Horizon 2020
European Union Funding
for Research & Innovation

Bio-based Industries Consortium

CELEBio

# D.2.1 Country report: Slovenia

*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***

February 2020

Gospodarska zbornica Slovenije

Chamber of Commerce and Industry of Slovenia

Association of Chemical Industries of Slovenia

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

# GENERAL INFORMATION

| | |
|---|---|
| **Project title** | CELEBio – Central European Leaders of Bioeconomy<br>Website: https://celebio.eu |
| **Project No.** | 838087 |
| **Financed from** | Horizon 2020 |
| **Project leader** | Iniziativa Centro Europea – Segretariato Esecutivo (INCE)<br>Dr. Peter Canciani, Project Manager, canciani@cei.int |
| **Partner countries** | Bulgaria, Croatia, Czech Republic, Hungary, Italy, Netherlands, United Kingdom, Slovakia, Slovenia |
| **Project partner in Slovenia** | CCIS – Association of Chemical Industries of Slovenia (Darja Boštjančič, director), Dimičeva 13, 1504 Ljubljana, Slovenia, tel.: + 386-1-58 98 257, e-mail: zki@gzs.si |
| **Work package** | WP3, Assessment of biomass potentials and mapping stakeholders |
| **Work package leader** | Wageningen Research (WR),<br>Dr. Berien Elbersen, Senior researcher land use and integrated environmental assessment, berien.elebersen@wur.nl |
| **Activity** | A.2.1 - Sustainable Biomass Assessment, |
| **Deliverable** | D.2.1 - Country report for Slovenia |
| **Country Report for Slovenia prepared by** | • Gašper Virant – Coordination of document preparation. Preparation of chapter(s): 1, 3, 4, 6<br>• Miha Koprivnikar Krajnc - Preparation of chapter(s): 1, 2, 8, 9<br>• Dr. Blaž Likozar – Preparation of chapters(s): 5, 7<br>• Dr. Berien Elbersen – Preparation of chapter(s): 1, 2, 3, 4 |
| **Document checked by** | • Dr. Luka Juvančič (Biotechnical Faculty)<br>• Mag. Mario Plešej (Ministry of Agriculture, Forestry and Food) |
| **Document approved by** | Management Board of the Association of Chemical Industries of Slovenia (5th of March, 2020) |

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

# TABLE OF CONTENTS

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

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

# TABLE OF ILLUSTRATIONS

## FIGURES

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

## TABLES

# Summary

Slovenia is the third country in the European Union when it comes to relative forest coverage, right after Finland and Sweden. Around 58 % of Slovenia's surface is covered by forests; they are mainly beech, fir-beech and beech-oak forests, all of which have a relatively high production capacity. However, one of the major hampering factors are strong export lines of raw wood to the neighbouring countries, predominantly to Austria and to Italy. Besides raw wood, another accessible and abundant source of biomass is waste. Slovenia is one of the countries with the highest percentage of collected waste and management of recycling. The latter is attainable thanks to the RCERO, which is the most modern plant in Europe for the treatment of biological waste. The facilities can process 150,000 tonnes of mixed waste and over 20,000 tonnes of biological waste per year. Another factor supporting bioeconomy in Slovenia is the strong R&I activity in the field of bio-based products. The most relevant research infrastructure equipment, related to bio-based industrial development may be found at the Pulp and Paper Institute, the National Institute of Chemistry and the Faculty of Chemistry and Chemical technology (University of Maribor). Considering the equipment of the Pulp and Paper Institute, the latter spans from the laboratory to pilots and represents the only papermaking infrastructure centre in the area of SE Europe. In the case of National Institute of Chemistry, the latter primarily relates to the production of various bio-based chemicals/materials. Research is oriented towards the development of new technologies and products, which will help to ensure the long-term development of Slovenia, and are at the same time internationally relevant. Industry is an important partner to the Institute in these endeavours. With respect to existing industries, domestic chemical sector is particularly inclined towards the transition to bio-based solutions. The spectrum of bio-based product is quite broad, covering polymers for textile industry, various coatings, resins, wood-derived chemicals, plant extracts, biological drugs etc. One of the most vital challenges to further expand bio-based industry is the implementation of bio-refining, which is presently lacking. There is a strong industrial pull for various chemical/material intermediates, but no biomass bio-refineries are in operation. Establishing a local bio-refining capacity would drastically promote the advancement of emerging bio-based initiatives/commercialization. With respect to the current policy framework - bioeconomy is not the central topic of any specific Slovenian strategy. There are, however, several national and EU frameworks that touch on the topic of bioeconomy. As mentioned before, Slovenia has a great potential for fostering bioeconomy, but the realization of this potential ultimately depends on the financing. In order to encourage the development of the economy (which is indirectly also related to bioeconomy), the Slovenian government has started offering special investment incentives: cost-sharing schemes designed to attract serious investors, as well as promoting well-developed infrastructure and supporting industries, and clusters of specialized suppliers. Ministry funding is provided from policies and strategies (especially the S4 strategy, further elaborated in chapter 8.1.1), whereas EU funding provides resources for research and innovation. Pro-business climate in Slovenia manifests as a growing recognition of the importance of FDI (Foreign direct investment in Slovenia) as a source of fixed capital formation to economic growth and performance.

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

# 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 Slovenia.

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 and the main interview outcomes with experts interviewed to refine the approach.

## 1.2 Reading guide

This report is organised in 9 chapters. Chapter 1 (section 1.3) gives an overview of Slovenia's key characteristics. In the chapters 2, 3, and 4 the biomass production including its current uses and opportunities of additional biomass mobilising, 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.

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

## 1.3 Short characteristics of country

Slovenia's land area is 20,273 km², making it one of the smaller EU countries. With 2 million inhabitants its corresponding population density is near the EU average (See table 1.3.1). The average income level is below the European mean and lower than the average of other Central European countries, but higher compared to Eastern European countries.

*Table 1.1 Main population, land surface, GDP and trade characteristics of Slovenia compared to EU average*

| Category | Slovenia | EU | Unit |
|---|---|---|---|
| **Population** | 2.1 | 512.4 | million (2018) |
| **Area (total)** | 2 | 447 | million ha (2018) |
| **% population in urban areas** | 0.0% | 44.9% | % of total population (2018) |
| **% territory predominantly rural** | 72.8% | 43.8% | % of total territory (2018) |
| **% territory predominantly urban** | 0.0% | 10.7% | % of total territory (2018) |
| **Agricultural Area** | 0.5 | 173.3 | million ha (2016) |
| **Forest area** | 1.3 | 164.8 | million ha (2016) |
| **Population density** | 102 | 115 | n°/km² (2018) |
| **Agricultural Area per capita** | 0.24 | 0.34 | ha/capita(2016) |
| **Forest area per capita** | 0.61 | 0.32 | ha/capita(2016) |
| **GDP/capita** | 22184 | 30 956 | at current prices in 2018 |
| | 26595 | 30 956 | GDP at purchasing power in 2018 |
| **GVA by Agriculture, forestry and fishing** | 2.2% | 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)*

More than half (58 %) of Slovenia's surface is represented by forests, and about a quarter of the total area is considered as agricultural area (of which more than half is covered by grass). The main land cover distribution is presented on figure 1.3.1. There are consequently very little urban areas, with most of the population spread out in rural areas. The population density however is pretty similar to the European average. The GDP and purchasing power in Slovenia are slightly below the European average, yet quite high compared to Eastern European countries.

