation, the Republic of Belarus, the Republic of Turkey, members of EFTA, CEFTA, etc.	• Insufficient use of biomass as a raw material in industry. • Insufficient introduction of innovations and modern technologies in industry. • Undeveloped waste management system and low recycling rate. • Incomplete public sector transition process. • High share of low value-added products in exports. • Insufficient development of clusters and other forms of association. • Large imbalance in the level of development of different regions. • Insufficient connection of industry with scientific research and educational institutions. • Increasingly unfavorable demographic structure of the working age population. • Small number of alternative sources of financing and underdeveloped financial markets.
Opportunities	**Threats**
• Approaching to EU membership. • Restructuring of exports in the direction of increasing the share of products with high domestic added value. • Successful international positioning in the market of high quality industrial products and services. • Increasing energy efficiency and the degree of resource reuse in industrial production. • Encouraging effective interactions between university and research institutions and companies. • Forming effective public-private partnerships. • Additional harmonization of quality standards and other regulations of the industry of the Republic of Serbia with the EU. • Developing financial markets and providing access to alternative sources of financing. • Strengthening the awareness of domestic consumers about the advantages of products made of biomass in relation to similar or the same products from other (artificial) materials and thus creating conditions for the growth of demand in the domestic market. • Determination of the Government for the introduction of green procurement in the public procurement system of Serbia.	• Negative impact of certain macroeconomic policy measures. • Lack of domestic private capital for investment. • More unfavorable aspects in the business environment for industry, especially in the introduction of new technologies (public administration support, regulatory framework, judicial efficiency, etc.). • Low level of cooperation between domestic industrial economic entities. • Infrastructure differences. • Price parity of raw materials and energy.

6 Infrastructure, logistics and energy sector

6.1 Existing industrial hubs and harbours

1 680 km of inland waterways out of the 36 000 km of water networks in Europe, belong to the Republic of Serbia. The geographical position of the RS provides natural advantages for intensive waterborne transport thanks to the Danube, Sava and Tisa rivers.

The Danube River forms the basis of the waterway system of the Republic of Serbia. There are nine ports open for international traffic on the Danube River, on the Tisa River there is one port open for international traffic, while on the River Sava there are two ports open for domestic traffic: Sremska Mitrovica and Šabac [71]. Ports open for international traffic are: Apatin (port operator: Port "Napredak"), Belgrade (port operator: Port "Belgrade" (Figure 6.1.1)), Bačka Palanka (port operator: "Port Bačka Palanka"), Beočin (port operator: "BFC Lafarge"), Novi Sad (port operator: "Port of Novi Sad"), Pančevo (port operator: Port "Danube" Pančevo), Prahovo (port operator: "Prahovo Harbor"), Smederevo (port operator: Smederevo Ironworks), Bogojevo (port operator: "Danube Port Bogojevo"), and on Tisa it is Senta (port operator: "Port Senta"). Ports on domestic rivers are generally equipped with standard coastal rail and/or mobile coastal cranes. Today, ports do not fulfill their essential role as drivers of the development of the economic regions located in their hinterland. They are characterized by low traffic and relatively poor port infrastructure. The most significant characteristics of the ports are shown in Table 6.1.1 [71].

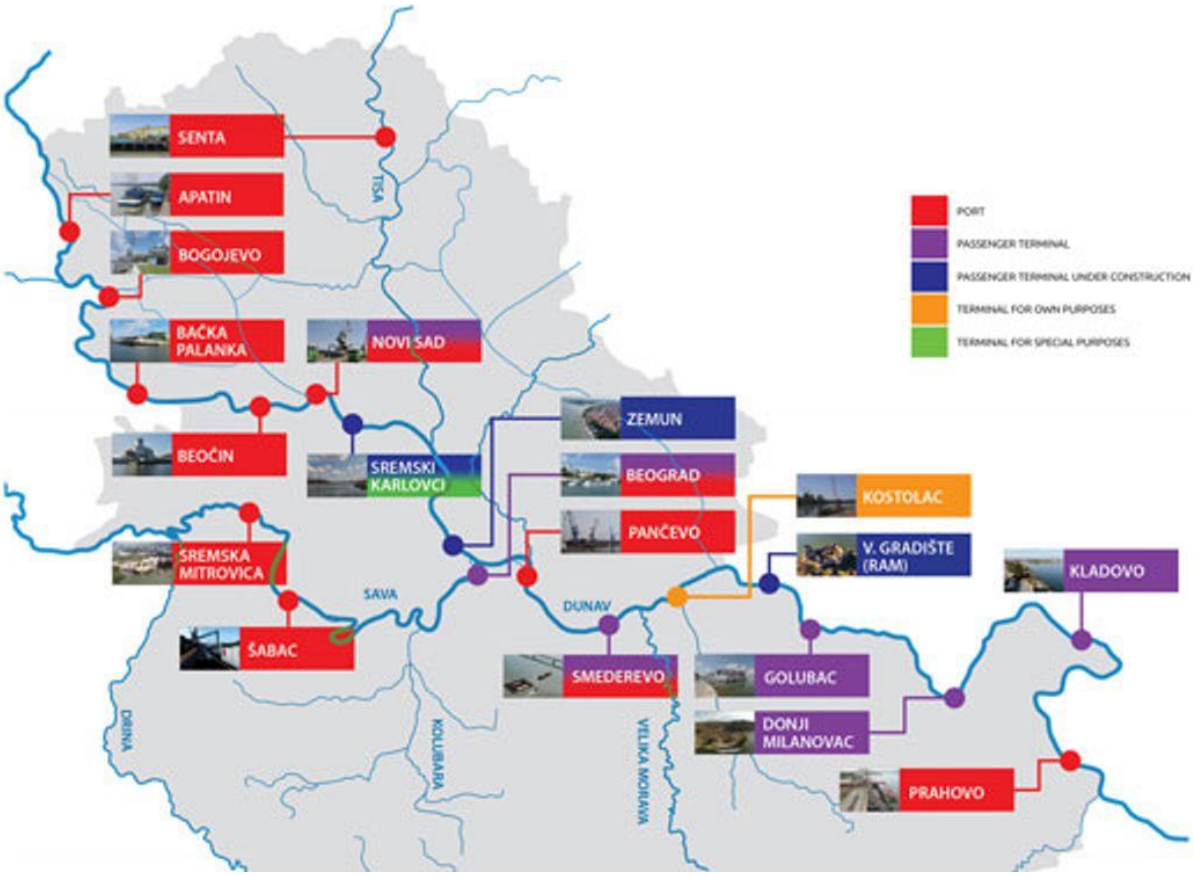

Figure 6.1.1: Cargo ports in Serbia [71]

Table 6.1.1: Main characteristics of river ports [71]

Port	km	Bank	Toral area (m2)	Characteristics
Apatin	1 401	Left	46 830	Provides the possibility of mooring three vessels simultaneously. The port is 70 km away from the E75 highway, direction Belgrade-Budapest, with 25 000 m² of open warehouses. The justification of the construction of the new port and the question of the status of the existing one are discussed.
Bogojevo	1 367	Left		The port has a silo capacity of 30 000 t; two road and one railway intake basket with a total capacity of 700 t/h; dryer with a capacity of 40 t/h; a portal crane with a capacity of 20 t; conveyor belt with a capacity of 400 t/h; closed storage area of 7500 m2; the necessary transshipment machinery and machinery for internal transport. Plans for the development of the port of Bogojevo directed to the complete port logistics center and to enable the construction and development of the intermodal terminal. In addition, the need to build storage facilities and associated port infrastructure was recognized.
Bačka Palanka	1 295	Left	1 168 100	The port is 30 km away from the E70 highway, Belgrade-Zagreb, and 45 km from the E75 highway, Belgrade-Budapest. The port is not connected to the national rail network. The company has 650 m² of closed warehouses and 8 260 m² of open warehouses in the function of public and public customs warehouses. The development plans are directed towards the construction of a container terminal, a liquid cargo terminal, as well as a grain handling and storage terminal.
Beočin	1 269	Right		The bulk cargo is transhipped in the port and it has an open warehouse with area of 28 000 m². A systemic solution for this port is considered in terms of its possible annexation to the port area of the port in Novi Sad, where this port would become a specialized bulk cargo terminal within the port of Novi Sad.
Novi Sad	1 254	Left	350 000	It has 44 000 m² of closed warehouses and 100 000 m² of open warehouses used as public and public customs warehouses. The volume of storage for petroleum products is 270 000 m³. Bulk cargoes, general cargoes, containers and liquid cargo are transhipped and stored. The development plans are based on increasing the handling of cereals, artificial fertilizers raw materials and artificial fertilizers and they include the extension of the operational shore - vertical quay, reconstruction of existing cranes and procurement of new

				handling equipment in order to increase the carrying capacity, modernization of the information system and development of automatic data processing.
Belgrade	1 168	Right	1 000 000	The port can handle eight vessels simultaneously. An industrial railway track over 12 km long is connected to the national railway network. It has 200 000 m² of closed warehouses and 600 000 m² of open warehouses. It has a container terminal for storing 10 000 TEUs annually. The structure of the new port in Belgrade should consist of: general cargo terminal, container terminal, bulk cargo terminal, liquid cargo terminal, RO-RO terminal, Hucke pack terminal, and other terminals.
Pančevo	1 153	Left	2 400 000	It has 40 000 m2 of closed warehouses and 100 000 m2 of open warehouses in the function of public and customs warehouses. The development plans primarily relate to the expansion of the port area, the construction of a new operational coast, the construction of new ones and the rehabilitation of existing port road roads, open storage facilities and industrial tracks within the future wider port area. In addition, it is planned to introduce multimodal traffic systems by constructing a container and Ro-Ro terminal.
Smederevo (old)	1 116	Right		U zavisnosti od obima proizvodnje Železare, godišnje se pretovari između 2.000 000 t i 4.000 000 t sirovine i gotovih proizvoda. Planovi razvoja luke u Smederevu obuhvataju izgradnju i proširenje operativne obale na lokaciji „Nove luke", kao i nabavka dodatnih portalnih dizalica.
Smederevo (new)	1 111	Right	31 000	
Kladovo	933	Right		-
Prahovo	861	Right	70 473	It has 2 000 m² of closed warehouses and 6 000 m² of open warehouses. The need to expand the port area and to build a hazardous cargo terminal, a container terminal, as well as to put into operation an existing grain silo or to build a new one, was recognized.
Senta	122 (river Tisa)	Right	12 000	It has 18 260 m² of closed warehouses, of which 1 290 m² consists of public customs warehouses and 20 000 m² of open warehouses, of which 5 000 m² are customs warehouses. The company also has a storage tank for liquefied petroleum gas (LPG) of 1 000 m³ capacity. The development plans include the construction of a silo with a dryer, a cold store, as well as the acquisition of other transshipment equipment.

The basic indicators of inland waterways and goods traffic in river ports in 2018 are presented in Tables 6.1.2 and 6.1.3 [1].

Transport of row materials, agricultural products, oils and construction materials (sand, stone and gravel) remains major cargo in Serbian inland water transport. In the cargo structure, bulk cargo dominates over general cargo, which is almost negligible. Agricultural products in bulk, as well as different fertilizers in bulk represent the majority of cargo transhipped in ports in Vojvodina. Imports of fertilizers are balancing still larger export volumes over the import of goods. The most commonly handled cargoes are grains, fertilizer components, scrap iron, ferrous metal products, etc. The percentage of goods transshipped in ports in 2017 on the rivers Danube, Sava and Tisa are given in Figure 6.1.2 and the structure of transhipped goods in Figure 6.1.3 [73].

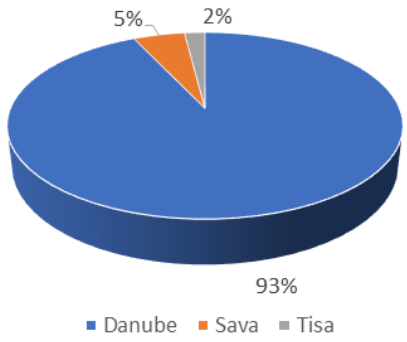

Figure 6.1.2: Percentage participation of the quantity of goods transported, by rivers

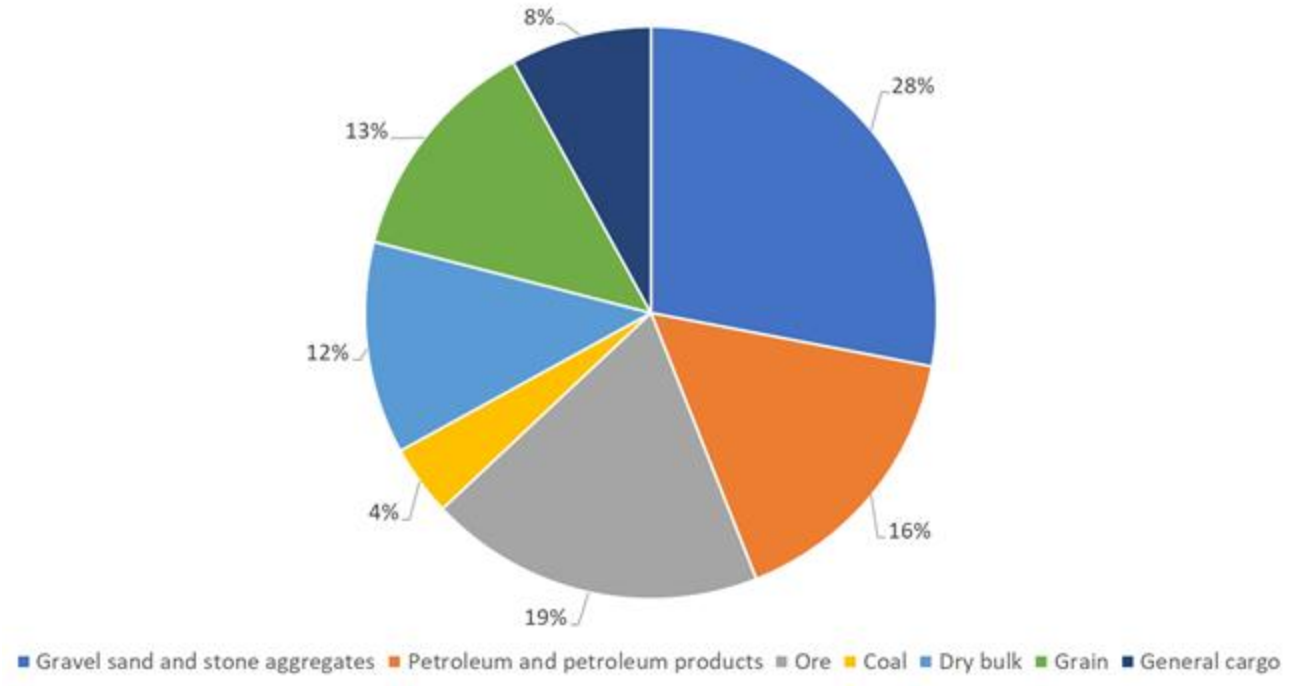

Figure 6.1.3: The percentage share of cargo in the total volume in 2017 (%)

Of the total traffic generated in ports, in 2018, exports were dominated by products from agriculture, hunting and forestry (1 297 thousand tonnes), and in the import of metal ore (2 569 thousand tonnes) [1].

Table 6.1.2: Basic indicator of inland waterway transport in 2018 [1]

Cargo vessels		Transport of goods, thous. t					Ton-kilometers, mil.
Total	Carrying capacity (tonnes, thous)	All	National transport	Exports	Imports	Transit	
123	134	1 599	1 044	150	305	60	580

Table 6.1.3: Goods traffic at river ports in 2018 [1]

Traffic									Transit		
Total traffic			National			International					
Total	Loading	Unloading	Total	Loading	Unloading	Total	Export	Import	Total	Upstream	Downstream
8 526	3 412	5 114	2 178	1 089	1 089	6 348	2 323	4 025	2 872	1 760	1 112

The continuation of investments will affect the continuation of the positive trend of increased cargo loads in the future and further development of existing ports.

There are currently 15 free zones active in the Republic of Serbia (Figure 6.1.4 [74]. Active free zones have generated a turnover of about 5 billion euros in 2018. There are over 200 multinational companies operating in the free zones of Serbia, employing over 35 000 people, while the investment in the zones amounts to three billion euros in 2018. The free zones currently existing in Serbia are: FZ Pirot, FZ Subotica, FZ Zrenjanin, FZ Novi Sad, FAS FZ Kragujevac, FZ Šumadija (Kragujevac), FZ Šabac, Užice, FZ Smederevo, FZ Kruševac, FZ Svilajnac, FZ Apatin, FZ Vranje, FZ Priboj and FZ Belgrade. They can handle all types of business and industrial activities including manufacturing, storage, packaging, trading, banking and insurance. Free zones can be established and managed by both domestic and foreign companies. By operating in free zones, the investor is provided with special benefits and a preferential tax regime (exemption from VAT and customs duty on imports with raw materials and materials intended for the production of export goods, machinery, equipment and construction materials). Import and export of goods to the zone is unlimited. Goods imported from the zone into the domestic market are subject to the regime of import of foreign goods. Employers within the free zone are allowed to rent business premises, workshops, warehouses under favorable conditions.

Figure 6.1.4: Free zones on the territory of the Republic of Serbia

Industrial zones are located in rural locations: Inđija, Šimanovci, Šabac, Zrenjanin, Stara Pazova, Mali Bajmok (Subotica), Ečka, Belgrade, Niš.

The transport and logistics centers are located in Dobanovci, Stara Pazova, Smederevo and Pirot (Table 6.1.4 [74, 75, 76, 77].