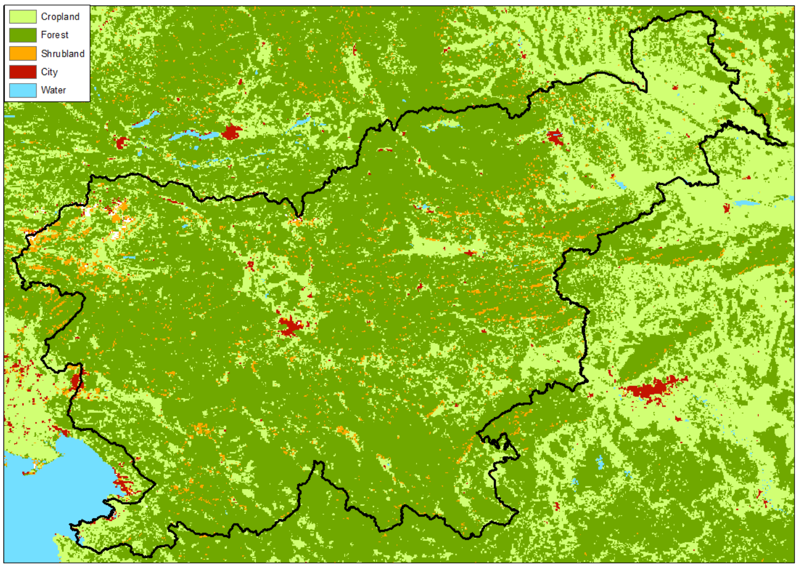



*Figure 1.3.1: Main land cover distribution over Slovenia.*

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

Slovenia shares its western border and a small coastal strip on the Adriatic Sea with Italy. On the south and east it borders with Croatia, while it shares the border on north-east with Hungary. On the north Slovenia borders with Austria. Slovenian border and its neighbouring countries are shown on figure 1.3.2.

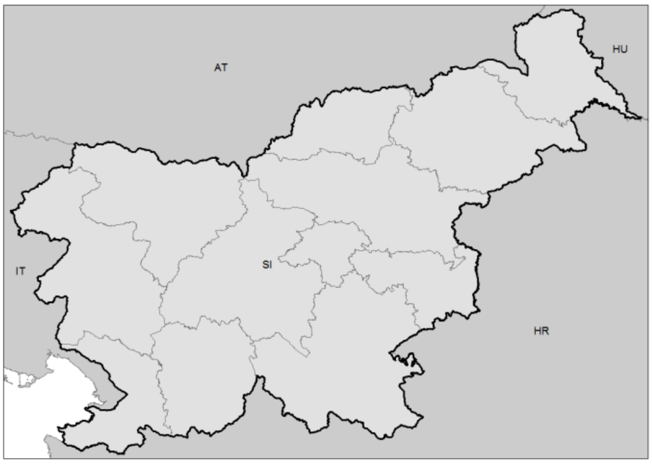



*Figure 1.3.2: Slovenia and its bordering countries*

In the case of traffic, Slovenia is a transit-heavy country. It is crossed by two priority railway freight corridors, namely the Baltic-Adriatic Corridor (RFC 5) and the Mediterranean Corridor (RFC 6). Also, two important road corridor cross Slovenia's territory, namely the 5$^{th}$ Pan-European transport Corridor (which links Lisbon via Barcelona and Ljubljana to Kiev) and the 10$^{th}$ Pan-European transport Corridor (links Munich via Jesenice and Ljubljana to Belgrade and Istanbul). Figure 1.3.3 shows the position of Slovenia in the Trans-Europe Transportation network.


*Figure 1.3.3 Position of Slovenia in the Trans-European Transportation Network*[1]

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

Figure 1.3.4 gives an insight into biomass flows in Slovenia (top) in comparison to average biomass flows of EU-28.

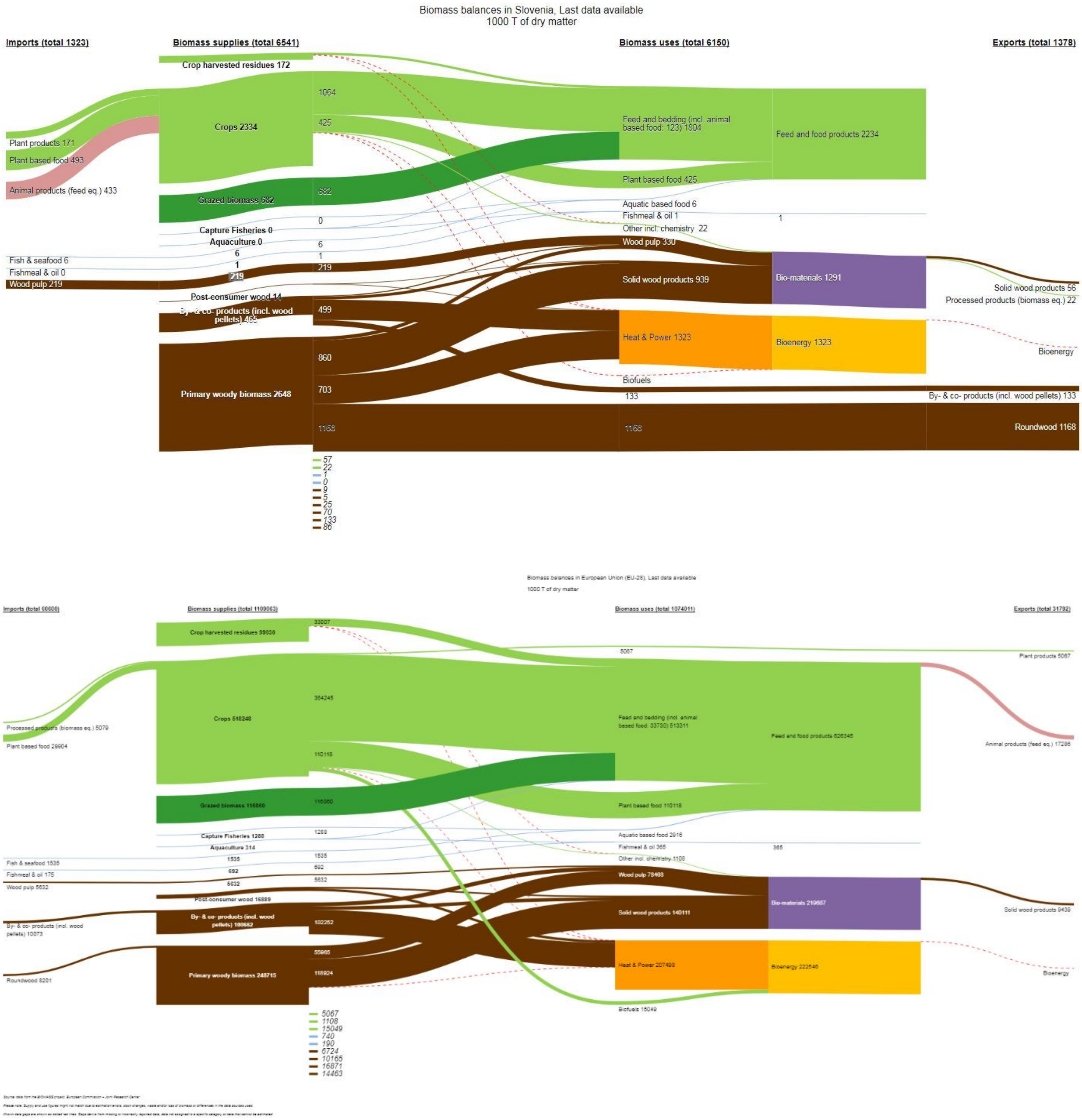



*Figure 1.3.4: Biomass flows in Slovenia (top) and EU-28 (bottom)*

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

**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 show 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 kilotons 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

From the above Sankey diagram for Slovenia (Figure 1.3.4) one can conclude that the main biomass supply (quantities below are all expressed in million tons of dry matter) is primary wood biomass (2.65), crops (2.33) and grazed biomass (0.682). Almost half of the wood produced is exported as roundwood (1.17) and the other half is converted to heat and power bioenergy (1.32), solid wood products (0.939) and wood pulp (0.33). Unlike many of the other CELEBIO countries, no plant products are exported. Imports consist mostly of plant products, plant-based food and animal products.

Another difference that can be observed while compering the Slovenian and the general EU Sankey diagram (Figure 1.3.4) is that the supply of primary wood biomass is proportionally more sizeable than the crop biomass supply.

The production of biomaterials and bioenergy is not as prevalent in Slovenia as food production. Wood biomass is the main export and greatest supply in Slovenia. Biofuels are not produced from crop residuals.

An analysis focused on utilization of Slovenian wood and wood biomass in the period from 2000 to 2017, showed that forestry, wood processing and furniture industry, as well as the pulp and paper industry, together on average created EUR 739.5 million in annual gross value added[2] (figure 1.3.5).

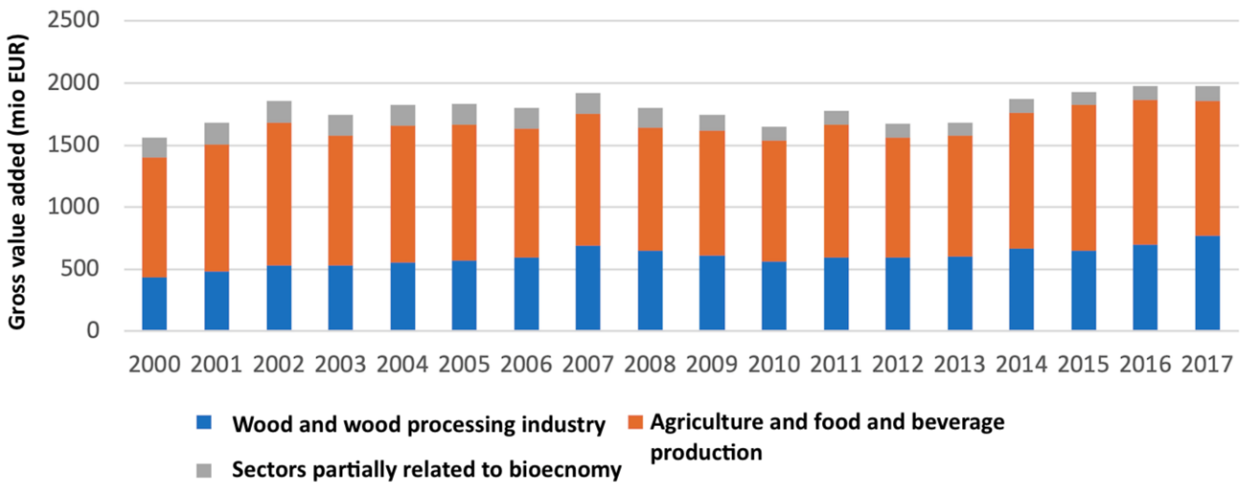



*Figure 1.3.5: The gross value added represented by the two main sectors in the Slovenian bioeconomy, namely "Wood and Wood Processing Industry" and "Agriculture and Food and Beverage Production" and sectors partly related to the bioeconomy*[2]

Potential source for entry into bio-refinery processing and production of new bio-based products is wood of lower quality, namely firewood and wood chips and wood residues. In 2018 production of these categories of wood biomass amounted to 2,500,000 $m^3$ [2].

Bioeconomy faces great development potential in the field of replacing products of the fossil fuel industry with bio-based products mainly through the development of chemical digestion of lignocellulosic biomass. With the introduction of modern chemical wood processing, changes in the market are also expected, in particular wise and innovative consumption of low-quality wood and wood residues, as well as investments in bio-refineries. Since Slovenia is abundant with lignocellulosic biomass on one hand and its chemical industry considering to be one of the most competitive industries on the another, Slovenia is gifted with great opportunities in bioeconomy[2].

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

# 2 Biomass supply: agriculture

## 2.1 Introduction

In this chapter, the agricultural biomass production and main uses are described. A distinction is made between the main economic products produced and their main process chains and residual biomass potentials from primary production. Another topic that will be touched upon is the availability of by-products in the food processing industry. The residual biomass sources, certainly the ones from primary sources are largely not used as already became clear from Section 1.3. The 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 agriculture sector covers about 1.4 % of Slovenia's GDP, which is about 642 million Euros, and it employs around 78,000 persons. Factor income per employee in agriculture is 7,634 Euros and gross fixed capital formation in agriculture are 305.3 million Euros. [3]

Slovenia's population is spread out through the country and is thus not concentrated in urban areas. The percentage of people living in rural area is 58.4 %, which is well above the EU average of 18.9 %. Despite this fact, Slovenian agriculture is still behind the EU average in terms of structural changes. The average size of the used arable land (UAA) of a farm is 7 hectares (EU average 16.9 ha), the number of livestock animals is 9.1 (EU average 22.9) and the percentage of specialized agricultural economies is 69 % (EU average 78 %). Slovenian farms are on average still very small, dispersed and not specialized – that is why the structural change in Slovenian agriculture has a long way to go to catch up with the goals and frankly with the current state of the EU agriculture. [4]

The age structure of the farm owners is not ideal, with 42 % of them being under the age of 55 and only about 5 % under 35, which is under the EU28 average. Also, more than three quarters of the agricultural land is located in the areas with natural or other restrictions. [5]

For a country with more than half of the surface covered by forest, it compares very well to the average in Europe in terms of % in agricultural employment and income, and % of total crop and livestock output. There are also relatively more low input farms (50%) compared to Europe (39%). The nutrient balance for nitrogen is similar (slightly higher) than the European average and the phosphorous is 3 kg of nutrient per ha (compared to 1 in Europe). This relatively high surplus per hectare is likely to be related with the still relatively low yields per hectare. The soil erosion is more than twice that of Europe, and as mentioned the farm holdings are very small (7 ha UAA, compared to 16.9 ha). [4]

In 2017 the value of agricultural production and services (output) was EUR 1,161 million. It was the lowest after 2013, mostly as a result of the drop-in crop output value as a result of bad weather conditions. On the other hand, agricultural production costs (input) – purchase of seeds and seedlings, energy, fodder, fertilisers, plant protection products, maintenance of machinery – amounted to EUR 722 million, i.e. 62% of the output. [6] The key characteristics of the Slovenian agricultural sector is shown in table 2.2.1.