Table 6.1.4:

TL center	Company	Chararacteristics
Dobanovci	California Šped	Area - 1.5 ha, facility of 5 500 m^2 consisting of office building and warehouse space (public customs and national warehouse), and has floor and shelter storage of goods, with a capacity of more than 10 000 pallets.
Stara Pazova	DTS - Delta Transportni Sistem	Area – 20 730 m^2, with the possibility to build another 14 500 m^2 of storage space in the second phase. The capacity of the center is 26 000 pallets, with different temperature regimes, from -20 to + 25 °C.
Smederevo		The three-modal logistics center enables the connection of rail, road and river intermodal transport. A platform view of this center is given in Figure 6.1.4 [h].
Pirot		The designed terminal capacity is 25 000 TEU annually and the terminal is expected to start operating in 2020. Users will be provided with quick transhipment of goods from rail to trucks and vice versa, connection with other intermodal nodes in SE Europe.

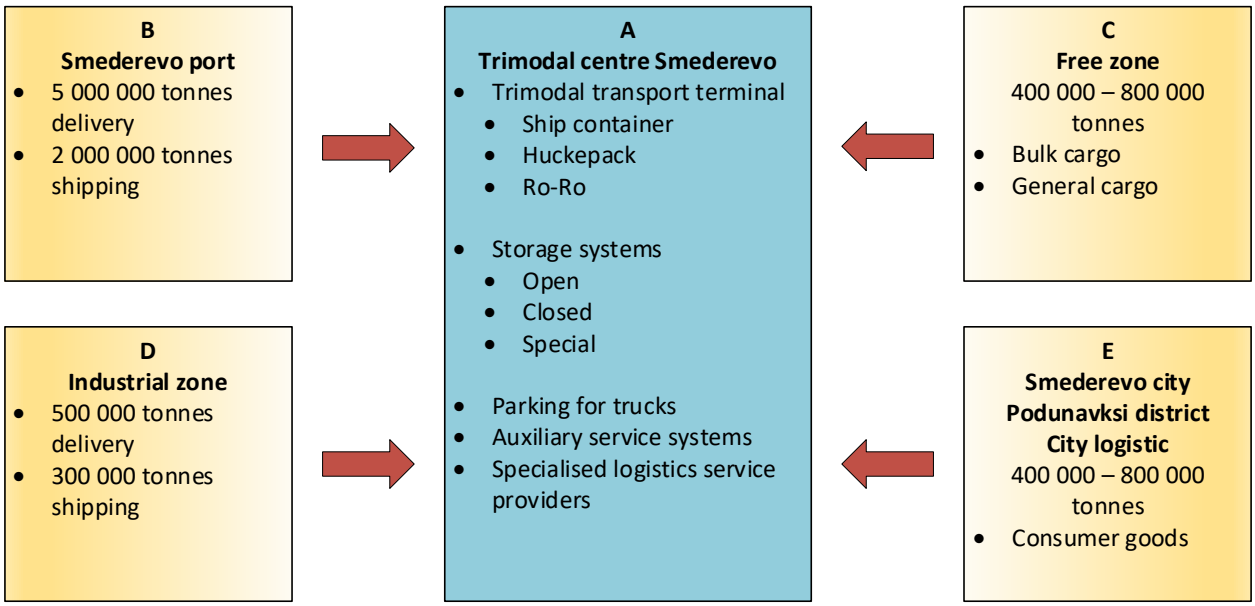

Figure 6.1.5: Intermodal logistic platform Smederevo

6.2 Existing railways

The main railway lines pass through all major cities and intersect in the zones of Belgrade and Niš. The total length of the railway line is 3 739 km, of which 3 444 km are single track and 295 double track [h]. Of these lengths: 1 762 km are main railway lines and 2 041 km for other railway lines. The total length of signle track main railway lines is 1 467 km, and of double track railway lines is 295 km (Figure 6.2.1 [h]). Accordingly, it follows that only 7.89 % of the railway lines in the Republic of Serbia are double track, which greatly limits the bandwidth and efficiency of the railway lines.

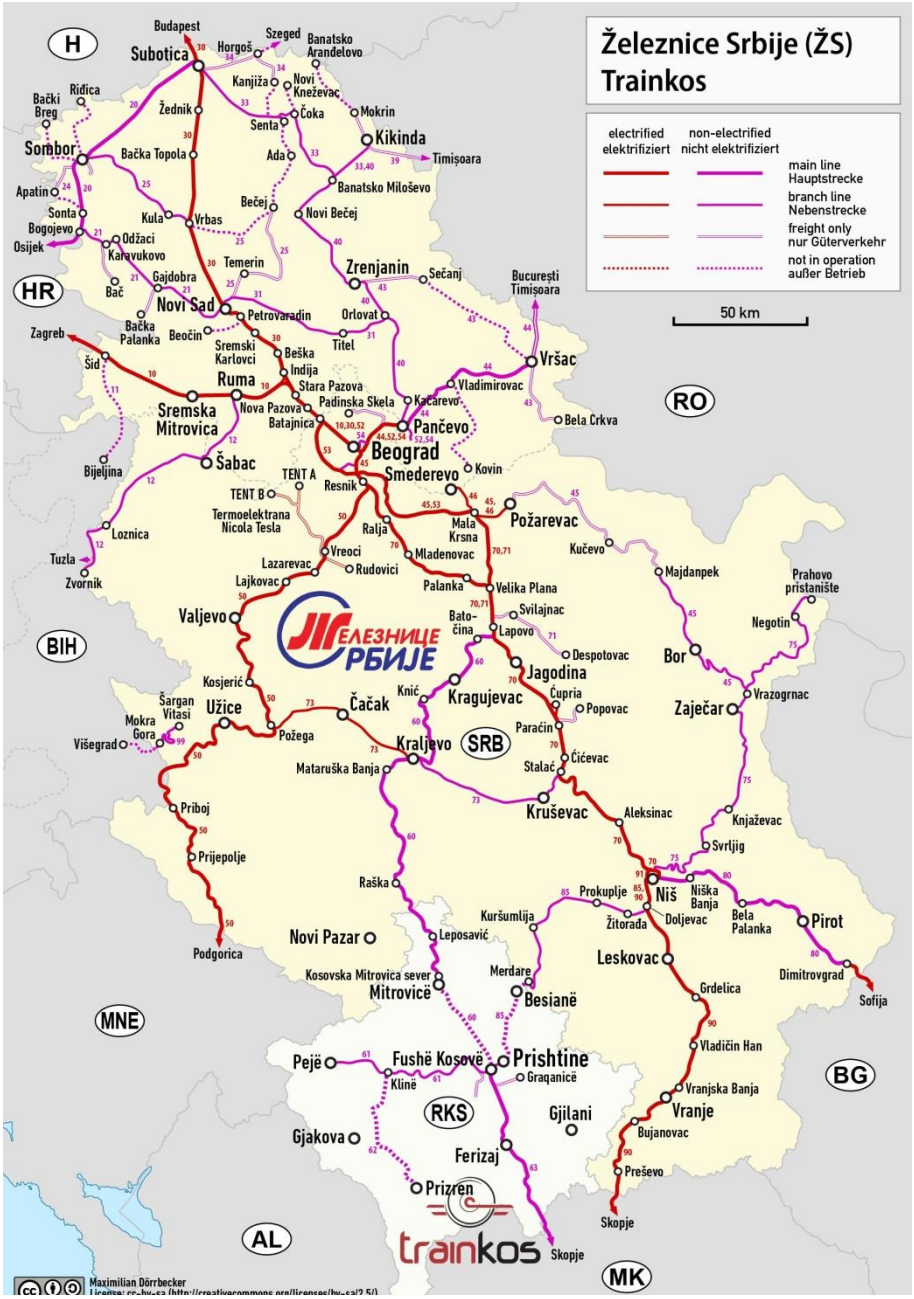

Figure 6.2.1: Railway Network of the Republic of Serbia

The average satisfactory network density at the level of the Republic of Serbia is very uneven and is noticeably decreasing towards the south. About 25 % of the main railway lines of the railway network are located on Corridor X and its branches - Xb and Xc. Only about 45 % of the railways have a permitted axle load of 22.5 t while on 30 % of the railways this load is below 16 t. The permitted speed exceeds 100 km/h on only 3.2 % of the railway lines, and the largest part (about 50 %) of the network allows a maximum speed of up to 60 km/h. The total length of tracks on electrified railways is 2 263 km, of which the length of electrified lines (open lines and main passageways) is 1 546 km. During 2018, 5 062 thousand passengers (347 passenger per km) and 12 297 thousands of tonnes (3 187 tonnes per km) of goods were transported by railway transport[1].

In the Republic of Serbia there is no fully developed terminal for combined transport (a place for transshipment of units and/or road vehicles from one mode of transport to another). Only Railway Integrated Transport (Železnički integralni transport - ŽIT d.o.o. Belgrade) and Port "Belgrade" (Luka „Beograd" a.d), are equipped to provide standard container transport.

In the period until 2027, it is envisaged that, among other things, it will be realized:

- Modernization of Corridor 10 and the Belgrade-Vrbnica (Bar) and Belgrade-Vršac railway lines to harmonized international standards, that is, to provide an adequate level of services for passenger and freight traffic;
- Improvement of the efficiency of the main nodes (Belgrade, Niš, Novi Sad), in order to increase their capacity, both for medium/long distance traffic and for local traffic.

Modernized, respectively new railway lines have interventions aimed at improving energy efficiency:

- By construction of a second railway track allowing the traffic of trains separately for each direction without crossing and without waiting for trains from the opposite direction;
- By designing new railway lines with up to 12 % gradients, which significantly reduces the amount of energy required to tow trains during track operation;
- By reconstruction of bends.

Cooperation with SEE countries is made through SEETO, but also through bilateral cooperation of interested countries. As a result of the mentioned cooperation, the following projects were identified:

- Modernization project of railway line Belgrade-Novi Sad-Subotica-Hungarian border (Budapest)
- Modernization project of railway line between the Republic of Serbia and Bosnia and Herzegovina
- Modernization project of railway lines between the Republic of Serbia and the Republic of Albania.

For projects related to the construction and reconstruction of railway infrastructure for which the sources of financing have been defined, i.e. there are potential sources of financing (credits), the estimated investment value is EUR 2 364 million. The estimated value of projects for the construction and reconstruction of railway infrastructure from 2017 to 2021 for which the technical documentation has been prepared, that is, at the stage of elaboration but not provided with financing, is around EUR 1 621 million. In addition, the estimated value of projects for which no technical documentation has been prepared and no funding has been provided is around EUR 1 1573 million [h].

6.3 Existing road infrastructure

With a total road length of approximately 38 000 km, the road network in the Republic of Serbia is well developed, although its quality has been reduced due to lack of investment and insufficient maintenance [i]. On the territory of the Republic of Serbia there are 792 km of roads of Corridor X with its branches - Xb and Xc. In the structure of the road network, the length of roads of I and II class is 16 844 km, namely [j]:

- State Roads of I A class (highways) – 962 km (September 2019)
- State Roads I B class – 4 516 km
- State Roads II A class – 7 903 km
- State Roads II B class – 3 462 km.

Road transport in the Republic of Serbia is a dynamic and dominant mode of transport, accounting for about 80 % of the total volume of transported cargo, or about 74 % of the total number of passengers carried. The corporate entities practising the road transportm that were state (public)owned, are mainly privatized and operate in conditions of free competition, and the role of state bodies is limited to regulating this area in terms of issuing licenses, permits for road transport, supervision, etc. Basic indicators of road freight transport in 2018 are provided in Table 6.3.1 [1].

Table 6.3.1: Basic indicators of freight transport in 2018

Freight vehicles	Vehicle-kilometers run, mill.	Goods carried, mill. t	Ton kilometers, mill.	Average distance of goods journey, km
7 281	493	13.1	6 443	492

International road transport in the Republic of Serbia, i.e. access to the international transport market, is mostly performed in the regime of quotas of bilateral and multilateral CEMT licenses, which additionally, in the presence of significant administrative and physical obstacles (e.g. delays at border crossings, etc.), has a negative impact on the competitiveness of our carriers in the international transport market.

Transport network of the Republic of Serbia is integrated into the Trans-European Transport Network (TEN). The goals of the transport network development are directed towards the rehabilitation, reconstruction and construction of Pan-European Corridors VII and X, as well as the direction Belgrade-South Adriatic and certain transversal connections significant for the TEN section. The main road transport axes of strategic importance for the Republic of Serbia are:

1) Corridor X: Ljubljana-Zagreb-Belgrade-Niš-Leskovac-Skoplje-Solun;
2) Corridor X, branch of the Corridor-Xb: Horgoš-Subotica-Novi Sad-Belgrade;
3) Corridor X, krak Corridor-Xc: Niš-Dimitrovgrad-Gradina-Sofija.

Other road routes as parts of the Basic Network that are important for the Republic of Serbia are:

1) Direction 3: link of the Corridor Vc with direction Belgrade-South Adriatic (border with Bosnia and Herzegovina-Kremna);
2) Direction 4: border with Romania-Vršac-Pančevo-Belgrade-Čačak-Užice-border with Montenegro;
3) Direction 5: link of the Corridor IVa with Corridor X (border with Bugarska-Zaječar-Paraćin);
4) Direction 6: link of the Corridor VIII with direction Belgrade-South Adriatic (border with Montenegro-Ribariće-AP Kosovo and Metohija);
5) Direction 7: link of the Corridor X with AP Kosovo i Metohija (Niš-Prokuplje-Kuršumlija-AP Kosovo i Metohija).

6.4 Energy sector

The table below summarizes data on the Serbian energy sector in 2019 [81].

Table 6.4.1: Serbian energy sector in 2019

Category	Republic of Serbia	EU average	Unit
Primary energy consumption	2.22	3.22	toe/capita (2012)
Energy dependence	32.28	55.4	%
Renewable energy share	20	17.9	%
GHG emissions		9.47	ton CO_2-eq/capita
Bioenergy in RE	56	69	%
Bioenergy in total energy	11.2	10.6	%
Biofuels prod. Capacity		0.051	ton/capita
CHP	-	17.3 %	% gross electricity generation
District heating	2 354 0.34	7 404 0.3	km m/capita

Total consumption of final energy in Serbia in 2019 was 9 215 million toe, with consumption divided by sectors and energy products presented in Figures 6.4.1 and 6.4.2 [81].

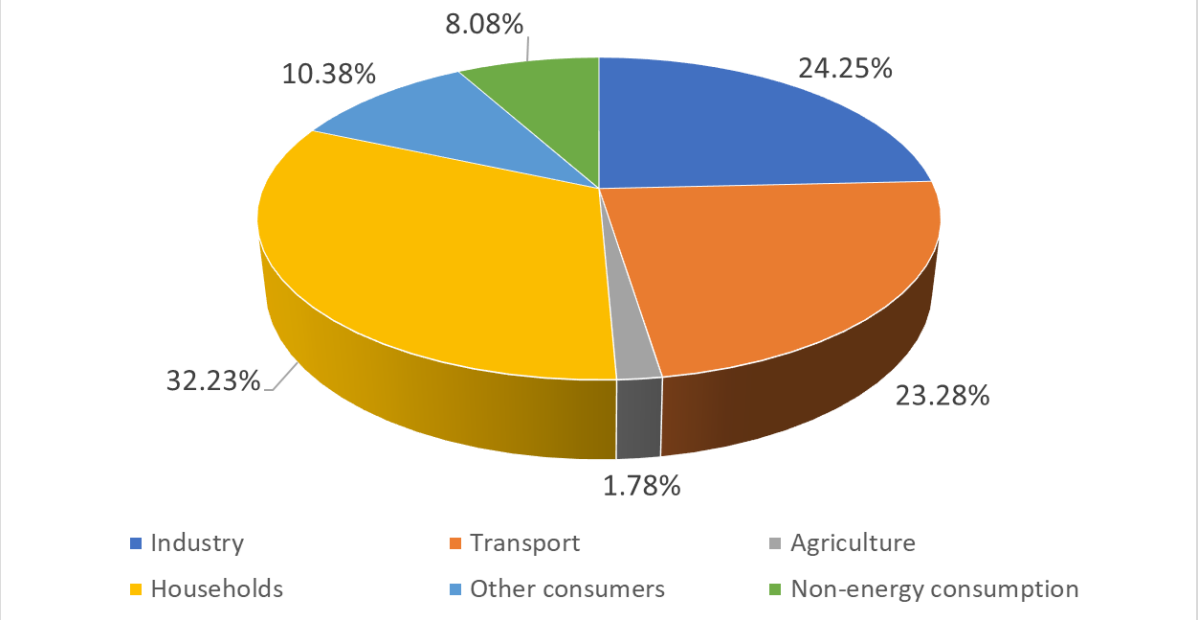

Figure 6.4.1: Structure of final energy consumption in 20l9 by sectors

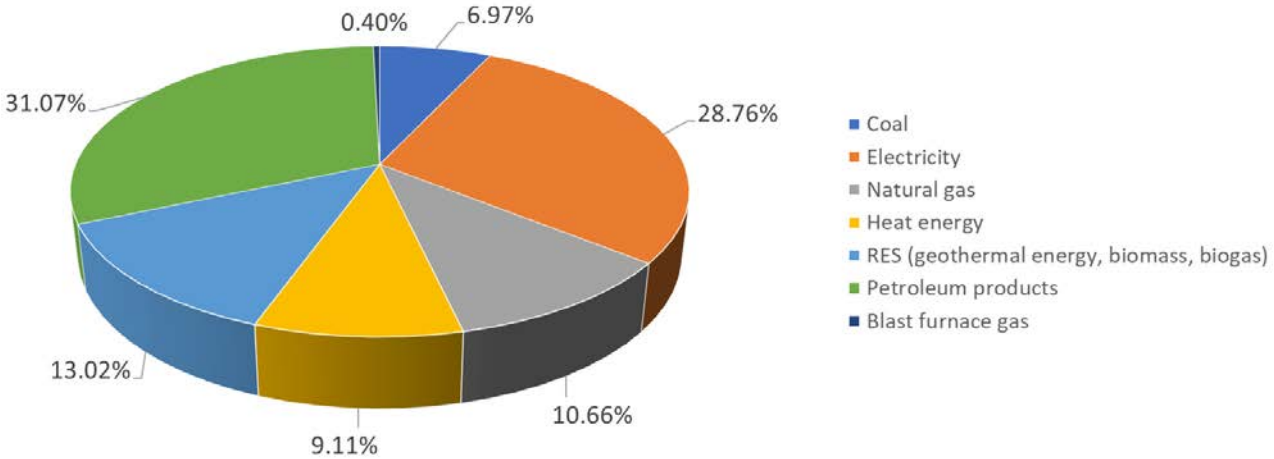

Figure 6.4.2: Structure of final energy consumptions in 2019 by energy products

Necessary coal amounts are secured from domestic production with over 90 %. Metallurgical coke and better-quality coal types are being imported. Unlike coal, about 70 % of crude oil and 84.5 % of natural gas are imported.