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

Table 2.2.1 Key characteristics for the agricultural sector in Slovenia [4,7,8]

| Category | Slovenia | EU average | Unit |
|---|---|---|---|
| **Agriculture in % of total employment** | 4.6% | 3.9% | % of total employment 2017 |
| **Agricultural area per capita** | 0.24 | 0.34 | ha/capita |
| **Cereal yield** | 4.7 | 5.2 | t/ha |
| **Crop output in total output** | 56% | 56% | % of total agricultural output value (2018) |
| **Livestock output in total output** | 44% | 44% | % of total agricultural output value (2018) |
| **Agricultural income (2010=100)** | 122 | 121 | Index 2010=100 (2018) |
| **Livestock density** | | 1.02 | LSU/ha UAA |
| **High input farms** | 29% | 29% | %/ total farms 2016 |
| **Low input farms** | 50% | 39% | %/ total farms 2016 |
| **Gross nutrient balance nitrogen** | 53 | 51 | kg of nutrient per ha (average 2011-2015) |
| **Gross nutrient balance phosphorus** | 3 | 1 | kg of nutrient per ha (average 2011-2015) |
| **Irrigated utilised agricultural area** | 0.7% | n.a. | % of UAA 2016 |
| **HNV farmland** | | | % of agricultural land |
| **Soil erosion** | 7.42 | 2.4 | tonnes/ha/yr 2012 |
| **Average farm size** | 7.0 | 16.6 | ha UAA/holding (2016) |
| **% of agr. holdings < 5 ha** | 59.5% | 62.6% | %/total no. of holdings |

*HNV= High Nature Value*

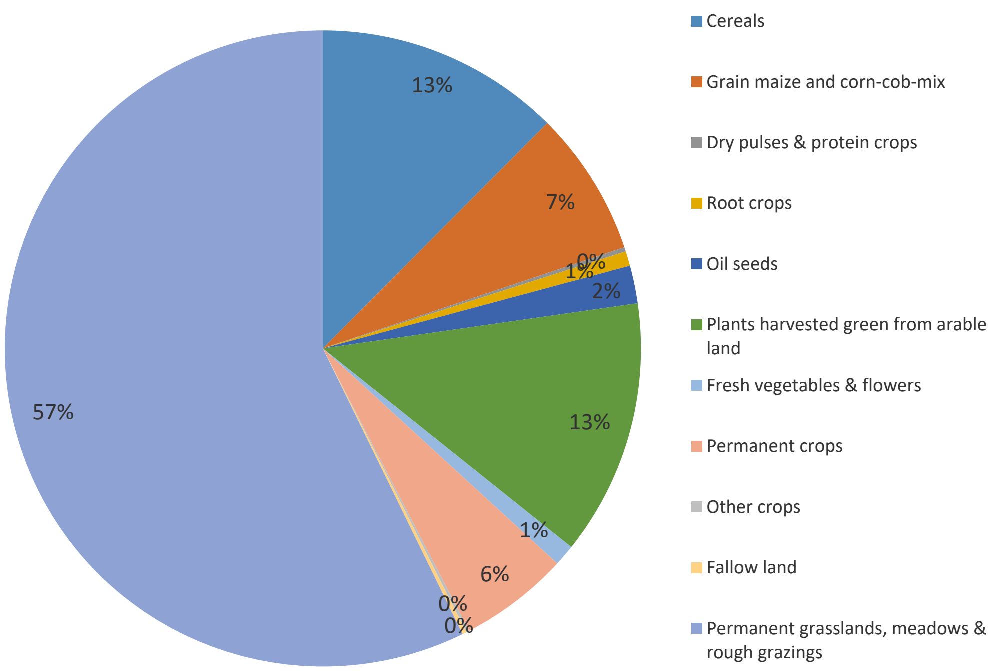



*Figure 2.2.1: Main crops and land uses in Slovenia* [8]

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

## 2.2.1 Crop production

When looking at the production of crops for existing food and feed uses, the Slovenian production is in the average position at EU level with 8.2 million-ton of dry matter (d.m.) production (see Figure 2.2.1). The most important crops in Slovenia are cereals, plants harvested green from the arable land and maize/cob-corn. The area utilized for growing cereals is about 13 % of the total used arable land. This includes wheat, spelt, barley and other cereals. Green-harvested plants are grown on 13 % of the area, while corn fields for maize and cob-corn take up about 8 %.

Permanent crops cover a relatively small percentage of the cropping area, particularly in comparison to the majority of EU countries. This number is only about 5 % in Slovenia.

In terms of agricultural turnover, in 2017 crop production represented 50 % of the out-put, while livestock accounted for 48 %. The remaining 2 % came from agricultural services. [6]

The EU28 and the EU average values for economic production from the main crop, expressed in Mt of dry matter per year, are shown in Figure 2.2.2.

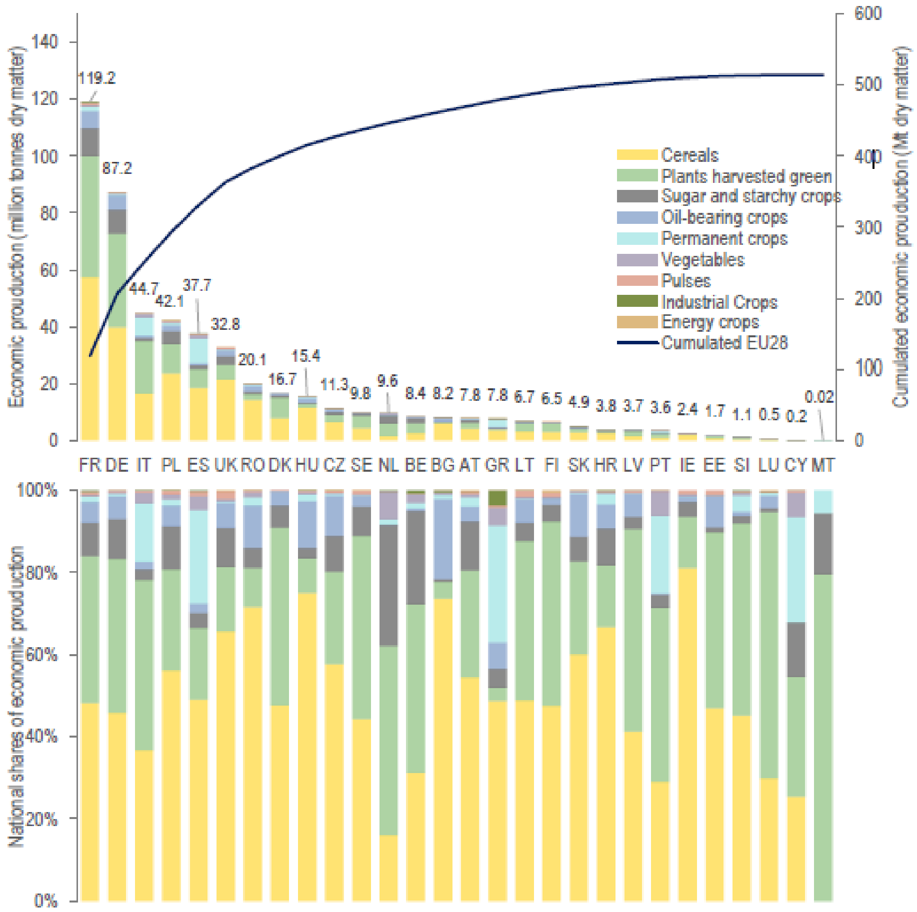



*Figure 2.2.2: Economic production (top pane) from the main crop groups per member state, expressed in Mt of dry matter per year; and the shares at national level (bottom pane). Average values over the reference period 2006-2015 [73].*

#### 2.2.1.1 Cereals

Maize is cultivated on an area of approximately 40,000 ha, which represents roughly 40 % of all cereal-growing agriculture areas. Needless to say, maize production in Slovenia is directly influenced by global and climate trends. The area of maize fields has been on a slow but steady decline throughout recent years. In the year 2020, it is projected to drop to about 38,000 ha, but despite this fact the maize production will increase – the reason being a better yield of maize. In 2018, the yield of maize in Slovenia was 9.5 tonnes per ha. The maize yield can fluctuate quite a bit, the main reasons being droughts, abnormal precipitation distribution throughout the year and very high temperatures. [9]

Wheat. In the year 2018, the area on which wheat was cultivated in Slovenia amounted to 27,294 ha. Altogether, the amount of wheat produced on this area was 120,732 tonnes, making the wheat yield for that year 4.4 tonnes per ha. In the period 2008-2018, the wheat yield has not had a trend of increase or decrease, but it has had some fluctuation. The yield however remained between 4.0 and 5.5 tonnes per ha, unlike maize which in the same period moved between 5.4 and 9.5 tonnes per ha.
The impact of weather conditions on wheat yield is lesser compared to maize because it is a winter crop that is not so exposed to the effects of deficiency of precipitations and high temperatures. [3]

Barley's UAA in 2018 was 20,994 ha and has not had a trend of growth or decline in the last 10 years. In 2018, 88,057tonnes of barley were produces and this number has had some fluctuations in the last 10 years, but has shown a trend of growth. Consequently, the same can be said for barley yield, which has moved between 3.5 and 4.9 tonnes per ha, currently being at 4.2 tonnes per ha.

Despite generally increasing or at least good yields for cereal production, Slovenia is far from being self-sufficient with cereal production. Domestic production of cereals reached almost 600,000 tons in 2018 and domestic consumption almost 880,000 tons, therefore the self-sufficiency rate for cereals was quite low (68%). [3]

#### 2.2.1.2 Oil Crops

The main oil crops in Slovenia are sunflower, rape and turnip rape seeds.
Sunflowers were grown on 288 ha in 2018, which is modest number compared to any type of cereal. The amount of crop was 791 tonnes, making the yield 2.8 tonnes per ha. This is the highest yield in the last 10 years at least, and sunflower yield has fluctuated in that period but has shown a trend of increase. [3]

Rape and turnip rape seed however are more prominent in Slovenian agriculture. The area their fields covered in 2018 was 3,397 ha. This area yielded 7,657 tonnes of oil crop, which means the yield was 2.3 tonnes per ha. This is far from being the highest the yield has been in the last 10 years, which was 3.6 tonnes per ha in 2014. The yield of rape and turnip rape seeds does not show a trend of growth. [3]

Oil crop residues are used for feed (protein cake), energy (husks), chemical compound for detergent, soups and cosmetics (technical fatty acid) and biogas substrate.

#### 2.2.1.3 Permanent crop production

Permanent crops are by no means a negligible part of Slovenia's agriculture. In 2018, the UAA utilised for permanent crop production was 27,783 ha, which was a slight decrease from the year before (27,836 ha). Nevertheless, this accounts for 6 % of the land use, or if we disregard the permanent grasslands, meadows and rough grazing, roughly 13.5 %. [3]

The predominant permanent crops are fruit crops, grape for wine-making and olives. Orchards for fruit crop production take up 10,562 ha, vineyards take up 15,630 ha and olive groves 1,302 ha.
Vineyards are a prominent par of Slovenian heritage and agriculture, partly because of the effect of the Mediterranean climate in the south-west, partly because of the low hills with abundant sunshine in the east and

south-east of the country. The total number of vineyards in 2015 was 49,473, covering an area of 15,688 ha. The number of vine plants according to that census is well over 57 million.

The most commonly grown fruit trees in orchards are apple trees, peach trees and pear trees. In the table below (Table 2.2.1), it is evident that apple trees are by far the most common of the three, considering there were close to 7 million apple trees in Slovenia in 2017. Pear trees are second most abundant, there being almost half a million of them, while the quantity of peach trees is about half that.

*Table 2.2.1: Orchard fruit trees species and respective data, 2017* [10]

| Fruit tree species | No. of trees | Gross area (ha) |
|---|---|---|
| **Apple trees** | 6,710,310 | 2,355.4 |
| **Pear trees** | 446,877 | 203.4 |
| **Peach trees** | 248,779 | 273.0 |

There is not a lot of current statistical information on olive groves and olive production, as it is not an extremely well-represented part of permanent crop production, let alone agriculture in general. The last available census of olive groves by the Statistical office if Slovenia is from 2002; then, there were 1,639 agricultural holdings with 187,166 olive trees and shrubs in total. The crop was produced on a gross area of 780.8 ha, and a net area of 543.8 ha. [3]

## 2.2.2 Livestock production

In 2016, there were 69,902 agricultural holdings in Slovenia with 418,684 livestock size units (LSU) [3]. In 2018, livestock production has increased compared to the previous two years, increasing by a little under 1% compared to 2017 [5].

Livestock production in Slovenia has experienced some fluctuation and undergone some change, but not quite as extensive as crop production has. The weak but long-term trend of diminishing production has stopped according to the data that shows the disappearance of the negative trend of the extent of pig-farming. The latter was the main reason for the shrinking of livestock production in Slovenia. [5]

Number of cattle has decreased in 2018 for the second year in a row – by the end of the year there were about 477,000 cattle (1 % less than the year before), of which about 166,000 cows (in 2017, about 169,000).
Number of pigs has experienced a cyclical fluctuation, but since the year 2006 this random fluctuation has turned into a trend of decreasing of the number of pigs. This trend has slowed down after 2016 and stopped in 2017. By the end of 2018, there were around 259,000 pigs, which is just under a percent more than the year before.
The number of small ruminant animals (sheep, goats etc.) has not changed drastically from 2017 to 2018, however, previously (in the last decade) it had shown a trend of decline. Despite the number remaining on the same level, the small ruminant animal growth was 3 % bigger. By the end of 2018, there were almost 135,000 small ruminant animals. [5]

Current statistical data on livestock production show that the extent of the production in 2018 (with the exception of milk and beef production) has increased in most livestock-producing agricultural holdings.
The growth of cattle, has decrease by 2 %, but is still 2 % over the five-year average (about 78 kt). The reduction in the amount of milk produced was about 1 %, now amounting to 627 kt. This is a result of the fact that there are less milk-cows – about 103,000, which is 6 % less than the year before.
That being said, the percentage of sold milk of all milk produced has reached the highest level since 1991 – 91 %. However, dairy factories have received 571 kt of cows' milk, which is just over a percent less than 2017. The percentage of milk that was sold to foreign dairy factories (i.e. direct export of raw milk) have decreased in 2018 once again – reaching 31 %. [5]

Pig production has not changed from 2017 to 2018 much, despite its previous fluctuations (and even reduction up until 2013). However, even though the extent of the production has not changed significantly, there were still almost a percent more pigs in Slovenian pig farms. This resulted in a growth of pork production of 37.3 kt.

Poultry production has shown growth in 2018 compared to the previous year, the growth being 1 %, which amounts to 97 kt – the highest so far.
Also, egg production in 2018 is the highest recorded – 413 million eggs. This is a 4 % increase from the year before, which is a result of a 6 % increase of the number of egg-laying hens. Of the total number of eggs laid in 2018, 82 % of them (produced by 84 % of all hens) were used for food.

Honey production, which is a staple of Slovenian agriculture, has shown a big improvement in 2018. In the year 2017, the conditions for honey production were extremely unfavourable, but in 2018, Slovenia produced 1,750 tonnes of honey, which in more than twice the amount produced in 2017 (approximately 800 tonnes). This (2018) was one of the best honey-producing seasons in the last decade. [5]

In terms of economics, animal output accounted for 43 % of the total agricultural goods output (1.31 billion EUR) in 2018. This is 0.3 % of the total EU agricultural animal output. [4]

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

## 2.3 Biomass potentials from residues and unused lands

When it comes to residual biomass production, Slovenia's levels are amongst the lowest in the EU – residue production of about 700 kt, as shown in Figure 2.3.1. The 0.7 million tonnes of residues are produced per year, of which the main sources are cereals.

According to the Sankey diagram (Figure 1.3.4.), Slovenia has 172,000 tonnes of crop harvested residues, which is also very low. Only this 0.2 million ton are known to be harvested at this moment. How much can be mobilised of this residual resource taking account of sustainability consideration of which the main is the conservation of organic carbon in the soil, will be discussed in next Section 2.3.1 in greater detail.