In July 2019, the the first cogeneration plant with a capacity of 2.38 MW/h of electricity and 8.3 MW/h of thermal energy was comissioned [82].

The planned capacity for electricity production in the Republic of Serbia for 2020 is 8 054 MW (Table 6.4.2) [81]. The capacities for the production of thermal energy in the Republic of Serbia are installed in: District heating plants within the district heating system (6 014.9 MW); Thermal Power Plants (432 MW); Thermal Power Plants – District Heating Plants (TE-TO), (482 MW); Industrial power plants (mostly used for the production of thermal energy for the purposes of production processes and heating of working space). Natural gas accounts for 80 % of total consumption, 11.7 % for petroleum products, 7.8 % for coal and less than 1 % for biomass [81].

The total planned production of primary energy from renewable energy sources in 2020 is 2 034 Mtoe, which is almost at the same level as the estimated production in 2019 [81]. In the structure of the planned total domestic production of primary energy for 2020, renewable energy sources account for 20 %. In this structure, the largest share is solid biomass 56 %, hydro potential 37 %, wind energy 5 %, while biogas, solar energy and geothermal energy account for 1 %. The production and consumption of solid biomass includes the production and consumption of firewood, pellets and briquettes for energy purposes (for the purposes of electricity and heat production). In the structure of this consumption, industry accounts for 14 %, households with 83 %, and other sectors with 3 %. Consumption of solid biomass occurs predominantly within the household sector for room heating purposes.

By adopting the Rulebook on Technical and Other Requirements for Biofuels, the Decree on the Sustainability Criteria for Biofuels and the Decree on the Share of Biofuels on the Market, the Government has complemented the legal framework for biofuels, which created the conditions for biofuels to appear on the Serbian market. The regulations are fully in line with EU regulations, and their implementation has been delayed until January 1, 2021, so that regulated entities and institutions have sufficient time to prepare logistics to fulfill their obligations.

Table 6.4.2: Capacities and planned production of electricity in 2020

Power plant type	Installe d capacity (MW)	Planned production (GWh)
Power plants	4 079	27 865
Thermal Power Plants – District Heating Plants	297	123
Hydropower plants	2 969	9 669 (310.35*)
Small Hydropower plants	114.30 (77.5*)	
Industrial power plants	108.27	
Wind power plants	397.96*	1 079*
Solar power plants	10.990(8.82*)	19 (12*)
Biogas power plants	38.51	161*
Combined plants for the production of electricity and heat	36.82 (20.94*)	98.7*
Biomass power plants	3.38*	20*

* will use incentive measures to generate electricity

6.5 Summary and conclusions in relation to SWOT elements

Table 6.5.1: SWOT analysis of Infrastructure, logistics and energy sector of Serbia

Strengths	Weaknesses
Railway, road, water and intermodal • geographical location and level of development of the transport network; • infrastructure resources; • a defined framework (which respects European and regional transport policy) and global objectives; • existence of professional and competent resources; • large resources available on inland waterways (Danube as Corridor VII, Sava, Tisa and the DTD channel system); • ports are positioned on high-ranking categories of waterways and with sufficient depth in port aquatoriums; • port infrastructure in individual ports was built for the needs of multiple physical volume of operation in the previous period; *Energy sector* • renewable energy sources potential; • potential for increase of energy efficiency in generation, transmission and consumption; • geographical position of transmission system between the regions with energy surpluses and regions with electricity deficiency; • technical characters of transmission system in accordance with requirements of European association transmission system operator (ENTSO-E) • geographical position of potential regional hub for electricity trading, transportation and storage capacities of natural gas • significant level of the development of transport and distribution gas pipeline system; • development of district heating system; • ratification and effectiveness of the Energy Community Treaty, by which the Republic of Serbia became part of connected European energy	*Railway, road, water and intermodal* • the transport infrastructure on the corridors through the Republic of Serbia is not fully constructed and is not equipped with modern technical and technological systems; • the need for significant investments in infrastructure reconstruction and construction of a new one; • many economic discontinuities in the previous period; • modes of the transport system are not integrated; • lack of stable funding sources; • unfavorable qualification structure and number of employees *Energy sector* • high external energy dependency • non- economic prices of energy and disparity of prices of energy and energy products • insufficient use of highly efficient technology for energy generation and consumption; • high specific energy consumption per unit of gross domestic product; • high specific energy consumption per unit of product in industry; • low quality and unfavorable structure of traffic in energy sense; • irrational use of electricity for heating purposes; • insufficient use of natural gas in households and commercial sector; • low share of RES in consumption; • lack of standards and regulations in energy sector; • technological obsolescence of the existing

market	and lack of new energy sector capacities • minimum cogeneration of electricity and heating energy; • limited funds for the investments in energy capacities; • Low efficiency of public energy utilities; • legacy of devastation of natural space and over pollution of water, air and land caused by energy sector • law level of utilisation of technologies with low level of emissions of harmful substances in all parts of energy cycle
Opportunities *Railway, road, water and intermodal* • the interests of countries in the region in the development of the Core Regional Transport Network; • shorter travel distances compared to the TEN-T Southeast Priority Axes (Corridor IV and IVa) in a better, more comfortable and convenient and more pleasant environment; • new investment models in the field of transport (concession, PPP, use of European funds); • development of a multimodal transport system; • conservation of ecological content; • increase of export potential; • inland water transport becomes more important Rhine-Danube corridor and EU strategy for the Danube region as an EU priority *Energy sector* • organization of the system of minimum mandatory oil stocks and petroleum products; • modernization of refineries in accordance with the EU standards; • increase of the possibilities and scope of publicprivate partnership in the energy field; • more intensive use of pre-accession funds of EU in the energy sector; • more efficient business operation of public energy utilities and other economy entities in the energy • field; • attraction of foreign partners, banks and investors in the safe and long-term investment in Serbian energy system; • increase of competition and competitiveness in energy sector; • improvement of energy efficiency; • introduction of energy management in public, commercial and industrial sector; • sustainable use of renewable energy sources; • construction of natural gas or biogas-fired facilities for combined generation of electricity and heating energy; • construction a new route for natural gas supply.	**Threats** *Railway, road, water and intermodal* • Pan-European Corridor IV, IVa and Vc in the immediate vicinity of the Republic of Serbia - at a distance of 50-100 km from Corridor X; • development strategies of neighboring countries that are not complementary to the transport strategy of the Republic of Serbia; • a large number of border crossings on major routes; • unresolved issues of financial responsibility, debt repayment, sustainable financing and guarantees for borrowing; • unstable and underfunded transport system development; • manifestation of partial and local interests within the state; • resistance to changes. *Energy sector* • deepening of social and economic crisis, poverty increase, indebtedness and slow economy development of the country; • lag for the changes in energy sector policy in the region due to the unsolved social and political issues; • absence of political will to conduct consistent market reforms in energy sector; • retention of principles of "social prices" of energy; • insufficient investments in renovation, modernization and construction of energy facilities and infrastructure; • reduction of reliability of energy facilities and equipment due to their age and insufficient maintenance;

7 Skills, education, research and innovation potential

7.1 Research infrastructure

In 2017, the development of the Research and Innovation Strategy for Smart Specialization (RIS3) began [40]. The key participants in planning and implementing the smart specialization process were the Ministry of Education, Science and Technological Development of the Republic of Serbia, the Republic Office for Public Policies, the Ministry of Economy of the Republic of Serbia, the Serbian Chamber of Commerce and the European Commission Joint Research Center. A quantitative analysis of the economic (employment and export), innovation (innovation companies, patents) and scientific (papers on the SCI list) potential of the Republic of Serbia was made. The results of the conducted analysis are shown in Figures 7.1.1-7.1.4 [41].

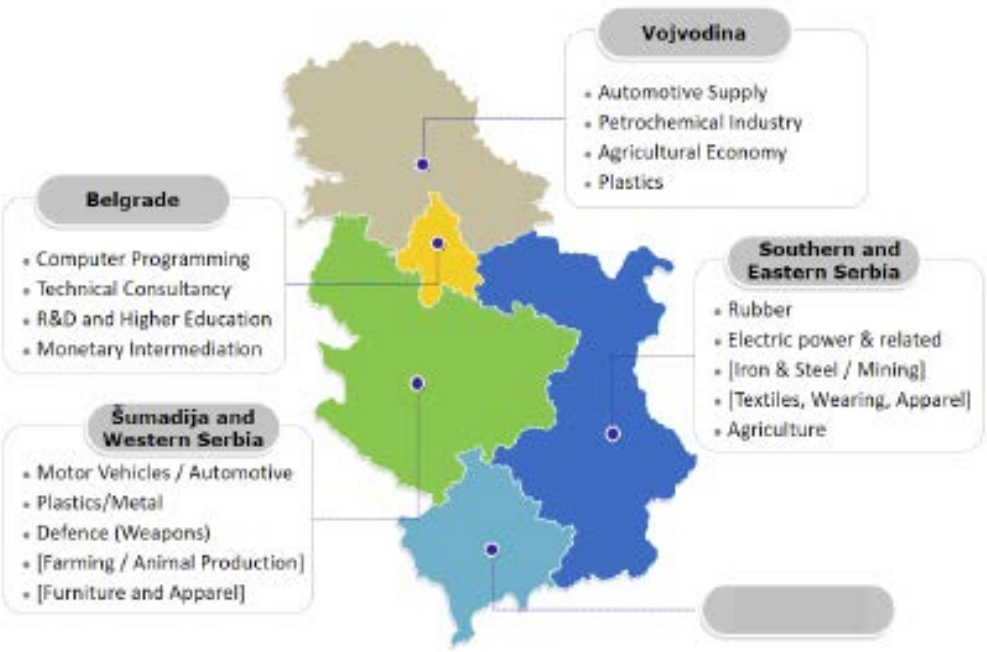

Figure 7.1.1: Potential Priority Domains from an Economic Point of View

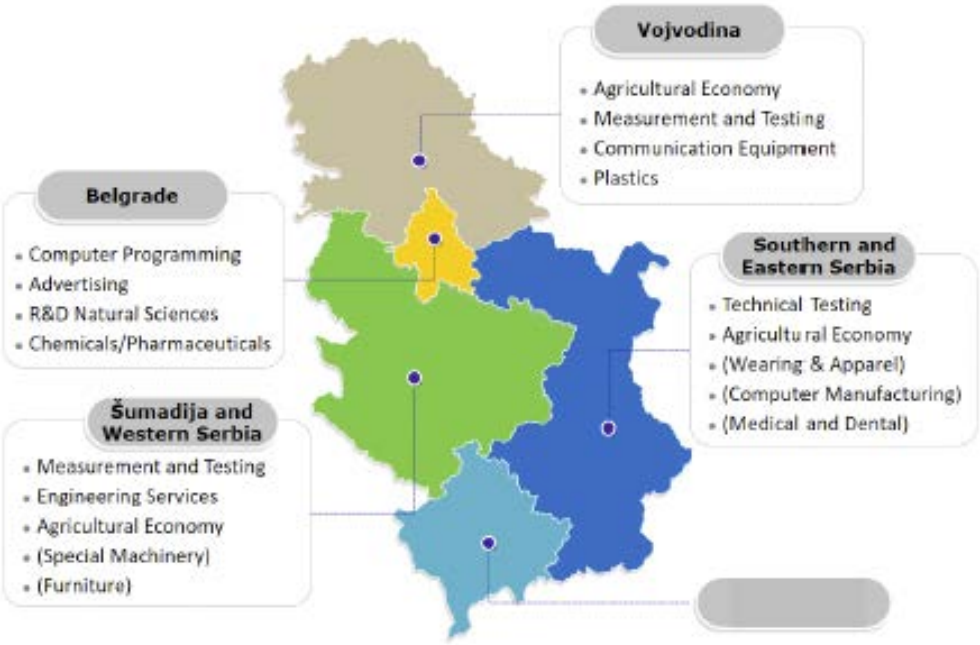

Figure 7.1.2: Potential Priority Domains from an Innovative Point of View

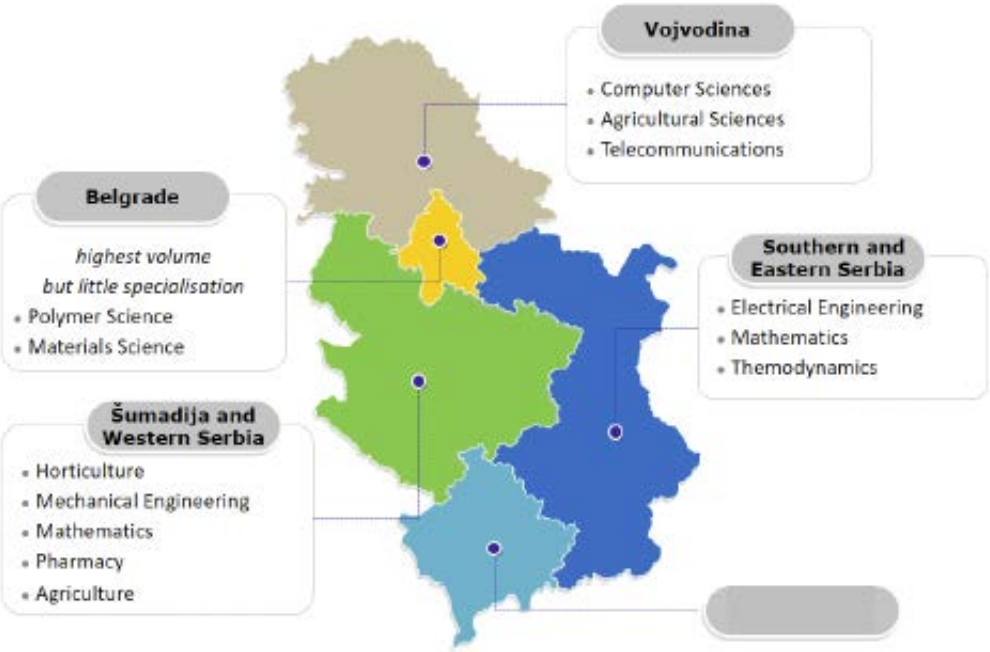

Figure 7.1.3: Potential Priority Domains from Scientific Point of View

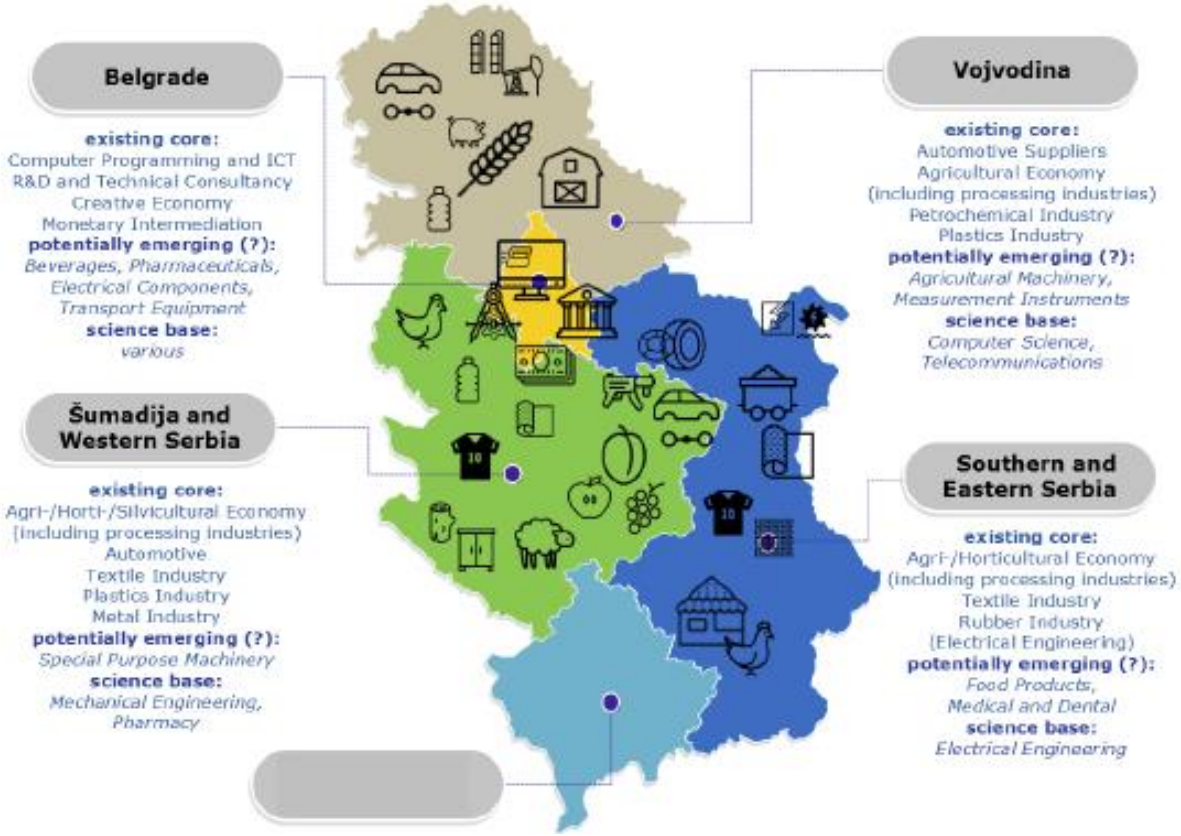

Figure 7.1.4: Illustrative Overview of Potential Priority Domains in Serbia

Within the vertical priority areas, the following have been isolated, among others [40]:

1. Food for Future
    a. High Tech Agriculture
    b. Value-Added Food
    c. Sustainable Food Chain
2. Creative industries
    a. Smart and Active Packaging
3. Future Machines and Manufacturing Systems
    a. Sustainable heat appliances and devices
    b. Solutions for smart Ecosystem,

and as horizontal (supporting) areas:

1. Energy Efficient and Eco-Smart Solutions
    a. Eco-Smart Energy Sources
2. Key Enabeling technologies (KET) and Emerging technologies
    a. Advanced materials
    b. industrial biotechnology.