In the area of realising residue biomass potential (and even raising the potential and new opportunities), Slovenia is lagging behind the average of the EU-28. The other smaller countries in the region (Hungary, Czech Republic, Slovakia) are doing a good job in improving this aspect, but the problem of mobilizing biomass residues in Slovenian is due to a lack of resources for production of agricultural biomass in a first place. One of the hampering factors is a lack of availability of arable land.

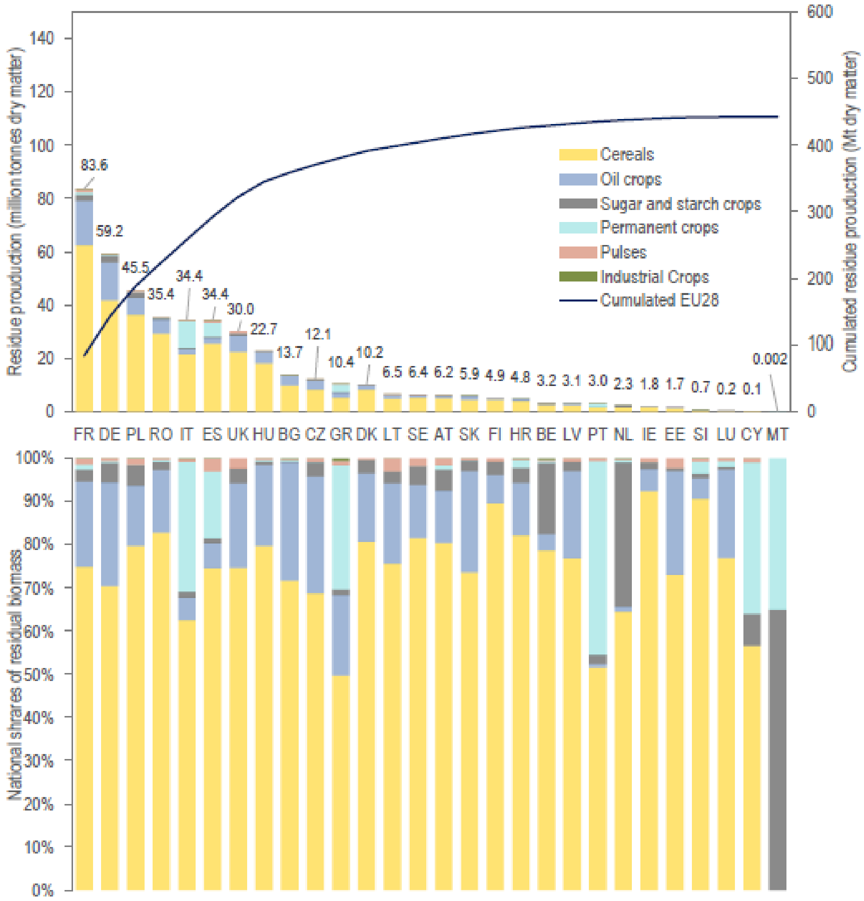



*Figure 2.3.1: Residue production (top pane) from the main crop groups per member state, expressed in Mt of dry matter per year; and the shares at national level (bottom pane). Average values over the reference period 2006-2015* [73]

### 2.3.1 Lignocellulosic residual biomass potential from crops

As already became clear the residual biomass potential from arable crops should be reinforced. However, how many crop residues (e.g. straw) can be removed sustainably depends on several factors. Especially the maintenance of soil organic matter is a relevant function of straw-removal. Also, the nutrient balance should be maintained, but nutrients are often replenished, mainly by manure from livestock or by mineral fertilizer application practices. The input of soil organic matter often depends only on crop residues left behind. The amount of straw to be kept in the field is complicated to estimate as it depends strongly on the soil and climate characteristics and the long-term management practices. To give a good estimate of residual biomass potentials that can be sustainable removed we use data generated in the S2BIOM project (Dees et al., 2017ab) (Table 2.3.1). In S2BIOM a 'UD1 potential' was assessed for residual biomass. How this potential was assessed is explained in Box 2.1. Further details on the whole assessment of biomass potentials in S2BOM are presented in Annex 2 of this report. In the following tables and text, the S2BIOM biomass potentials are presented for Slovenia.

*Table 2.1: Residual biomass potentials* from arable crops 2020 in ton d.m. (=S2BIOM UD1 potential) (see for assessment approach Box 2.1 and Annex 2)*[7].

| Region | Cereals straw | Oil seed rape straw | Maize stover | Total |
|---|---|---|---|---|
| **Pomurska** | 0 | 0 | 2 | 2 |
| **Podravska** | 0 | 0 | 3 | 3 |
| **Koroška** | 0 | 0 | 1 | 1 |
| **Savinjska** | 0 | 0 | 3 | 3 |
| **Zasavska** | 0 | 0 | 1 | 1 |
| **Posavska** | 0 | 0 | 1 | 1 |
| **Jugovzhod Slovenija** | 0 | 0 | 3 | 3 |
| **Primorsko-notranjska** | 0 | 0 | 2 | 2 |
| **Osrednjeslovenska** | 0 | 0 | 3 | 3 |
| **Gorenjska** | 0 | 0 | 3 | 3 |
| **Goriška** | 0 | 0 | 3 | 3 |
| **Obalno-kraška** | 0 | 0 | 1 | 1 |
| **Total** | 0 | 0 | 26 | 26 |

**Box 2.2: Methodology of S2BIOM to calculate the crop residues potentials in table 2.3.1, 2.3.2 and 2.3.3.**
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.

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

Potential for residual biomass that can be sustainably removed is estimated to be very small in Slovenia, particularly when the uses in livestock production of cereal straws are subtracted. The only crop that yields some additional biomass that can be used is grain maize but the total sustainable potential only amounts 25 ton for the whole of Slovenia. It is likely that also this type of biomass is used in livestock production. It should be noted that before considering energy retrieval from biomass, the use of this biomass as food, livestock feed and manure must first be excluded, as these are more sensible and sustainable uses for the biomass.

**Residues from permanent (woody) crops**

Current use of by-products from managing permanent crops is at very basic level. Prunings are used either for slow burning as a frost prevention or for heating, although most remain on field or are burned. To assess the potential for prunings from permanent crops in S2BIOM account of sustainable removal rates were taken. The potential is larger than assessed for arable crops but still small with a total amount of 3.2 Kton. For further details on the assessment approach see Box 2.1 in the former and for whole assessment details consult Dees et al and a summary is given in Annex 2.

## 2.3.2 Dedicated crop potentials from unused/abandoned lands

Biomass crops (e.g. lignocellulosic biomass crops, perennials) cannot compete with food or feed crops, because the latter have higher yields – the exception being if the soil is low-productive, in which case such crops could have better yields. However, this exception does not change the fact that such biomass is generally not competitive to food and feed. That is why in case, if there is a market for lignocellulosic biomass crops in the future, the land used to grow it would be unused and abandoned feed and food crop lands that went out of agricultural use. Nonetheless, when considering the cultivation of energy crops, it should be noted that abandoned areas are almost exclusively grassland, but growing of energy biomass plants is still not really feasible due to incline of the land, climate, shallow soil etc. [11,12]

A study of unused agricultural land in Croatia showed that out of almost 3 million ha of their agricultural land, only just over 1 million ha is suitable for farming, and even less is actually put to use. The rest could be utilized to generate over 670 kt of biofuels each year. Slovenia does not have as much agricultural land, neither such high percentage of unused or unusable agricultural land, but nonetheless it is applicable as well to a smaller scale. [12]

As assessed in S2BIOM project, the unused pruning shares (already going to energy and/or not removed or used for soil improvement) vary strongly on the type of crop. Orchards with seed fruit trees (apples, pear etc) have an unused pruning potential of 2 %, whereas stone fruit trees (e.g. cherry) have a potential of 30 %. The unused potential is extremely high for vine pruning, as vineyard potential is assessed at 95 % in Slovenia[11]

Another assessment of unused potential was made via estimating the ratio of sawmill residue (or sawdust) to product – for conifers and non-conifers. For conifers, the Slovenian product recovery rate is 58 % and, because the share of sawdust is 15 %, the sawdust to product rate is 25.9 %. For non-conifers, the values are similar: 60 % product recovery rate, 13 % sawdust share and 21.7 % sawdust to product rate. The potential for this residue is therefore slightly greater for conifers. [11]

### 2.3.3 Residual biomass potentials from livestock

Livestock manure shows a great deal of potential for further use, mainly due to relatively well-developed livestock production in Slovenia. According to a theoretical calculation, the electrical energy produced from the manure of cattle, pigs and poultry would amount to 315 GWh, whereas the heat produced could reach 245 GWh. Because the farms in Slovenia are relatively small and dispersed, only a third of this potential could technically be put to actual use. According to a document from 2011, we use 0.2 % of the potential of cattle manure, 13.8 % of pig manure potential and 5.8 % of poultry manure potential. [13]

According to a study by the JRC (Scarlat et al. 2018) on the development and perspective for biogas in Europe, Slovenia produces 1,242 TJ of biogas, which amounts to 35 million cubic meters. Overall natural gas use in Slovenia is 773 million cubic meters, which makes the use of biogas in particular at 4.5 % of natural gas use. Anaerobic digestion (including that of manure) is the leading way of producing biogas in Slovenia, the share of this process being about 75 %. Other processes for biogas productions are recovery of landfill gas and recovery of sewage gas. In a more general sense, the electricity production yield from electricity in Slovenia is about 132 GWh, and the heat production from biogas is 383 TJ, of which derived heat accounts for 304 TJ. [14]

## 2.4 Agricultural processing industries

### 2.4.1 Main agri-food processing industries

Slovenia had 733 registered food processing enterprises in 2017, and this number has been growing for at least the last five years. The added value produced by these companies in 2017 was 499 million EUR and the number of employees was 13,683 – making the added value per employee 36,472 EUR. Out of those enterprises, 78 % are micro-sized, 16 % are small, 4 % are medium and the remaining 2 % are large. Despite the fact that large enterprises constitute a mere 2 per cent of all food processing enterprises, they contribute significantly to the highest share of employment (53 %), added value (64 %) and net sales revenue (62 %). [15]

The most common types of such enterprises are in the field of Manufacture of bread, manufacture of fresh pastry goods and cakes (322/733), followed by production of meat and poultry meat products (53/733), processing and preserving of meat (42/733) and manufacture of beer (32/733). The biggest employer is Perutnina Ptuj d.d. (poultry production), the enterprise with the highest net sales revenue in Slovenia and in foreign markets is Droga Kolinska d.d. (food-processing) and the enterprise with the highest total added value is Pivovarna Laško d.o.o. (brewery). [15]

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

### 2.4.2 Side-products from agri-food processing

Residues from food and fruit processing represent an excellent opportunity to improve cost efficiency of agro-food processing companies. While food processing industry is generally well-adapted and able to keep up the pace with the technological development, some weak-spots are the brewing industry, dairy industry and flour-makers/bakers. Generating yield from waste streams just started to be considered as a good opportunity to improve competitiveness. It is likely that hesitation lies in the necessity to step out from the current market place and food processing as core business. However another obstacle is that, waste streams might not be abundant enough to enable achieving economies of scale in later stages of bio-refining processes.
Another aspect of this is that documents such as the 2030 Agenda dictate the reduction of food waste and food loss (it should be cut in half for each member state). The total food waste is about 68 kg per capita in Slovenia, and about 25 kg per capita of the edible portion of food waste.
Table 2.4.1, gives an overview 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).

*Table 2.2: Biomass potentials from agro-food processing industries 2020 in Ton d.m. (=S2BIOM base potential)[11] (see also Annex 2)*

| Region | Olive stones | Pressed grapes dregs | Cereal bran | Total |
|---|---|---|---|---|
| **Pomurska** | 18 | 178 | 3,643 | 3,839 |
| **Podravska** | 30 | 290 | 5,933 | 6,252 |
| **Koroška** | 14 | 139 | 2,843 | 2,996 |
| **Savinjska** | 31 | 307 | 6,295 | 6,634 |
| **Zasavska** | 7 | 65 | 1,328 | 1,399 |
| **Posavska** | 13 | 129 | 2,646 | 2,788 |
| **Jugovzhodna Slovenija** | 37 | 356 | 7,303 | 7,696 |
| **Primorsko-Notranjska** | 20 | 194 | 3,981 | 4,195 |
| **Osrednjeslovenska** | 32 | 312 | 6,388 | 6,732 |
| **Gorenjska** | 29 | 285 | 5,847 | 6,161 |
| **Goriška** | 32 | 310 | 6,358 | 6,700 |
| **Obalno-Kraška** | 14 | 139 | 2,850 | 3,004 |
| **Total** | 277 | 2,704 | 55,416 | 58,397 |

**Box 2.3: Methodology of S2BIOM to calculate the secondary residue potentials from food processing in Table 2.4.1**

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.

The largest potential from secondary residues is from cereal bran with a total amount of 55 Kton d.m. per year. Another 2.7 Kton d.m. of pressed grape dregs should be available from the wine industry.

## 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 2.5.1 below; for further details on the cost calculation in S2BOM see Annex 2.

*Table 2.3: Road side cost levels (€/ton d.m.) for agricultural biomass sources based on S2BIOM cost calculations* [16]

| Road side cost for agricultural biomass | Average (€ ton d.m.) / 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 |

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

## 2.6 Summary and conclusions in relation to SWOT elements

The percentage of people living in rural area is 58.4 %, which is well above the EU average of 18.9 %. Despite this fact, Slovenian agriculture is still behind the EU average in terms of structural changes. The agriculture sector covers about 1.4 % of Slovenia's GDP. Slovenian farms are on average still very small, dispersed and not specialized. There are also relatively more low input farms (50%) compared to Europe (39%). Slovenian crop production is in the average position at EU level and the most important crops in Slovenia are cereals, plants harvested green from the arable land and maize/cob-corn. The previous shrinking of livestock production has stopped and is slowly growing, representing 43 % of the total agricultural goods output. The potential for residual biomass that can be sustainably removed is very small in Slovenia, particularly when the uses in livestock production of cereal straws are subtracted; before considering energy retrieval from biomass, the use of this biomass as food, livestock feed and manure must first be excluded. Also, the production of biomass crops cannot compete with food or feed crops, unless the land they are grown on is low-productive. Livestock manure biomass potential is significant due to a relatively well-developed livestock production in Slovenia, the major problem, however, being the dispersion and small size of the individual farms. The food processing industry is generally well-adapted, but weak spots of food residue processing are the brewing industry, dairy industry and flour-makers/bakers.