The Science Fund of the Republic of Serbia is a public organization that supports scientific and research activities [42]. It was established in March 2019, with the aim of providing funds and supporting the conditions for the continuous development of scientific and research activities in the Republic of Serbia necessary for the advancement of a knowledge-based society. The Fund's activities are represented through research, as well as through technological and developmental programs. Within the programs of the Fund, projects are funded through public bidding. The projects aim to provide high-level research, innovative results, competitiveness at international level, and relevance to society in general. Project financing is implemented in a manner that ensures competitiveness, quality, practical value, transparency, and the functionality of the results. Programs of the Science Fund support the professional development of researchers, integration into the international

scientific and technological projects, and cooperation with the scientific diaspora and industry. Additionally, the programs ensure the protection of property rights for research results, protection of intellectual property, copyright protection, as well as data protection.

The Innovation Fund was established in 2011 and has been a pioneering effort to operationalize and institutionalize this imperative – first by increasing the capacity of start-up s and resources available for their growth [43]. The Republic of Serbia Innovation Fund aims to contribute to the country's economic development, facilitate the bridging of the technology and development gap, by promoting enterprise innovation through various financial instruments, particularly by fostering the establishment of new and strengthening the existing companies, by positioning them to access venture capital markets, and serve as the key state actor in developing innovation entrepreneurship in Serbia. The Innovation Fund promotes enterprise innovation by managing financial and technical support provided by public and donor sources to support innovative Serbian companies and strengthen linkages between research and business sectors, following the highest ethical, financial and business standards and practices in its internal operations, treatment of staff and external relations with stakeholders. Innovation Fund aims to promote linkages between research and technology development and economy and encourage and support the development of innovative technologies. The EU's support for the Innovation Fund has been instrumental in advancing Serbia's innovation financing and promoting better integration between the research and private sectors. The Fund is thus an important step towards closer links between Serbia's and EU's research communities and innovation ecosystems. It enables the positioning of Serbia as a leader in the region and the establishment of links with the EU and global markets. So far, the EU has allocated around EUR 15.8 million from the IPA funds to the Innovation Fund.

The Innovation Fund has established an independent governance structure, with a robust international peer review system and a distinguished Investment Committee that includes international and diaspora professionals experienced in managing technology firms, scientific research, commercialization, and the investor community. Different programs have been established:

- Mini grants program
- Matching grants program
- Collaborative grant scheme program
- Innovation vouchers
- Proof of concept
- Technology transfer facility program.

Since its inception, 1,900 applications for innovative projects have been submitted to public calls. A total of EUR 20.1M was approved for 695 projects.
Eight Regional Innovation start-up centers were opened - those start-up centers in the following areas: Čačak, Gornji Milanovac, Stara Pazova, Kruševac, Subotica, Pirot, Zrenjanin, Valjevo. In 2020, six more Regional Innovation Start-up Centers will be established in the following areas: Kragujevac, Uzice, Arilje, Priboj, Svilajnac and Backi Petrovac.

Science and technology parks [44]:

- STP Belgradr was established in partnership with the Government of the Republic of Serbia, the City of Belgrade and the University of Belgrade, in order to create a favorable environment for connecting the economy and scientific research and educational organizations, knowledge transfer, development of new technologies, commercialization of innovations, networking and stimulating knowledge-based economy. STP Belgrade is developing into a new technological core of the city that brings together technological development companies, domestic and foreign, and encourages the establishment of start-up companies, creating a favorable environment for innovation, technological development and competitiveness.
- STP Novi Sad was opened in January 2020. It is intended for the Faculty of Technical Sciences (Fakultet tehničkin nauka - FTN), and is a joint project of the Government of the Republic of Serbia and the Provincial Government with the support of the City of Novi Sad and FTN, worth 26 million euros.

In addition to the above, the construction of two more parks is planned, as follows:

- A special educational-innovation center "Verokio" will be built within the campus of the Institute of Physics, as one of the CERN centers. The project is in preparation, and the completion is planned for the last quarter of 2020.
- Science and Technology Park Nis, which should be completed in July 2020
- Serbian-Chinese industrial park "Mihajlo Pupin".

BioSense - a scientific research institute dedicated to modern applied and market - oriented research in the field of agriculture and food. For the "Antares" project, the BioSense Institute won the first place in Europe within the call "Horizon 2020 - timing" intended for the creation of a European center of excellence in scientific research. The budget of the "Antares" project is 28 million euros, of which 14 million are EU grants, while 14 million euros are provided from the project "Research and Development in the Public Sector" financed by the European Investment Bank and the Council of Europe Development Bank. The total gross area of the new building of the BioSens Institute will be around 6,200 m2. The Center of Digital Agriculture of Serbia was opened at the BioSense Institute in Novi Sad - an example of practical application of innovative IT solutions and digitalization in order to increase efficiency and competitiveness of domestic agriculture. In addition to this, the digital platform AgroSens was launched, whose basic services are free for all farmers. The platform allows the mobile phone to become a tool through which relevant information about farmers' activities is exchanged. These are data that have practical application: satellite monitoring of crop condition, localized meteorological data, data on chemical and mechanical composition of soil, log of activities on the parcel as well as a catalog of seeds and chemical preparations. Also, in Krivaja, next to Bačka Topola, the first digital farm was opened that will enable farmers to learn for free and from the "first hand" how to reduce production risks, consume less water and fertilizers and invest less, and get higher yields. BioSense Institute coordinates or participates in a large number of international research projects, including Horizon2020, FP7 and Eureka.

Serbia has twice applied for a project to establish a center of excellence called: Strengthening capacities in Western Balkan Countries for a Biobased Economy by developing a Transnational Centre of Excellence (Be-We). The project application stemmed from the need to establish a center of excellence in the field of biomass in the region.

This project received funding from the BBI JU under the EU Horizon 2020 research and innovation programme under grant agreement No.838087

7.2 Education infrastructure

The system of higher education in the Republic of Serbia includes 18 accredited universities (public and private) where almost 250 000 students are educated, and more than 20 000 experts are engaged in teaching and scientific research [45]. In addition to universities, there are also academies that were created by merging higher business schools. An overview of universities and academies where study programs related to the topic of this study are studied are shown in Table 7.2.1.

Table 7.2.1: Overview of universities and academies

State Universities	
University of Belgrade	
• Faculty of Agriculture	http://www.agrif.bg.ac.rs/
• Faculty of Forestry	http://www.sfb.bg.ac.rs/
• Faculty of Mechanical Engineering	http://www.mas.bg.ac.rs/
• Faculty of Technology and Metalurgy	http://www.tmf.bg.ac.rs/
• Technical Faculty in Bor	https://www.tfbor.bg.ac.rs/
• Faculty of Pharmacy	http://www.pharmacy.bg.ac.rs/
• Faculty of Veterinary Medicine	http://www.vet.bg.ac.rs/
• Faculty of Biology	https://www.bio.bg.ac.rs/
• Faculty of Chemistry	http://www.chem.bg.ac.rs/
• Faculty of Physical Chemistry	http://www.ffh.bg.ac.rs/
• Institute of Agricultural Economics	https://www.iep.bg.ac.rs/
• Institute of Molecular Genetics and Genetic Engineering	https://www.imgge.bg.ac.rs/index.php/yu/
• Institute of Medicinal Plant Research	http://www.imi.bg.ac.rs/
• Institute for Biological Research "Slnisa Stankovic"	http://www.ibiss.bg.ac.rs/index.php/sr-yu/
• Vinca Institute of Nuclear Sciences	https://www.vin.bg.ac.rs/
• Institute for Chemistry, Technology and Metallurgy	https://www.ihtm.bg.ac.rs/
University of Novi Sad	
• Faculty of Agriculture	http://polj.uns.ac.rs/
• Faculty of Technology	http://www.tf.uns.ac.rs/site/index.php/sr-lat/
• Faculty of Technical Sciences	http://www.ftn.uns.ac.rs/691618389/fakultet-tehnickih-nauka
• Institute of Lowland Forestry and Environment	http://www.ilfe.org/
• Institute of Food Technology	http://www.fins.uns.ac.rs/index.php
• BioSense Institute	https://biosens.rs/?page_id=7651&lang=sr
University of Nis	
• Faculty of Agriculture	https://poljfak.ni.ac.rs/
• Faculty of Mechanical Engineering	http://www.masfak.ni.ac.rs/index.php/sr/
• Faculty of Technology	http://tf.ni.ac.rs/
University of Kragujevac	
• Faculty of Agronomy	https://afc.kg.ac.rs/index.php/sr/
• Faculty of Engineering	http://www.mfkg.rs/sr/
• Faculty of Technical Sciences, Cacak	http://www.ftn.kg.ac.rs/
• Faculty of Mechanical and Civil Engineering, Kraljevo	https://www.mfkv.kg.ac.rs/
State University of Novi Pazar	
• Department of Biomedical Sciences	http://www.dunp.np.ac.rs/biomedicinskenauke/
• Department of Chemical-Technological Sciences	http://www.dunp.np.ac.rs/hemisko-tehnoloskenauke/
• Department of Technical Sciences	http://www.dunp.np.ac.rs/tehnickenauke/

University of Pristina, Kosovska Mitrovica	
• Faculty of Agriculture	http://www.agr.pr.ac.rs/
• Faculty of Technical Sciences	http://xn--j1aebtj.xn--90a3ac/
Private Universities	
Singidinum University	
• Faculty of Technical Sciences	http://tf.singidunum.ac.rs/
Univerzitet Educons	
• Zastita zivotne sredine	https://educons.edu.rs/fakulteti/zastita-zivotne-sredine/
• Ekoloska poljoprireda	https://educons.edu.rs/fakulteti/ekoloska-poljoprivreda/
Univerzitet Union "Nikola Tesla"	
• Fakultet za ekologiju I zastitu zivotne sredine	https://unionnikolatesla.edu.rs/sr/prikaz/zastita-zivotne-sredine/14/o-osnovnim-studijama
Megatrend University	
• Faculty of Biofarming, Backa Topola	http://megatrend.edu.rs/sr/fakultet-za-biofarming-backa-topola/
Academies	
Akademija tehnickih strukovnih studija Beograd	https://www.tehnikum.edu.rs/akademija/
Akademija strukovnih studija Sabac	http://www.akademijasabac.edu.rs/
Akademija strukovnih studija Juzna Srbija	https://www.akademijajs.edu.rs/
Institutes	
Fruit Research Institute	www.institut-cacak.org
Pesticides and environmental protection institute	www.pesting.org.rs
Institute for Science Application in Agriculture	www.psss.rs
Institute for Animal Husbandry	www.istocar.bg.ac.rs
Institute for Plant Protection and Environment	www.izbis.com
Maize Research Institute	www.mrizp.rs
Institute for Vegetable Crops	www.institut-palanka.co.rs
Institute of Field and Vegetable Crops	www.nsseme.com
Institute of Soil Science	www.soilinst.rs
Institute of Meat Hygiene and Technology	www.inmesbgd.com
Institute for Biological Research	www.ibiss.bg.ac.rs

University of Belgrade - University of Belgrade is a state university founded in 1808 and it's the oldest university in Serbia. Currently there are 31 faculties, 11 research institutes, and 12 research centres, over 4 500 academic staff employees and nearly 90 000 students [52]. Faculties of the University are organised in 4 groups: social sciences and humanities, sciences and mathematics, medical sciences, and technology and engineering sciences. The mission of the University of Belgrade is to provide superior education and exceptional knowledge to its students, not only in terms of their intellectual growth and development, but also in terms of growth and development of their human qualities and ethical values, and inspiring their wish and inclination to be leaders; moving the boundaries of knowledge and higher education, promoting intellectual surroundings which cherishes and honours true values, respect and accepting people's differences and devotion to knowledge, development and human values. According to the official rankings, it is ranked in top 300 universities of the world according to the Academic Ranking of World Universities lists based on its strong devotion to studying, education, progress and prosperity. University of Belgrade strives to set the strongest standards in higher education, to cherish and encourage intellectual and personal growth and to stimulate meaningful work and effort which serve to the well-being of the entire society.

University of Novi Sad - The University of Novi Sad, with around 50 000 students and 5 000 employees, is one of the largest educational and research centers in Central Europe [53]. It belongs to the group of comprehensive universities, which are characterized by providing nearly all fields of science and higher education. The University of Novi Sad has a well-developed research infrastructure and great potential for innovation. The University encompasses around 250 laboratories. Of special significance to the strengthening of innovativeness is the Technology Park of the University of Novi Sad. With the support of the Faculty of Technical Sciences,

around 140 start-up and spin-off companies have been founded, mainly in the IT sector, employing young engineers who graduated from the University of Novi Sad. Some of these companies implement projects for large international corporations and have contributed to Novi Sad becoming recognized internationally as a "Software Valley". Project teams and prominent researchers from the University of Novi Sad have been the recipients of numerous international and national awards for best technical innovations. The members of university, among others, are: Faculty of Agriculture, Faculty of Technology, Faculty of Technical Sciences, Institute of Laowland Forestry and Environment, Institute of Food Technology and BioSense Institute.

University of Niš – a modern and recognizable Serbian and European university that is comparable to foreign higher education institutions of the highest rank in terms of quality of study programs, teaching activities, research and professional work [54].The University of Niš maintains rich bilateral and multilateral collaboration with many academic and research institutions and associations from the country and abroad. University of Niš incorporates 14 faculties, among others: Faculty of Agriculture, Faculty of Technology and Faculty of Mechanical Engineering,

University of Kragujevac - The University was established and developed based on the concept of dispersed university, comprising 12 faculties in six towns of the Central Serbia region: Kragujevac, Čačak, Jagodina, Kraljevo, Užice and Vrnjačka Banja. However, the University managed to turn this into one of its most distinctive advantages which allows it to use economic and geographical potentials and human resources from the territory which spreads over an area of 5 000 square kilometers and has about 2.5 million citizens [62]. Today the University of Kragujevac is a modern education and research center embracing almost all major areas of teaching and research, with a student population of 20 000 and 1 200 academic staff.

SUNP is the only integrated state university in Serbia. With more than 4 000 students and 250 permanent teaching staff (170 professors and lecturers and 80 assistants and research fellows) it is contributing to comprehensive development of the region. Integrated structure of SUNP has enabled it, as the youngest state university in Serbia, to develop much faster with the available funds and teaching and administration staff [63].

University of Pristina – Kosovska Mitrovica - The University has the status of a state university, as a comprehensive/multidisciplinary university, and comprises ten Faculties. Currently, there are nearly 10 000 students and 900 academic and administrative staff [64].

7.3 Environment for start-ups

According to the research of the world's most relevant organization for research of start-up ecosystems, Start-up Genome from San Francisco, the Serbian engineering staff is ranked among the five best in the world. Serbia is the only country in the region covered by this global survey and was rated the best: 10 for investment growth and 9 for the growth of the total number of start-up companies [47, 48]. The cities of Belgrade and Novi Sad are recognized as a unique start-up ecosystem, along with London, Tel Aviv, Barcelona and Helsinki, ranked among the five leading ecosystems in Europe in the field of gaming and blockchain. The key advantage of the Serbian ecosystem is identified as a talented workforce and high-quality engineering staff, which is ranked among the top five in the world.

Based on the Program of support for the opening of regional innovation start-up centers for 2018, 8 projects were implemented throughout the Republic of Serbia [47]:

- Start-up center of the Science and Technology Park Cacak
- Regional innovation start-up center Gornji Milanovac
- Regional Center for Sustainable Development of Srem - Phase I: Establishment of an innovative start-up center Stara Pazova
- Opening of the regional start-up center of Rasina district
- Regional start-up center Subotica
- Establishment of a start-up center in Pirot
- Innovation Network of Serbia - Start up center Zrenjanin
- Valjevo Regional Innovation Center.

7.4 Public private partnerships

Since the enactment of the Law on Public-Private Partnership and Concessions in the Republic of Serbia and the establishment of the Commission for Public-Private Partnership, 150 public-private partnership projects with or without concession elements have been approved [49]. The City of Belgrade, as the largest local self-government unit with the greatest potential in the Republic of Serbia, has eight approved projects, of which seven signed public contracts, and the signing of contracts with the selected partner in the eighth project is expected. In Belgrade, the most important is the realization of the contract on the construction of a waste incineration plant, which will enable the closure and rehabilitation of the landfill in Vinča. The Vinca project aims to improve existing solid waste disposal practices: it includes premeditation of the existing landfill, construction of a new sanitary landfill, electricity and heat generation plants, collection and leachate treatment plants, landfill gas collection systems and its use in a cogeneration plant and construction of a plant for processing construction waste and demolition waste [50].

Other examples of public-private partnerships are projects implemented by Resalta [51]:

- Project with Atlantic Group in the Foodland factory on Kopaonik. Following the Reactive Energy Compensation Project in 2018, Resalta will now modernize process cooling in the production facility. The existing process cooling system is energy inefficient, and the project aims to provide reliable and constant cooling through a separate and independent closed-loop solution that will not have a negative impact on the environment. Moreover, the preservation of drinking water, especially in the summer when it was most needed, was an additional technical goal. Cooling is used in the process of pasteurization of jams and spreads, which are the main activity of the factory, under the brand Bakina Tajna. To improve efficiency and reduce environmental impact, Resalta will install two new Daikin air-to-water refrigeration units with a nominal power of 106 kW and 331 kW. Foodland, as part of Atlantic Group and located on Kopaonik, one of the most beautiful national parks in Serbia, considers environmental protection one of the main priorities. The implemented solution will achieve water savings of 24 000 m3 each year. Resalta will finance the entire project and take care of its implementation, as well as maintenance, and the client will return the investment to Resalta from the savings over a period of 10 years. Resalta assumes all risks, including financial and technical, while the customer enjoys the new cooling system with greater efficiency and reliability, as well as with less impact on the environment.
- Project with one of the leaders in the field of meat industry in Serbia. MI Topola is located in the North Bačka district of Vojvodina and is engaged in the production of various meat products. The company has a complete production process, "from field to table" - from fields where crops are produced for livestock, and two farms for fattening and its own veterinary station, to the production, processing and sale of meat and meat products. In order to reduce costs for the customer and improve energy efficiency, Resalta will install a new highly efficient natural gas steam boiler in MI Topola, which is necessary for the customer's primary production. Resalta will also install new equipment that includes a new gas burner, a feed tank with degasser, a condensate tank and the construction of a new line to return condensate from production. The project includes the delivery and installation of complete new mechanical and electrical equipment in the steam boiler room. After the implementation of the project, the client will achieve 20 % savings on steam production costs and reduce CO_2 emissions by 600 tonnes each year.

7.5 Summary and conclusions in relation to SWOT elements

Table 7.5.1: SWOT analysis of Skills, education, research and innovation potential of Republic of Serbia

Strengths	**Weaknesses**
• Well-educated professional staff • Existence of a wide network of higher education institutions and a wide range of educational profiles • Accreditation of study programs and international harmonization of study programs • Introduction of modern forms of teaching • Examples of developed innovation activities • Successful examples of cross-sectoral cooperation and diversification	• Lack of applied modern knowledge and practice in the education system • Low degree of technology transfer from science to economy • Insufficient perception of the need to protect intellectual property • Insufficiently developed technological infrastructure • Fragmentation of production capacities and insufficient functionality of clusters and other forms of association • Insufficiently used potential of intersectoral cooperation • Investments in insufficiently sustainable, insufficiently profitable and non-competitive sectors and technologies • Distrust of producers towards domestic innovations
Opportunities	**Threats**
• The existence of a need for high-quality workforce (investments, the need for new qualifications, self-employment - starting your own business) • Strengthening cross-sectoral cooperation and multidisciplinarity • Increasing the share of value-added products through innovation • Product certification and their market valorization • Placement on markets with privileged status • Use of technologies and new ways of selling and promoting • More efficient use and development of support networks • Possibility of access to EU funds	• Outflow of human resources abroad and young people from rural areas • Insufficient financial allocations for science and equipping higher education institutions • Insufficient technological preparedness for climate change • Lack of continuity in the implementation of incentive policies and strategies • Distrust and resistance to innovation by consumers

8 Policy framework: Regulations, legislation, rule of law & taxes and tariffs

Serbia does not have a strategy that would encourage the development of the bioeconomy. Although there is no such strategy, there are a number of other, sectoral, strategies that to some extent cover individual sectors of the bioeconomy. Strategies and regulations are being developed and harmonized within the process of association and accession to the European Union. The Ministry of European Integration is responsible for coordination, monitoring and reporting [55]. Negotiations for the accession of the Republic of Serbia to the European Union in the field of cohesion policy, in terms of meeting the requirements and principles, and preparing for its effective implementation, are conducted through Chapter 22 - Regional Policy and Coordination of Structural Instruments.

The Ministry of Environmental Protection, with the support of the UNDP project "Circular Economy Platform for Sustainable Development in Serbia", has developed a document entitled Roadmap for Circular Economy [56]. The goal of the Roadmap is to initiate a dialogue between decision makers and representatives of industry, academic sector and civil society, in order to encourage industry to innovate, increase market opportunities for production through circular business models, create new jobs and improve business, while preserving the environment. The intention of this document is to encourage the whole society to radical changes in thinking, culture and attitude towards resources. The road map is modeled on this type of documents that EU countries have, such as Slovenia, Finland, the Netherlands, Spain, France, etc. The Republic of Serbia is the first country in the region of the Western Balkans to have a Roadmap for the circular economy

8.1 Strategy for Agriculture and Rural Development of the Republic of Serbia from 2014 to 2024 General comments and suggestions Recognizing the importance of agriculture Introduction

The strategy recognizes the importance of agriculture for the overall economy of the country and is one of the strategic documents in the form of a strategy, especially in the process of accession to the EU and integration into the WTO. The strategy is structured through a comprehensive and modern approach in order to define policies [57].

The vision of the development of agriculture and rural areas of the Republic of Serbia reflects the projected state of the agricultural sector and envisages [3]:

1. That in 2024 the agriculture of the Republic of Serbia will be a sector whose development is based on knowledge, modern technologies and standards, which offers innovative products to domestic and demanding foreign markets, and provides producers with a sustainable and stable income;
2. That the natural resources, environment and cultural heritage of rural areas are managed in accordance with the principles of sustainable development, in order to make rural areas an attractive place to live and work for young people and other inhabitants of rural areas.

The realization of this vision implies respect for several key principles: sustainable agriculture, polycentric development based on respect for the diversity of the agricultural system and types of agricultural holdings, modernization of bodies and organizations and stability and consistency of the agricultural budget.

The strategy sets the following development goals:

1. production growth and income stability of producers;
2. growth of competitiveness with adaptation to the requirements of domestic and foreign markets and technical-technological improvement of the agricultural sector;
3. sustainable resource management and environmental protection;
4. improving the quality of life in rural areas and reducing poverty;
5. efficient management of public policies and improvement of the institutional framework for the development of agriculture and rural areas.

The adoption of this Strategy was, among other things, one of the important factors for the implementation of the IPARD program and thus providing significant funds for the agricultural sector.

8.2 Forestry development strategy of the Republic of Serbia

The strategy aims to launch all those activities that will simultaneously solve forest problems (increasing the area, rational use in the scope and quality that is in the function of forest improvement), and infrastructure works (road construction, afforestation, rural tourism, etc.) for the population in rural communities to enable further development through their work [12].

The main goals of the strategy are:

- conservation and enhancement of forests' condition and the development of forestry as an economy branch;
- increase the contribution of the forest sector to the economic and social development of the Republic of Serbia;
- enhancement of sustainable management of the forests in the protected nature areas, based on the harmonised development of the ecological, economic, social and cultural forest functions;
- sustainable development of the state forest sector taking into account the ecological, social and cultural demands, as well as the creation of the highest possible added value of forest products;
- enhancement of private forests and the sustainable development of private forestry in the framework of rural development;
- sustainable and economically efficient wood industry sector competitive on the world market and contributing to the advancement of the forest sector, environmental protection and development of the national economy.

8.3 National Waste Management Strategy including National Waste Management Plan for the period 2020-2025

The Waste Management Strategy (WMS) defines the goals of an integrated national waste management system and the objectives necessary. The Startegy will facilitate the process of approximation with EU legislation in the process of negotiation the accession to the Union the Strategy, as it reviews the waste management goals in the light of the requests of community legislation and provide a stepwise short-term and mid-term approach to fulfil such requirements [23]. The Strategy defines short- and long-term objectives:

- Short term objectives are:
  - Stepwise introduction of a separate collection of recyclables;
  - Increase the recycling rate of waste from households to overall 25 % by weight by 2025;
  - Increase the level of diversion as percentage of totally generated paper and cardboard in Serbia to 25 % by 2025,
- Long term objectives
  - By end of 2030, the recycling rate of waste from households will be increased to overall 35 % by weight; respectively 45 % by end of 2035 and finally 65 % by 2054;
  - By end of 2029, increase the recycling rate for C&D waste to 40 % by weight to 70 % by weight by end of 2034;
  - By end of 2029, increase the level of diversion as percentage of totally generated paper and cardboard in Serbia to 35 %; respectively 50 % by end of 2034;
  - By end of 2029, increase the level of diversion as percentage of totally generated bio-waste in Serbia should to 40 %; respectively 60 % by end of 2034;

By end of 2028, reduce the biodegradable waste going to landfills to 75 % of the total amount of biodegradable waste generated in 2008 (maximum amount to be landfilled); respectively 50 % by end of 2032 and 35 % by end of 2039.

8.4 Strategy of Industrial Policy for the period 2021-2030

Based on the vision for 2030, the industry of Serbia should be transformed into an open, regionally and globally competitive, investment-active, educated, innovative and digitally transformed industry that strongly supports economic growth and raising the quality of life of its citizens [58]. The general goal of the industrial policy is to raise the competitiveness of the industry of the Republic of Serbia, and the special goals are:

- improving the digitization of business models of industrial production;
- development of industry based on innovation and development of higher stages of technological production;
- increased total volume of investments in industry with growth of investment quality;
- improving the technological structure of exports;
- transformation of the industry from a linear to a circular model.

8.5 Taxes and tariffs in Agriculture sector

Directorate for Agrarian Payments, as a part of the Ministry of Agriculture and Environmental Protection and performs the activities related to the implementation of the subsidies program in agriculture, making calls for applications, decides upon the right to assistance, making payments to the final beneficiary, performs administrative and on the spot checks, establishes and keeps accounting records of contractual obligations and payments, implements international assistance to agricultural policy in the Republic of Serbia, manages the Farm Register.

One of the goals of the Directorate is fulfillment of the requirements for using of the European funds in the area of agriculture. After gaining the EU candidacy status for full EU membership Serbian agriculture will become eligible for fifth component of Instrument of pre-accession (IPA) related to the rural development. By establishing of the Directorate necessary institutional framework has been set up which will enable not only use of the IPA pre-accession funds, but also further integration of the Serbian agriculture into EU Common Agricultural policy (after the full membership into EU), namely European Agricultural Guarantee Fund (EAGF) and European Agricultural Fund for Rural Development (EAFRD) [60].

IPARD II - Instrument for Pre-Accession Assistance in Rural Development for the 2014-2020 programming period provides € 175 million investment support to strengthen the competitiveness of the food production and processing sector, which will help gradually adapt to EU standards in the areas of hygiene, food safety, veterinary and environmental protection, as well as the diversification of the rural economy [61]. The program can also support the establishment of producer groups, rural infrastructure, training, including advisory services, agri-environmental schemes, as well as local initiatives, and through this program candidate country for EU membership prepare for the use of European Agricultural Fund for rural development (EAFRD).

The IPARD II program was approved by the EU and adopted by the Government of the Republic of Serbia. It is implemented through the Ministry of Agriculture, Forestry and Water Management and the Directorate for Agrarian Payments. The Financing Agreement 2014-2020 between the Government of the Republic of Serbia and the European Commission, enabling the implementation of the IPARD II program, entered into force on 12 June 2018.

IPARD support is the first aid of its kind aimed directly at beneficiaries, i.e. agricultural producers - legal entities and individual farmers, and covers the following regions: Belgrade region, Vojvodina region, Sumadija region and Western Serbia and the region of Southern and Eastern Serbia.

Currently, the IPARD II program is implemented through two measures:

- Measure 1 - Investments in physical assets of farms - Significant support for investments in material assets and technical improvements (construction of facilities and procurement of agricultural machinery) increases the productivity and competitiveness of agricultural production.

- Measure 3 - Investments in physical assets related to the processing and marketing of agricultural and fishery products: by supporting investments in the modernization of processing capacities, it increases the overall performance of the sector and contributes to meeting the required EU standards.
- Measure 7 - Diversification of agricultural farms and business development: aims to increase the degree of development of economic activities in rural areas, with the possibility of job creation, which will directly increase farm income.
- Measure 9 - Technical Assistance: The measure supports technical assistance and costs related to the implementation of the IPARD program. The aim of this measure is to assist in the implementation and monitoring of the program, as well as in its possible modification.

A procedural framework for the accreditation of the following measures is under preparation:

- Measure 4 - Measures in the fields of agriculture, environment, climate and organic production: the main objective of the measure is to gain experience in implementing and introducing EU methodologies and practices in this sector.
- Measure 5 - Preparation and implementation of Local Development Strategies (LEADER approach): should contribute to the development of civil society and strengthen social dialogue within rural areas. Supporting good governance, promoting employment and developing human capital, while implementing the measure through local partnerships, contributes to the sustainable development of rural areas.
- The procedure for exercising the right to IPARD support is different compared to the procedure for requesting subsidies from the national budget, primarily because of the number of the controls on the fields that are mandatory. The process consists of two phases - the approval phase of the project and the approval phase of the payment request.

In the first phase, the applicant is obliged to submit with the Request for Project Approval all necessary documentation required for him to enter into the project approval process at all. Once the project is approved, the beneficiary can start the investment and finish it within the period prescribed by the project approval decision. When the investment is completed within the stipulated time, the user submits a request for payment approval. The IPARD Incentive Payment Decision sets out all the rights and obligations that the beneficiary must honor within the next five years from the moment of payment.

The financial benefits and incentives in agriculture sector include the following:

- Agricultural incentives
- Incentives for food processing – investment projects
- Corporate income tax relief
- Construction land transfer subsidy
- Payroll tax incentives
- Cash grants
- Double taxation avoidance.

Agricultural Incentives - Agricultural estates performing agricultural activities (milk and crop production, cattle breeding, etc.), and registered within the Register of Agricultural Estates are entitled to apply for agricultural incentives.

Incentives for Food Processing-Investment Projects - Minimum level of investments in the field of food-processing project (regardless of the level of development of the local self-government unit) is 2 000 000 €, and minimum number of new jobs created is 30 [61].

Corporate Income Tax Relief - A 10-year Corporate Profit Tax Holiday is available for investors who hire more than 100 employees and invest more than 8.4 million euros. Tax holiday begins once the company starts making a profit.

Construction Land Transfer Subsidy - Government or the local municipality can sell construction land at a price which is lower than the market price in support of an investment project that is of national importance (if the land is owned by the government) or an investment projects that promotes local economic development (if the land is owned by the local municipality).

Payroll Tax Incentives - Employment of people who were registered with the National Unemployment Agency for more than 6 months entitles employers to a sizable relief of taxes paid on net salary from the moment of employment until December 31, 2019:

- 1-9 new jobs: 65 % reduction;
- 10-99 new jobs: 70 % reduction;
- 100+ new jobs: 75 % reduction. (payroll tax incentives can't be combined with Cash Grants).

In 2020, companies that increase the number of employees and employ persons who were not employed during 2019 will be exempt from paying 70 percent of taxes on salaries and contributions for disability pension insurance for those persons during 2020, or 65 percent in 2021 and 60 percent in year 2022. This measure will refer to the employment of unemployed persons, regardless of whether they are registered with the national employment service, students and entrepreneurs - lump sums.

Cash Grants - To offset initial capital investments and ease the start-up of business endeavours, the Government of Serbia offers financial support for Greenfield and Brownfield projects in manufacturing, and the services sector which may be subject to international trade.

Double Taxation Avoidance - Republic of Serbia has 59 effective double taxation agreements in place that cover income, capital and property. In addition to having double taxation agreements in place with most European countries, Serbia has double taxation treaties in place with many countries in Asia and Africa.

8.6 Innovation Fund

The Innovation Fund is the only state organization specialized in providing support to innovation activity and managing financial resources to encourage innovation. The main goal of the fund, improving the links between science, technology and economy and contributing to the development of innovative entrepreneurship, is realized through the following activities [47]:

- Support for innovative entrepreneurship, especially in the early stages of development;
- Connecting scientific research organizations and private companies for the development and commercialization of innovations;
- Providing opportunities for entering the market of new products, services and technologies;
- Establishment of long-term institutional support of the state to innovative entrepreneurship in cooperation with international financial institutions, organizations, donors and the private sector.

An overview of the Innovation Fund program and the achieved results are given below [47]:

- Early development program
  - Amount of funding: up to 80 000 euros or up to 85 % of the total approved project budget;
  - In 2017, 20 innovative projects worth a total of 1.45 million euros were approved;
  - In 2018, 13 innovative projects worth a total of 1 million euros were approved.
- Innovation co-financing program
  - Amount of financing: up to EUR 300 000 or 70 % of the total approved budget for micro and small/60 % for medium enterprises;
  - In 2017, the financing of 5 innovative projects with a total value of 1 million euros was approved;
  - In 2018, the financing of 9 innovative projects with a total value of 2.04 million euros was approved.
- Program of cooperation between science and economy
  - Amount of funding: up to EUR 300 000, i.e. up to 70 % of the total approved project budget;
  - In 2018, the financing of 9 innovative projects with a total value of 2.25 million euros was approved.
- Innovation vouchers
  - Amount of financing: up to 800 000 dinars, i.e. 80 % of the total costs of the service;
  - During 2018, 220 innovation vouchers were awarded to 180 small and medium enterprises in the total amount of 1.17 million euros;

- In the first half of 2019, 105 innovation vouchers were approved for 92 companies in the total amount of 550 000 euros
-

– Technology transfer program
  - Amount of funding: up to 50 000 euros

By the end of May 2019, 19 innovative development projects with more than 380 thousand euros were supported.

8.7 Summary and conclusions in relation to SWOT elements

Table 8.7.1: SWOT analysis of Bioeconomy Policy Framework of Republic of Serbia

Strengths	**Weaknesses**
• Specific measures are taken in the field of bioeconomy • The fact that bioeconomy is mentioned in policies of sectors as agriculture shows the general understanding that these sectors play a role in Slovenia's transition into a circular economy • There is a growing awareness that structural changes in policies are required for the development of bioeconomy	• no explicit legislative bioeconomy support and stimulation, only measures that contribute to bioeconomy development • most measures rely on voluntary pledges from the private sector • limited resources for possible measure implementation • a lack of a circular agricultural policy • a lack of financial incentive/ subsidies to foster bioeconomy development
Opportunities	**Threats**
• Future policies should focus on clusters: pairing innovation centres with industry and state • Policies for improved biomass managing, increase in the use of forest wood and stimulation of the use of recognized certificates • Removing administrative issues, e.g. via voucher schemes (proposed in Poly4EmI, 2014)	• No new and bioeconomy-specific policies and legislation (status quo) • Ignoring of the raising awareness of the need for structural change in policy • Continuous relying on voluntary pledges from companies

9 Financing

Serbia has continued its path toward EU membership: EU negotiation process officially started, ready for accession by 2025. Serbia has confirmed its top position holding 1st place as the top investment destination country in the world, measured by the estimated number of jobs relative to the size of the population [65]. According to IBM Global Location Trends 2019 report, IBM Global Business Services Efforts in attracting new investments in the Republic of Serbia were also recognized by the new "E&Y European Attractiveness Survey 2019" [66].

Serbia has attracted a record number of Foreign Direct Investment (FDI) in 2018, and it is listed as one of the top 15 countries in Europe by the number of FDIs. Serbia is the only country outside of the Commonwealth of Independent States that has a Free Trade Agreement with Russian Federation. On WB Doing Business List, Serbia moved up by 49 places over the past 5 years, and is now ranked 44th globally [66]. FDI Ranking per Sector by No. of Projects is shown in Figure 9.1.1[66].

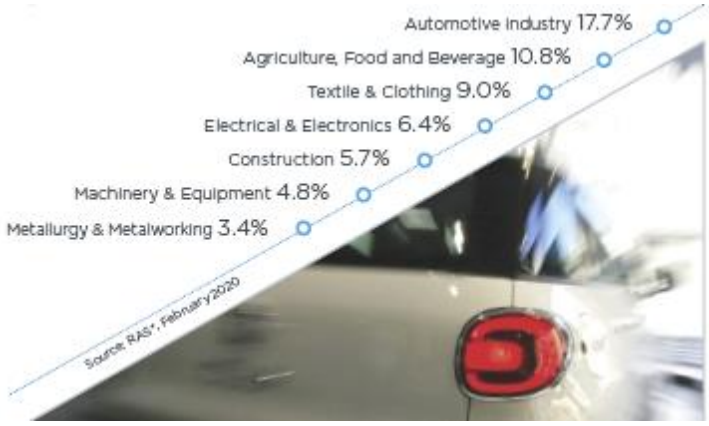

Figure 8.7.1: FDI Ranking per Sector

Serbia has transformed to a low inflation and stable growing economy, with a balanced fiscal position, declining public debt, significantly reduced external imbalances and labour market recovery, which helped the economy to respond readily to ongoing challenges [67]. Inflation has moved in accordance with the expectations, and in April 2020 it measured 0.6% y-o-y. Low inflationary pressures are also confirmed by the core inflation of 1.4%, as well as by anchored inflation expectations. Inflation is expected to average 1.5% and 1.8% in 2020 and 2021, respectively.

GDP growth in 2019 continued with strong economic expansion reaching a rate of 4.2%, driven by investments. The trend continued in Q1 2020 with growth estimated at 5%, despite first effects of COVID-19. Pandemic effect on the economy will peak in Q2, but it is expected fully recovery by the end of the year. The adopted fiscal policy measures (EUR 5.1 bn, around 11% of GDP) will allow GDP to return to pre-crisis levels by the end of the year and sustainable growth of around 4% in the medium term. In May, Government issued a 7Y Eurobond of EUR 2 bn, at an interest rate of 3.375% (coupon rate 3.125%), while public debt is estimated to remain below the Maastricht criteria of 60% of GDP. Public debt stood at 51.9% of GDP in March.

CAD is set to decline to 5% of GDP in 2020. Macroeconomic stability and business environment improvements contributed to high FDI inflows of EUR 7.3 bn in 2018–2019. Strong FDI inflow continued in Q1 2020 (7.4% of GDP).
Unemployment rate reached the lowest level in 2019, while employment rate reached the highest comparable level.

The main reasons for investing in Serbia are:

- Availability of High-Quality Labor
- Competitive Operating Costs
- Customs Free Access to 1.3bn Consumers
- Political and Economic Stability
- Financial Benefits and Incentives
- Optimal Geographic Location.

Serbia has ideal natural conditions for agricultural production (one of the cleanest soils in Europe, diverse climate, a tradition of quality and healthy food production). As an important indicator of its efforts to produce quality food, Serbian law prohibits the production and import of any genetically modified foods and seeds (GMO). Some of the largest investors in the food industry are: Molson Coors, Calsberg, Nestle, Rauch, Nellenic (Coca-Cola), Alltech, Strauss and Pepsico [68].

Wood and furniture industry is one of the sub-sectors of the industry with the brightest future is the production of large furniture. This area offers comparative advantages such as: high-quality local raw materials, a low-priced labor force, low energy prices compared to other European countries, and a strategic geographic position that allows for fast shipment. In addition to that, the Free Trade Agreements with EU countries and Russia, and the good reputation and quality, has helped these sub-sectors record a trade surplus. Some of the largest foreign investors in the wood and furniture sector are: Jysk, Tarkett and Pontex [68].

The EBRD has achieved an historic record in Serbia in 2019 with €516 million of new financial commitments, lifting the Bank's results to a new level, especially in the private sector and the green economy [69]. In total, the EBRD signed more than 20 new projects and registered the highest investment volume in the country since Serbia joined the EBRD in 2001. Fostering the competiveness of the private sector, supporting Serbia's environmental infrastructure and supporting investments in energy efficiency and clean energy remain the Bank's key priorities in the country.

To enhance the competitiveness of the private sector, the Bank channelled €226.2 million in credit lines to commercial banks for on-lending to local small and medium-sized enterprises (SMEs), while it channelled €5 million direct financing through WB EDIF and Enterprise Expansion Fund. SMEs were also given access to credit lines blended with incentives funded by the European Union, while 140 SMEs received advisory support for building export capacity, digitalisation, marketing, financial management or business skills development.

In the agriculture sector, the EBRD provided a €15 million loan to Serbia to finance the rehabilitation and construction of irrigation infrastructure in two regions, Negotin and Svilajnac. Serbia's agricultural infrastructure, which has suffered from severe floods and droughts in recent years, will become more resilient to climate change. The EBRD and Food and Agriculture Organization of the United Nations will additionally assist Serbia to prepare a national irrigation strategy aimed both at increasing the competitiveness of the agricultural sector and adapting it to climate change.

The EBRD is a leading institutional investor in Serbia. The Bank has invested more than €5.6 billion across 255 projects in the country. The EBRD is supporting private-sector development and the transition towards a green economy, as well as investing in infrastructure to improve private sector competitiveness and boost connectivity in the Western Balkans region.

9.1 Summary and conclusions in relation to SWOT elements

Table 9.1.1: SWOT analysis of Bioeconomy Financing of Republic of Serbia

Strengths	**Weaknesses**
• Educated labor force, language skills and willingness to learn • Areas of excellence in academia and industrial research • Streamlined investment promotion and incentives • Increase in demand for bio-based products in export-oriented companies (e.g. automotive industry)	• Finding funds for the transition fromresearch at loboratory scale(TRL 4) to applications at pilot and demo scale (TRL 5-6) • Finding funds for the transition from demo scale (TRL 6) to market • Small scope of international projects, platforms, networks that are based in specific measure • Weak investment activity in processing activities in the direction of transitioning to bio-based alternatives • Weak supporting activity of financial institutions towards bioeconomy projects (e.g. venture capital funds)
Opportunities	**Threats**
• Enhance State or Government funding and subsidies for fostering bioeconomy • Better use of available EU funding in the field of bioeconomy • Promoting cluster formation • Regional resource connecting (RDI, production, logistics)	• Stagnant or reduced Government funding and use of EU funds • Possible risky nature of investment • A lack of agencies providing equity and loans for bio-based initiatives

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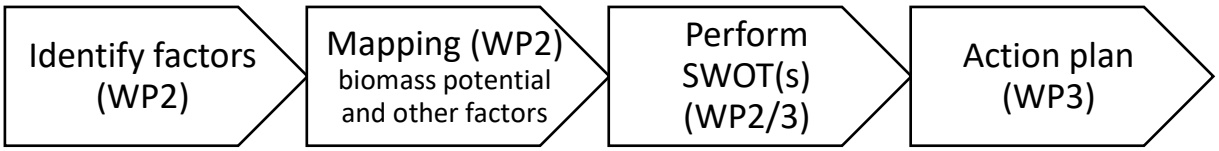
Annex 1 Approach guiding the structure and contents of this report

Identification of factors that are important for establishing bio-based production chains in a country

One of the objectives of the CELEBio project is to map opportunities in the target countries for setting up bio-based business activities. This includes the mapping of the biomass feedstock potentials, and other key success factors for establishing bio-based production chains, e.g. business activities, what bio-based products can be generated, and what is the market demand of these products.
The BBI is focused on the next bio-based products and markets: Chemicals, Plastics (polymers, materials, packaging), Specialties (surfactants, lubricants, pharmaceuticals, nutraceuticals, cosmetics), Textiles, Food ingredients and feed, Advanced biofuels.

To be able to perform SWOT(s) and generate action plans, the first step is to identify which factors are important. These factors should be determined based on the perspective of both entrepreneurs/business developers and governments. The identified factors should be mapped and will be the basis for performing a SWOT (Strength, Weakness, Opportunity and Threat) analysis for development of biobased production chains.



Based on input from industry and business developers a logical set of factors was identified that guide the choice of investing in the bio-based economy and location of conversion plants (Van Dam et al., 2014). This set is expanded/updated (amongst others based on the BBI project BIOFOREVER (bioforever.org)). Via an interview sheet, different stakeholders (15) from different countries (the Netherlands, Croatia, Czech Republic, Hungary, and Slovenia) were asked to comment on the factors and rank them.

Highest ranked factors:

- Feedstock supply: price, security of supply, quality
- Product market: price, off-take security
- Regulations, legislation, and rule of law

Medium raked factors:

- Financing: investors, subsidies, guarantees, risk minimization options
- Taxes and Tariffs
- By-product valorization: heat, CO2, fodder, lignin

Lowest ranked factors:

- Infrastructure: what part of the chain is already available (harbor, industries)
- Logistics: cost, reliable
- Technology: TRL, robustness, yield, CAPEX, OPEX
- Sustainability: economical, environmental, and social aspects

Overall, the ranking of the factors only differed slightly. Most of the experts mentioned that all the identified factors are important and that a system approach is key in developing biobased initiatives. If one link in the chain is missing, the biobased initiative will not succeed.

According the experts the most important stakeholders for establishing biobased production chains are:

- Producers/suppliers of biomass
- Chemical industry
- Energy industry
- R&D organizations
- Regulatory authority
- Environmental organizations
- Public

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Annex 2 Explanation of the S2BIOM approach to assessing lignocellulosic biomass potentials from agriculture, forestry and waste

In S2BIOM project the core biomass cost supply data was generated in WP1 for 37 European countries at regional level. Lignocellulosic biomass assessed by S2BIOM includes biomass originating from the following:

- Primary residues from agriculture
- Dedicated cropping of lignocellulos biomass on agricultural area
- Wood production and primary residues from forests
- Other land use
- Secondary residues from wood industry
- Secondary residues of industry utilising agricultural products
- Waste collection/ tertiary residues

Data have been assessed for 2012, 2020 and 2030. They are provided for several 'potentials' including: a technical potential; a base potential considering currently applied sustainability practises; and further potential levels that are determined considering changing sustainability restrictions, mobilisation measures and different constraints to account for competing use.

The technical potential represents the absolute maximum amount of lignocellulosic biomass potentially available for energy use assuming the absolute minimum of technical constraints and the absolute minimum constraints by competing uses. This potential is provided to illustrate the maximum that would be available without consideration of sustainability constraints.

The base potential can be defined as the technical potential considering agreed sustainability standards for agricultural forestry and land management. The base potential is thus considered as the sustainable technical potential, considering agreed sustainability standards in CAP (Common Agricultural Policy) for agricultural farming practices and land management and in agreed (national and regional) forestry management plans for forests (equivalent to current potentials described in EFSOS II). This also includes the consideration of legal restrictions such as restrictions from management plans in protected areas and sustainability restrictions from current legislation. Further restrictions resulting from RED (Renewable Energy Directive) and CAP are considered as restrictions in the base potential as well. CAP sustainable agricultural farming practices include applying conservation of Soil Organic Carbon (SOC) (e.g. Cross Compliance issues of 'maintaining agricultural land in good farming and management condition' and avoiding soil erosion).

The user-defined potentials vary in terms of type and number of considerations per biomass type. Following the general nomenclature of potentials the user defined potentials can also be considered as sustainable technical potentials but differ in the constraints considered vs the base potential and among each other. The user can choose the type of biomass and the considerations he would like to employ and calculate the respective potential accordingly. This flexibility is meant to help the user to understand the effect on the total biomass potential of one type of consideration against the other. These can include both increased potentials (e.g. because of enhanced biomass production) or more strongly constrained potentials (e.g. because of selection of stricter sustainability constraints).

Technical, base and one user defined (UD) potential has been assessed for all biomass groups. For forest biomass many more user defined potentials were quantified. See underneath:

Table A2.1: Overview of agricultural residual biomass potential types and considerations in S2BIOM.

	Area/ Basis	Yield, Growth	Technical & environmental constraints on the biomass retrieval (per area)	Consideration of competing use	Mobilisation
Technical (straw & stubbles)	Area in 2012, 2020, 2030 with cereals, rice, sunflower, rape, corn maize	Growth based on regional growing conditions & management. Yield according to regional averages including expected developments in yield towards 2020 and 2030	Maximum volume of straw and stubbles that could be harvested in 2012, 2020 and 2030	None	None
Technical (prunings permanent crops)	Area in 2012, 2020, 2030 with fruit trees, vineyards, olive & citrus	Growth based on regional growing conditions & management. Yield according to regional averages including expected developments in yield towards 2020 and 2030	Maximum volume of prunings and cuttings that could be harvested in 2012, 2020 and 2030	None	None
Technical (sugarbeet leaves & tops)	Area in 2012, 2020, 2030 with sugar beet	Growth based on regional growing conditions & management. Yield according to regional averages including expected developments in yield towards 2020 and 2030	Maximum volume of sugarbeet leaves and tops that could be harvested in 2012, 2020 and 2030	None	None
Base (straw & stubbles)	As for technical potential	As for technical potential	Only the biomass part can be removed that is not needed to keep the SOC stable. This is assessed according to carbon content that is removed with the residue and the SOC level in the soil that has to be maintained.	None	None
Base (prunings permanent crops)	As for technical potential	As for technical potential		None	None
Base (sugar beet leaves & tops)	As for technical potential	As for technical potential	Removal of leaves and tops from field is only allowed in Nitrate vulnerable zones where nitrogen surplus needs to be declined through removal of nitrogen rich biomass.	None	None
User potential (straw & stubbles)	As for technical potential	As for technical potential	As in base	In cereal straw a subtraction is applied according to demand for straw for animal bedding & feed . For rice straw, corn stover and sunflower and rape stubbles no competing uses are assumed.	None
User potential (prunings & cuttings)	As for technical potential	As for technical potential	All pruned material is available that is currently according to real practices NOT used to maintain the SOC and fertility of the soil. So the part that is now removed to the side of the field for energy uses or that is burned with & without energy recovery is seen as potential and can be removed. This follows the common treatment practices of prunings as assessed in the EUROpruning project.	None	The potential that is NOT used for SOC and fertility maintenance according to current practices needs to be mobilised gradually as it requires a change in management. It is therefore assumed; it becomes available from 50% in 2012 to 60% in 2020 and 70% in 2030.

Table A2.2: Overview of woody biomass potential types used in S2BIOM.

	Area/ Basis	Yield, Growth	Technical & environmental constraints on the biomass retrieval (per area)	Consideration of competing use	Mobilisation

This project received funding from the BBI JU under the EU Horizon 2020 research and innovation programme under grant agreement No.838087

	Area/ Basis	Yield, Growth	Technical & environmental constraints on the biomass retrieval (per area)	Consideration of competing use	Mobilisation
Technical	Forest area available for wood supply. This excludes protected and protective areas, where harvesting is not allowed according to protection purpose.	Growth based on regional to national growing conditions, including changes in biomass increment due to climate change. Yield according to regional management guidelines for age limits for thinnings and final fellings.	Maximum volume of stemwood that could be harvested annually during 50-year periods. Technical constraints on residue and stump extraction (recovery rate)	None	None
High	As for technical potential	As for technical potential	As for technical potential, but considering additional less stringent constraints (compared with base potential) for residue and stump extraction: Site productivity -Soil and water protection: ruggedness, soil depth, soil surface texture, soil compaction risk -Biodiversity (protected forest areas) -Soil bearing capacity.	None	None
Base	As for technical potential	As for technical potential	As for technical potential, but considering additional constraints for residue and stump extraction: -Site productivity -Soil and water protection: ruggedness, soil depth, soil surface texture, soil compaction risk -Biodiversity (protected forest areas) -Soil bearing capacity.	None	None
User potential - option 1	Reduction of FAWS by 5%	As for technical potential	Equivalent to increase of protected forest area by 5%.	None	None
User potential - option 2	Reduction of FAWS by 5%	As for technical potential	Increase of protected forest area by 5% and increase in retained trees by 5%.	None	Reduction in harvest by 5%
User potential - option 3	As for technical potential	As for technical potential	No stump extraction.	None	None
User potential - option 4	Reduction of FAWS by 5%	As for technical potential	Increase in protected forest by 5% plus increase in retained trees by 5% plus no stump extraction	None	Reduction in potentials by 5%
User potential - option 5	As for base potential	As for base potential	As for base potential	Roundwood production for material use (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Pulpwood, Round & Split + Other Industrial Roundwood) in period 2010-2014) subtracted from BP.	None
User potential - option 6	As for base potential	As for base potential	As for base potential	Roundwood production for material use excl. for pulp and paper and board industry (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Other Industrial Roundwood) in period 2010-2014) subtracted from UP4.	None
User potential - option 7	As for user potential - option 4	As for user potential - option 4	As for user potential - option 4	Roundwood production for material use (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Pulpwood, Round & Split + Other Industrial Roundwood) in period 2010-2014 subtracted from BP.	As for user potential - option 4
User potential - option 8	As for user potential - option 4	As for user potential - option 4	As for user potential - option 4	Roundwood production for material use excl. for pulp and paper and board industry (aggregate of FAO Production categories: Sawlogs & Veneer Logs + Other Industrial Roundwood in period 2010-2014) subtracted from UP4.	As for user potential - option 4

Table A2.3: Overview of potentials calculated for biowaste and wood waste.

Technical potential The Technical potential represents the amount of biomass assuming only technical constraints and a minimum of constraints by competing uses. In case of biowaste no constraints are considered in the technical potential. In case of post-consumer wood, the technical potential assumes that 5% of all wood waste cannot be recovered and used for energy application for technical reasons. Competing uses (current material application of the wood) are not taken into account.
Base potential This is the sustainable technical potential, considering currently agreed sustainability standards. In case of biowaste the base potential equals the technical potential. In case of post-consumer wood, the base potential takes into account the current material application of recovered wood, and assumes that this material application remains constant in 2020 and 2030
User defined potential The user-defined potentials vary in terms of type and number of considerations per biomass type. The user can choose the type of biomass and the considerations he would like to add and calculate the respective potential. This flexibility is meant to help the user to understand the effect on the total biomass potential of one type of consideration against the other. In case of biowaste no user-defined potentials have been developed. In case of post-consumer wood, one user-defined potential has been developed. This user defined potential on cascading use of post-consumer wood takes into account the current material application of post-consumer wood in 2012, and assumes that the material application of non-hazardous post-consumer wood will increase to 49.2% in 2020 and 61.5% in 2030, or remain stable if current (2012) material use is higher.

Primary agricultural residual biomass assessments

For the assessment in S2BIOM (like for Biomass Policies) land-use and livestock production levels are used based on the most recent CAPRI baseline run 2008-2050, providing intermediate results for 2010, 2020, 2030 and 2050.

The potential supply of agricultural residues was estimated for the period from 2012, 2020 and 2030. It uses as main input the cultivated land and main crop production and yield combinations made for these years by the CAPRI model. Residual biomass covered in S2BIOM from agriculture comes from primary residues from arable crops (straw and stubbles) and pruning, cutting and harvesting residues from permanent crops.

The assessment of residues from arable crops builds on methodologies and assessments already done in Biomass Policies and Bioboost. The assessment for vineyards, olive groves and fruit plantation residues bases builds on work done in EuroPruning project.

The aim of S2BIOM was to identify the part of the residues that can be removed from the field without adversely affecting the SOC content in the soil.

It is the carbon balance module in the MITERRA-Europe that has been further adapted in S2BIOM (and Biomass Policies) to take account of removal of straw (and also prunings, see next). This was done by incorporating the RothC model (Coleman and Jenkinson, 1999) into MITERRA-Europe. RothC (version 26.3) is a model of the turnover of organic carbon in non-waterlogged soils that allows for the effects of soil type, temperature, moisture content and plant cover on the turnover process. It uses a monthly time step to calculate total organic carbon (ton C ha-1), microbial biomass carbon (ton C ha-1) and Δ14C (from which the radiocarbon age of the soil can be calculated) on a years to centuries timescale (Coleman and Jenkinson, 1999). For this study RothC was only used to calculate the current SOC balance based on the current carbon inputs to assess taking account of soil types (including Soil C levels) the sustainable crop residue removal rates at which the carbon C in the soil remains constant.

Primary forest biomass potential assessment

The potential supply of woody biomass was estimated for the period from 2012 to 2030 for stemwood; branches and harvest losses (further: 'logging residues'); and stumps and coarse roots (further: 'stumps') (Table 20). First, we estimated the theoretical potential of forest biomass supply in Europe based on detailed forest inventory data. This theoretical potential was defined as the overall, maximum amount of forest biomass that could be harvested annually within fundamental bio-physical limits (adapted from Vis and Dees 2011, Dees et al. 2012), taking into account increment, the age-structure and stocking level of the forests. Second, multiple environmental and technical constraints were defined and quantified that reduce the amount of biomass that can be extracted from forests for different biomass potential types. Third, the theoretical potentials from the first step were combined with the constraints for the biomass potential types.

This sequence of steps is based on the approach developed and applied within the EUwood and EFSOS II studies (Verkerk et al. 2011; UNECE et al. 2011; Verkerk 2015). The approach in S2BIOM differs from previous studies in several ways, with the main difference being that that woody biomass potentials have been estimated using a typology of potentials developed within S2BIOM. Other changes include (i) an updated of the forest inventory data used as a basis to estimate biomass potentials; (ii) extension of the geographical scope to include all 37 S2Biom countries; (iii) improvements to set the of constraints; and (iv) improve the potential estimates at regional level by spatially disaggregating estimated biomass potentials. All improvements are described below.

The large-scale European Forest Information SCENario model was applied (EFISCEN) (Sallnäs, 1990) to assess the theoretical potential of forest biomass at regional to national level. Versions 3.1.3 (Schelhaas et al. 2007) and 4.1 (Verkerk et al. 2016a) were used because the former version is included in a script to estimated biomass potentials Verkerk et al. (2011), while the latter version has the ability to directly store results in a database, which is used to run the EFISCEN disaggregation tool (Verkerk et al. 2016b). EFISCEN describes the state of the forest as an area distribution over age- and volume-classes in matrices, based on data on the forest area available for wood supply (FAWS), average growing stock and net annual increment collected from NFIs. Forest development is determined by different natural processes (e.g. increment) and is influenced by human actions (e.g. management). A detailed model description is given by Schelhaas et al. (2007; 2016). National forest inventory data on area, growing stock and net annual increment are used to initialize the EFISCEN model.

The amount of wood that can be felled in a time-step is controlled by a basic management regime that defines the period during which thinnings can take place and a minimum age for final harvest. Age-limits for thinnings and final fellings were based on conventional forest management according to handbooks at regional to national level (Nabuurs et al. 2007) and by consulting national correspondents (UNECE-FAO 2011). The amount of stemwood potential removed as logs was estimated by subtracting harvest losses from the stemwood felling potential. Harvest losses were estimated using the ratio between fellings and removals as reported by UNECE-FAO (2000) for coniferous and broadleaved species separately.

Branches together with harvest losses represent logging residues that can be potentially extracted as well. In addition, stumps could potentially be extracted, separately from logging residues. The volume of branches, stumps and coarse roots was estimated from stemwood volume (incl. harvest losses) using age-dependent, species-specific biomass distribution functions (Vilén et al., 2005; Romano et al., 2009; Mokany et al., 2006; Anderl et al. 2009). We assumed no difference in basic wood density between stems and other tree compartments, due to lack of information.

Climate change is accounted using results from LPJmL (Sitch et al. 2003, Bondeau et al. 2007). Data are an average for several climate models for the A1b SRES scenario. Annual tree Net Primary Production (NPP) in gC/m2 for 3 individual years (2010, 2020, 2030) was calculated with LPJmL and used to scale the increment functions used in EFISCEN.

Secondary biomass potentials from agro-food industry

For an overview of the calculation methods and assumptions of secondary biomass sources from agro-food industries see the table below.

Table A2.4: Overview of assessment rules applied in S2BIOM to assess potentials for olive stones, rice husk, pressed grapes residues and cereal bran.

Biomass type	Area / Source	Residue factor	Technical & Environmental constraints
Olive-stones	CAPRI & national statistics: Area with all olive trees (table=oil olives) 2012, 2020, 2030	Olive pits make up between 10%-12.5% of the weight of olive according to Garcia et al. (2012) and Pattarra et al., (2010)	Base= pits from all oil olives + 30% of table olives
Rice husk	CAPRI & national statistics: Area with rice in Europe 2012, 2020, 2030	Rice husk is approximately 20% of the processed rice, with average moisture content of 10% ((Nikolaou, 2002)). It is assumed that all rice produced in the S2BIOM countries is locally processed	None
Pressed grapes residues (pressing residues & stalks)	CAPRI & national statistics: Area with vineyards in Europe 2012, 2020, 2030	Of the processed grapes 4.6% consists of dregs and 1.5% of stalks (FABbiogas (2015)- Italian country report)	None
Cereal bran	CAPRI total estimate of tons processed cereals per EU country	In wheat processing 20% to 25% wheat offals (Kent et al., 1994). Wheat bran represents roughly 50% of wheat offals and about 10 to 19% of the kernel, depending on the variety and milling process (WMC, 2008; Prikhodko et al., 2009; Hassan et al., 2008). . So the residue to yield factor used is 10% of cereals processed domestically.	None

For the calculation of the olive stones, rice husk and pressed grapes dregs we assumed that all domestic production would also be processed locally and that is no further processing of imported olives, rice and grapes. This implied that the residues would be available locally and that the regional distribution of the processing residues is a direct outcome of the cropping area distribution over regions in every country.

For cereal bran it is more logical to assume that the basis should be the total amount of cereals processed in every country. This implies that cereal bran needs to be calculated for a total net domestic cereal production and imports:

$$Domestic\ production_{cereals} - export_{cereals} + import_{cereals}$$

The data on total domestic production, exports and imports levels were available from CAPRI for 2010 (extrapolated to 2012), 2020 and 2030 for all S2BIOM countries except for Ukraine.

To come to a regional distribution of the cereal bran potentials in every S2BIOM country 2 assumptions were made:

1) The bran based on the net domestic production (=domestic production – exports) is distributed regionally according to cereal production area share.
2) The cereal bran based on processing of imported biomass is distributed over largest (port) cities per country as it is expected that processing industries are there where imports enter the country and where population is concentrated. The residues were spatially distributed to regions with the large and medium sized cities (>100,000 inh.), every city was equally weighted.

Method used to estimate secondary forest biomass produced in the forest processing industry

The EU-Wood study (Mantau, 2010) projects the demand for material use without considering competition with other sectors in order to explore if the increasing demand for energy will lead to a strong competitive situation

where the demand substantially exceeds the supply. The EU-Wood project (Mantau, 2010) has aligned the prediction of the future demand to the real GDP (Gross domestic product) and thus the prediction that utilises the IPCC B2 scenario assumptions shows a strong increase (see figure below).

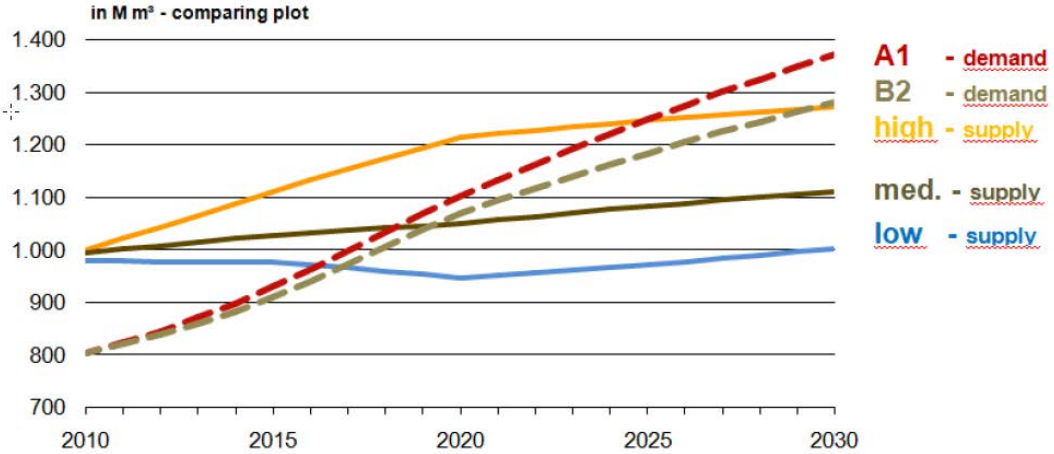

Figure 1-4: Development woody biomass potential demand and potential supply

Source: EUwood 2010

Figure A2.1: Future development of demand and supply as projected by the EU-Wood project for different scenarios (Mantau, 2010).

Thus, to constrain the potentials by such demand projection would constrain the potential with strong preference to material use. The recent trends of the forest products consumption index indicate that the production has changed its relation to the GDP (see figure below).

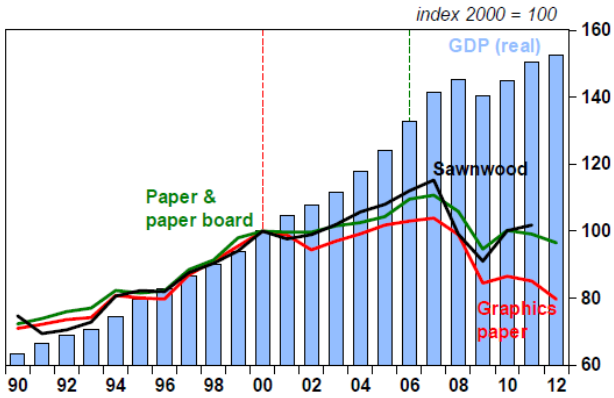

Figure 2.1.2. EU GDP (real) and forest products consumption index over the period 1990-2012 (2000 = 100). (Forest products data from FAO; GDP data from IMF, Gross domestic product based on purchasing-power-parity (PPP) valuation of country GDP).

Figure A2.2 EU GDP and forest products consumption index[5]

An alternative to use predict the future industry production results from modelling that considers economic competition. Such estimates are available from the EFSOS II study for 2010, 2020 and 2030. The trends of the EFSOS II study are utilised by S2BIOM. Figures 3 and 4 show for sawn wood and panels that the S2BIOM data for 2012 are close to EFSOS II reference scenario projections 2010.

[5] Source: Birger Solberg, Lauri Hetemäki, A. Maarit I. Kallio, Alexander Moiseyev and Hanne K. Sjølie (2015) Impacts of forest bioenergy and policies on the forest sector markets in Europe – what do we know?

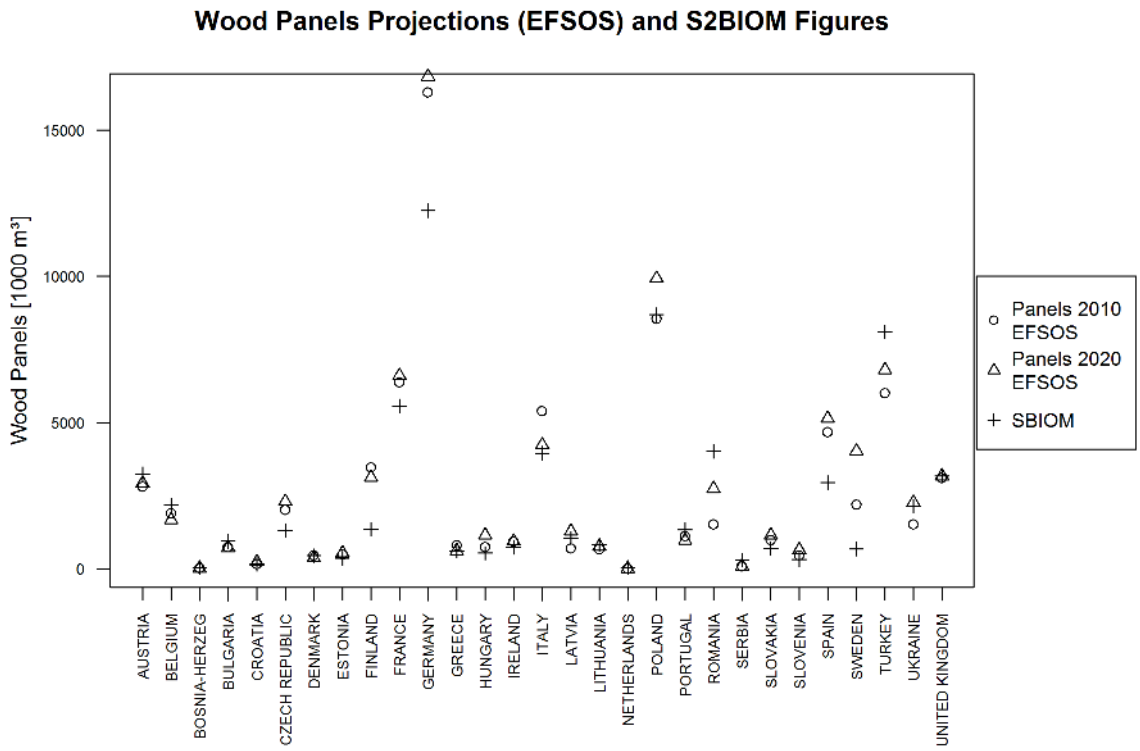

Figure A2.3 Wood panel production, EFSOS 2 reference scenario projections, and S2BIOM 2012 estimates

The S2BIOM residue and production figures of the timber industry were thus projected to the years 2020 and 2030 using the growth rates of the reference scenario of the UNECE European Forest Sector Outlook Study II (EFSOS II) for sawnwood and wood based panel production.

For the pulp and paper sector there was a huge difference between S2BIOM 2012 quantities and the EFOS reference scenario projections.

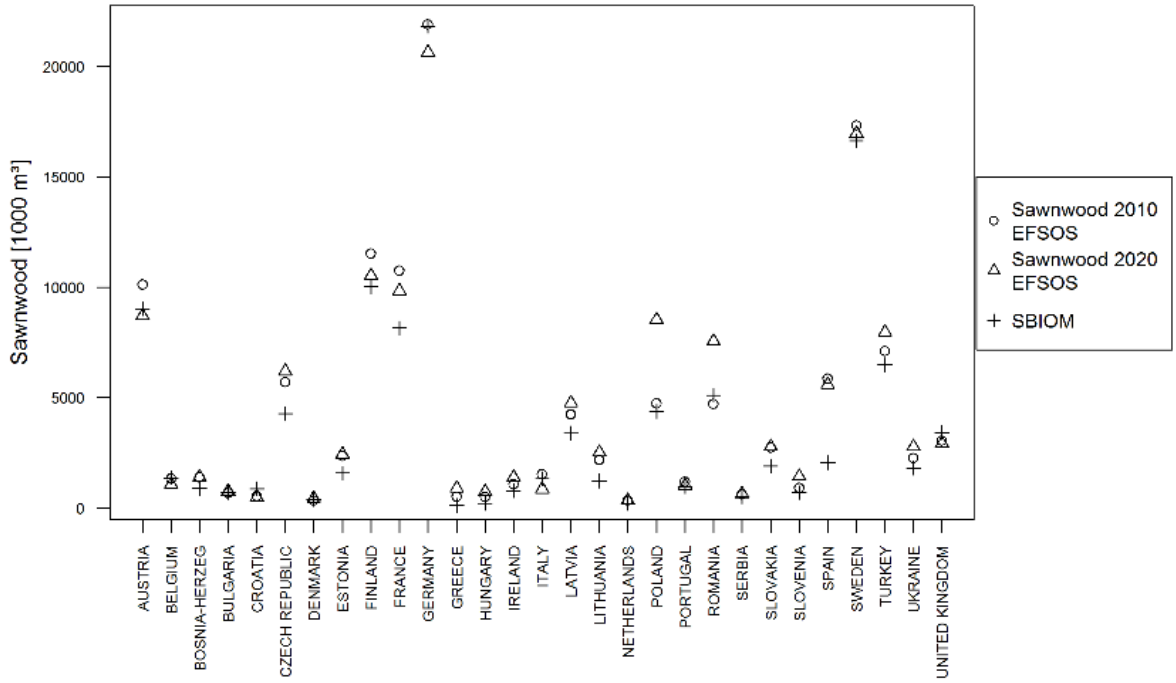

Figure A2.4 Sawnwood production, EFSOS 2 reference scenario projections and S2BIOM 2012 estimates

The visualisation of the figures from the "Historic Statistics" report of CEPI on pulp and paper production are shown in Figure 5. This figure shows the changes of pulp production for the CEPI member states which are: Austria, France, Netherlands, Romania, Sweden, Belgium, Germany, Norway, Slovak Republic United Kingdom, Czech Republic, Hungary, Poland, Slovenia, Finland, Italy, Portugal and Spain. It is for S2BIOM assumed that the changes in production after some bigger fluctuations in the past will be in 2020 and 2030 in the same dimension as in 2012. Hence the production quantities from 2012 are used for 2020 and 2030 as well.

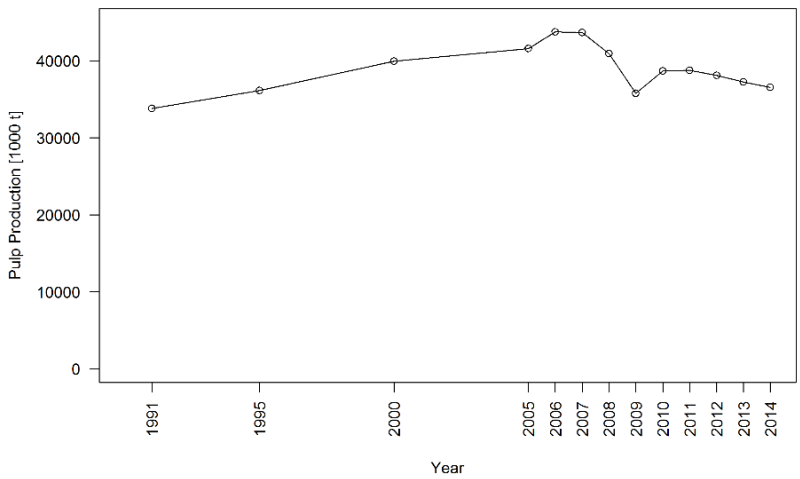

Figure A2.5 Development of Pulp production, CEPI data

The approach used is summarised by category in the table below.

Table A2.5: Approach used to estimate future production amount in the wood industry.

Sector	Approach
Saw mill residues, conifers	EFSOS II sawnwood, reference scenario
Saw mill residues, non-conifers	
Residues from industries producing semi - finished wood based panels	EFSOS II wood based panels production, reference scenario
Residues from further wood processing	EFSOS II sawnwood, reference scenario
Secondary residues from pulp and paper industry	Kept constant

Assessment of biowaste and post-consumer wood potentials

The availability of biowaste in 2012 on NUTS3 level was established as:

MSW generated per capita (kg/capita) x
biowaste fraction (%) x
population of the NUTS3 area (persons).

A further distinction has been made between the separately collected biowaste and biowaste as part of mixed waste.

In Arcadis and Eunomia (2010) projections have been provided of the shares of biowaste going to the different treatment options like landfill, incineration, MBT, composting, backyard composting, anaerobic digestion and others have been made for the years 2008-2020. It has been assumed that all countries meet the requirement of the landfill directive, e.g. that maximally 35% of the amount of biodegradable waste generated in base year 1995 is landfilled in 2020, even if current developments show that diversion from landfill has not been successful yet. Furthermore, the projections are based on policy views and current changes in treatment of biowaste in the member state concerned. For instance, some countries have a strong preference for MBT, others for incineration with energy recovery. For the year 2030 the same shares between treatment options are used as in the year 2020. Currently no policies are known that influence the production of biowaste after 2030, therefore it is assumed that the projected status quo in 2020 will be maintained in 2030.

Projections on the development of the total quantity of biowaste are assumed to be proportional to population growth. The main scenario on population development from Eurostat has been used to predict the population in 2020.

The calculation of the post-consumer wood potential is calculated according to the following formula:

$PCW_{technical\ potential} = PCW_{material} + PCW_{energy} + PCW_{disposed}$
$PCW_{base\ potential} = PCW_{energy} + PCW_{disposed}$

in which:

- $PCW_{recovered}$ = PCW used for materials like panels and chipboards
- PCW_{energy} = PCW used for energy production
- $PCW_{disposed}$ = landfilled and/or incinerated with MSW

Eurostat gives data on "wood waste", but this includes not only post-consumer wood but processing wastes from agriculture forestry and fishing sectors. Because of this mixture of secondary wood processing and tertiary post-consumer wood within one category, Eurostat data could not be used to determine the potential of post-consumer wood. For S2BIOM, data on recovered wood were used from a forest biomass resource

assessment done for the EUwood and EFSOS II studies (Mantau et al. 2010; UN-ECE/FAO 2011[6]). EUwood combines among others Eurostat and COST Action E31 data. The EFSOS II data on demolition wood is based on EU wood, but covers Europe as a whole instead of EU28. In order to determine the base potential PCW available for energy, it is necessary to estimate how much is used for material applications. In the Methodology report of the EUwood project[7], a table is given on the availability of *PCW recovered* [for material recycling] and *PCW energy* for 2007, page 119-120, which have been used in S2BIOM as well.

Assessment of cost levels for different biomass categories in S2BIOM

Because we are still in the early stages of a transition of fossil based feedstock towards bio-based feedstock there is hardly any information of enough quality to conduct a meaningful market analysis. In this light it is important to keep in mind that a distinction needs to be made between different types of cost and price levels specific per biomass type:

- Market prices exist for already traded biomass types (e.g. straw, wood chips and pellets based on primary and secondary forestry residues).
- Road-side-cost for biomass for which markets are (practically) not developed yet (e.g. many agricultural and forestry residues, dedicated crops for ligno-cellulosic and woody biomass and waste streams such as vegetal waste). These may cover the following cost:
    - Production cost (in case of dedicated crops, not for residues or waste)
    - Pre-treatment in field/forest (chipping, baling)
    - Collection up to road side/farm gate
- At-gate-cost which cover the cost at roadside plus transport and pre-treatment cost of biomass until the biomass reaches the conversion plant gate (e.g. bioethanol plant, power plant).

The cost assessed in S2BIOM are limited to the road-side cost. So, the cost from road side for transport and possible in-between treatment to the gate of the conversion installation or the pre-treatment installation are NOT included.

Cost assessment for agricultural biomass potentials

The overall methodology followed to gain insight in the minimum costs of production is the *Activity Based Costing* (ABC). It involves the whole production process of alternative production routes that can be divided in logical organisational units, i.e. activities. The general purpose of this model is to provide minimum cost prices for the primary production of biomass feedstock at the road side. ABC generates the costs of different components based on specific input and output associated with the choice of the means of production, varying with the local conditions and cost of inputs (e.g. labour, energy, fertilisers, lubricants etc.). Since the production of most biomass is spread over several years, often long-term cycles in which cost are incurred continuously while harvest only takes place once in so many years, the Net Present Values (NPV) of the future costs are calculated. This provides for compensating for the time preference of money. To account for the fact that the costs are declining in different periods of time in the future the Net Present Value annuity is applied. In this way annual, perennial crops and forest biomass cost are made comparable (=all expressed in present Euros).

The costs are automatically calculated for all field operations per year in a 60-year cycle in the case of agricultural biomass. The costs of wood production were not considered in this study as these costs need to be allocated to the main product, while here the focus is on the cost of the residues. Cost are presented as NPV per annum and expressed in € per ton dm or per GJ.

[6] UNECE (United Nations Economic Commission for Europe), FAO (Food and Agricultural Organization of the United Nations) 2011: The European Forest Sector Outlook Study II; Geneva

[7] EU Wood (2010) Methodology report, real potential for changes in growth and use of EU forests EUwood. Call for tenders No. TREN/D2/491-2008.

It is also important to note that the costs calculated in here are at the farm level cost. We are aware that the costs for the next link in the value chain might be higher because of rent seeking behaviour. However, in this approach we did not take account of it as we did not include a profit margin.
As explained in the former cost of agricultural biomass are calculated for *Net Present Value annuity* taking a 60-year coverage period. These 60 years are chosen to fit all possible cycles in the cost calculation as 60 is fully synchronizable to 1,3,5,10,15,20,30 and 60 years cycles. Cost differences after that period are negligible. In this way, cost for biomass from residues and from dedicated crops can be assessed with the same model and can be made comparable.

First the Net Present Values of all activities are calculated as follows:

Formula:
$NPv=Fv/(1+i)^n$
Where:

NPv = Net Present value
Fv = Future value
i = the interest rate used for discounting (set to 4%)
n = number of years to discount

Then the Net Present Value annuity is applied, assuming that the sum of NPVs cover the annual capital payments attracted against the same interest rate (4%) as the discount rate used for calculating the NPVs.

Formula:
$NPVa= \Sigma NPv*(1/((1-(1+i)^{-n})/i))$
Where:

NPVa = Net Present Value annuity
ΣNPv = sum of NPVs
n = number of years
i = the interest rate (set to 4%)

The cost also allow for national differentiation of cost according to main inputs having national specific prices levels. This organised through the **'Country inputs'** module in the ABC model. It contains detailed information concerning the prices of various resources needed as input for the production process of biomass specific per country. These are specified, either in absolute price levels or as an index related to the known price level in one or two specific countries (mostly Germany). This is necessary as prices of key production factors differ a lot at national level across Europe. National level price data (ex. VAT) included cover cost/prices for labour (skilled, unskilled and average), fuel, electricity, fertilizers (N, P2O5, K2), machinery, water, crop protection and land. Most of these data were gathered from statistical sources such as FADN (Farm Accountancy Data Network), Eurostat and OECD. Most cost levels were gathered for the year 2012.

The cost data elaboration also requires a feedstock specific approach. If costs are estimated for biomass that is specifically produced for energy or biobased products, i.e. in the case of dedicated crops the cost structure is clear and all cost can be allocated to the final product. All cost should include the fixed and variable cost of producing the biomass including land, machinery, seeds, input costs and on field harvesting costs. If the biomass is a waste, i.e. cuttings of landscape elements or grass from road side verges, the cost could be zero, as cutting and removing these cutting is part of normal management. However, bringing the biomass to the conversion installation requires some pre-treatment costs, e.g. for drying or densifying and then transport costs have to be made to bring it to the conversion installation. These costs will not be assessed here however as we concentrate on the road side cost.

Crop residues also require a separate approach as harvesting cost can usually be allocated to the main products, i.e. grain in the case of cereal straw, and not to the residue. However, the baling of the straw and the collection up to the roadside can be included in the costs.

For the elaboration of cost levels account also needs to be taken of the local circumstances and type of systems used for the production and harvesting of the biomass. This is particularly complex in the case of

dedicated crops for which cost estimates are mostly and/or only available from pilot plots and practically no commercial plantations. Costs vary strongly per type of management, soil and climate zone. Furthermore, cost need to be allocated per ton harvested mass over the whole life-time of a plantation as harvest levels are very low in the first years and increase in time.
The costs are determined for 2012, the reference year and are kept constant in the future years 2020 and 2030. The reason for keeping cost constant in time has several advantages:

1) Estimations of future changes in prices for (fossil) energy (fuel & electricity), labour, and machinery are difficult to predict. If predictions are used this implies automatically adding additional uncertainties in the cost assessment.
2) If cost levels do not alter in time the uses of the cost-supply data in other models in and outside S2BIOM (e.g. Resolve and BeWhere) deliver results that can only be explained from the internal logic of the models and not by differences in cost level increases based on a large number of uncertainties.
3) The cost levels presented in S2BIOM can still be further adapted by other users applying their own assumptions on future cost level changes. This enables them to use the S2BIOM cost-supply data consistently with their own modelling assumptions.

Cost assessment for forest biomass

The estimation of harvesting and comminution costs is following the approach presented earlier by Ranta (2002, 2005), Ilavský et al. (2007), Anttila et al. (2011) and Laitila et al. (2015). In contrast to the cost estimates for energy crops, the production costs are not considered in the cost estimates.
The data are mostly determined by the S2Biom project. A survey of cost factors related to forest harvesting operations was carried out in cooperation with INFRES project (Dees et al. 2015).
The methodology can be divided into two main components: 1) the estimation of hourly machine costs, and 2) the estimation of productivity. All the cost estimations pertain to current cost level (year 2012).

The general work flow is illustrated in the figure below.

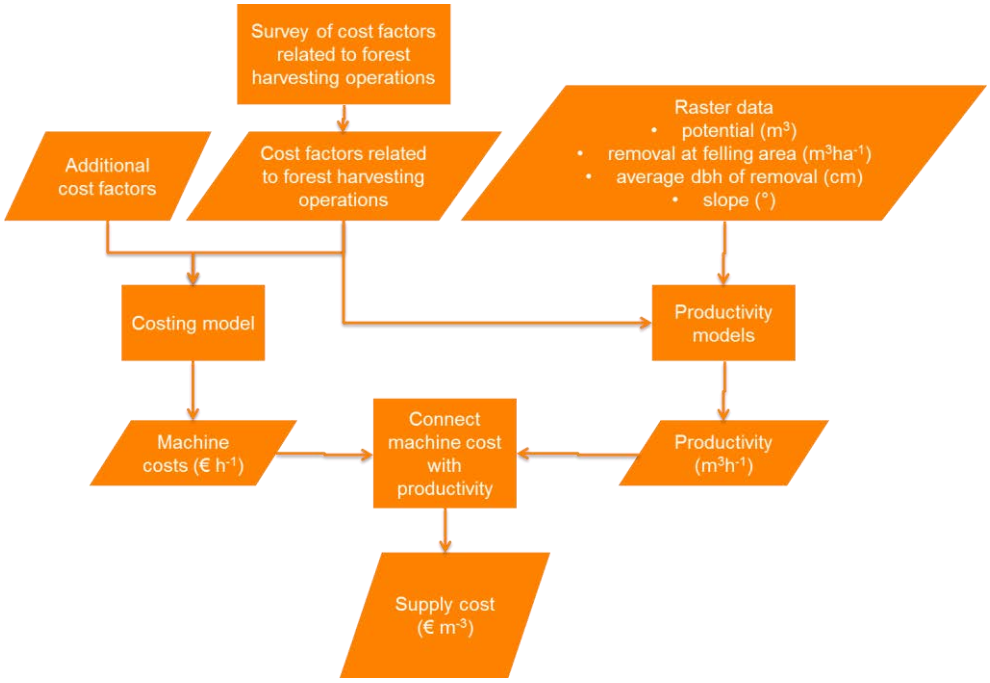

Figure A2.6 General work flow of the forest biomass cost calculations

Cost estimates for biowaste and post-consumer wood

This study follows the activity-based costing approach. In principle, the costs of harvesting collection and forwarding to the roadside need to be considered. The cost to put the biowaste in a container at roadside is assumed to be zero. The cost of further collection and processing is covered by the households and organisations that need to discard the biowaste, regardless its possible further application for energy production. Waste collection and treatment is part of the public tasks and the cost for it cannot be allocated to the processor of the waste. In case of biowaste we could define the municipal collection point as "at roadside". From this municipal collection point, the municipality can select which waste treatment option is preferred, within the framework of European and national policy, considering costs and sustainability of the treatment methods.

The cost of discarding post-consumer wood in a container at roadside is regarded zero. For instance, demolition activities are performed to make space for another building, and not with the purpose to generate wood waste. Demolition activities will follow legal instruction, i.e. put waste wood fractions in separate containers if this is required by law. For other sources of post-consumer wood such as packaging materials or household waste a similar approach can be applied. Packaging waste is of no value to organisations. Consumers bring wooden furniture to a central collection point, or put it at roadside for pick-up, not the sake of providing energy wood. Once collected and sorted, waste wood fractions have an economic value, which can be considerable if there is sufficient demand. However, as said, S2BIOM follows an activity based costing approach, considering the costs, not the economic value of the material. The roadside cost of demolition wood is therefore assumed zero.