*Table 2.4 SWOT factors regarding biomass feedstock*

| **Strengths** | **Weaknesses** |
|---|---|
| • Gradual improvement of education in agriculture sector<br>• Quality professional institutions and organizations in the field of research, education and consulting<br>• Suitable conditions for irrigation (availability of water, precipitation)<br>• Increased no. of complementary activities and establishing of micro and small enterprises in rural area | • Agriculture in general is not very attractive to younger generations<br>• Poor economic and environmental performance and high exposure to climate change<br>• High CAPEX and OPEX |
| **Opportunities** | **Threats** |
| • Promoting access to specialized advisory services<br>• Increasing demand for sustainably produced local product of higher quality and products from above standard breeding.<br>• Promotion of organic farming | • Too slow restructuring due to lack of own resources to co-finance investments<br>• Lack of interest in taking over the farm and continuing farming in the younger generations |

# 3 Biomass supply: Forestry

## 3.1 Introduction

In terms of relative forest coverage, Slovenia is the third in the European Union after Finland & Sweden. Most of its forests are located within the area of beech, fir-beech and beech-oak sites (70 %), which have a relatively high production capacity [17].

Table 3.1.1. summarizes the main characteristics of Slovenian forests.

*Table 3.1: Slovenian forests in numbers, 2017[17]*

| **Forrest area** | **1,180,281 ha** |
|---|---|
| **Forestation** | 58.2 % |
| Growing stock | 352,878,333 $m^3$ or 299 $m^3$/ha |
| Annual increment | 8,695,069 $m^3$ |
| Possible cut | 6,607,265 $m^3$ |
| **Coniferous trees** | 2,973,607 $m^3$ |
| **Deciduous trees** | 3,633,658 $m^3$ |
| Length of forest roads | 12,624 km |
| Length of forest borders | cca 115,000 km |

74% of forests in Slovenia are privately owned and the remaining 26% of forests are owned by the state or by municipalities, which is presented on figure 3.1.1. Larger and unfragmented forest lands enable centralized and professional management. Private forest lands are small, with an average area of only 3 ha and even these are further fragmented into several separate plots. For the great majority of these lands, forests are not of an economic interest. Private forest property is becoming even more fragmented as the number of forest owners is increasing. According to the latest data, there are already 314,000 (with co-owners even 489,000) forest owners in Slovenia. The major fragmentation of forest property, the number of forest owners and co-owners, present a serious obstacle to an efficient and professional management in private forests which is a serious obstacle for optimizing timber production and utilization of forest potential [17].

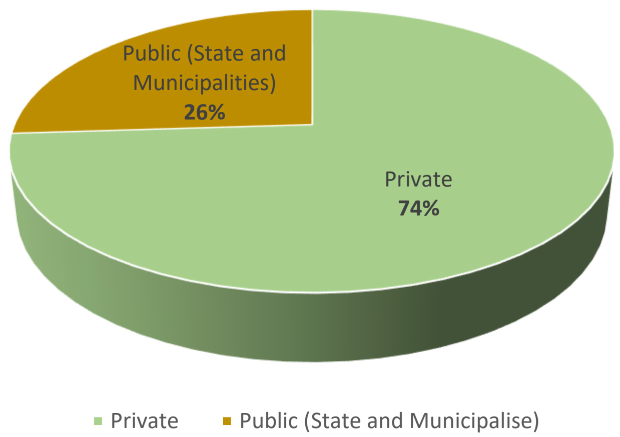



*Figure 3.1.1: Ownership of Slovenian forests [17]*

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

WoodChainManager's web page offers an access to an interactive schematic representation of roundwood flows in Slovenia (shown on figure 3.1.2). Data, which is for the year 2014, suggests that a substantial amount of Slovenian wood is exported. Mainly it is exported as a roundwood and a firewood. Only a little fragment is exported as added-value products such as chemicals, pulpwood, fibreboard and particleboard[18].

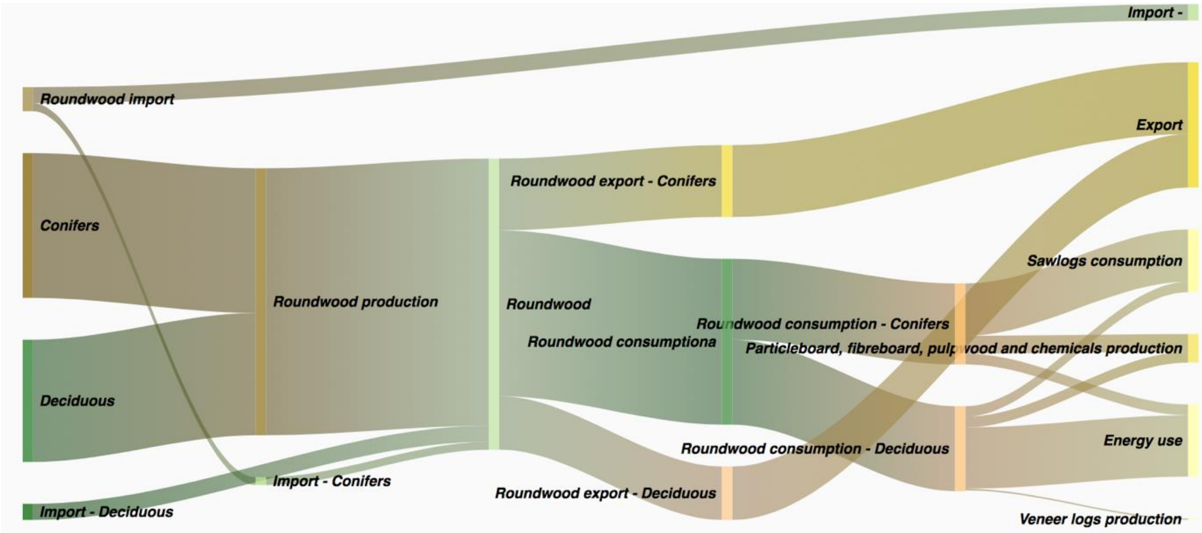



*Figure 3.1.2: Sankey diagram of roundwood flows in Slovenia, 2014*[18]

## 3.2 Primary biomass resources from forestry

The assessment of the roundwood and primary residue potentials in S2BIOM is done 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 up-dated data from national sources. In addition to this overall potential assessment, a pilot study for the Slovenian forest sector was performed by the Slovenian Forest institute as part of the S2BIOM study providing information on low quality wood potentials available in Slovenia.

Slovenia has a relatively large forest potential for the small size country it is. The latter results in a large primary and secondary forestry potential. This potential is large and remains large and can be further mobilized.

Slovenian Forest Service reported that in 2018 possible cut of forest increased by 3.4 % compared to 2017, which totalled to 6.837.356 m$^3$. In the period from 1994 to 2018, possible cut increased by 117 % (in 1994 it amounted to 3.147.771 m$^3$.) With respect to the 6,060,959 m$^3$ cut in 2018, the ratio describing realised cut over the possible cut is 88.6 % [19]. However, an important fact, that forest cut was increased in recent years due to natural disasters occurrence should also be considered.

Table 3.2.1. describes the primary biomass potential from Slovenian forests in 2020. Data was obtained in the scope of 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 m$^3$) coincide relatively well with estimated data for 2020 (expressed in Kton d.m.).

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

*Table 3.2: Primary biomass potential from forests in Kton d.m. (S2Biom Base 2020 potential)*

| Region | Final fellings [Kton] | Thinnings [Kton] | Logging residues from final fellings [Kton] | Logging residues from thinnings [Kton] | Total [Kton] |
|---|---|---|---|---|---|
| **Pomurska** | 183 | 61 | 6 | 1 | 252 |
| **Podravska** | 308 | 104 | 31 | 6 | 448 |
| **Koroška** | 215 | 72 | 33 | 6 | 325 |
| **Savinjska** | 382 | 128 | 55 | 11 | 575 |
| **Zasavska** | 72 | 24 | 9 | 2 | 107 |
| **Posavska** | 131 | 44 | 18 | 3 | 197 |
| **Jugovzhodna Slovenija** | 628 | 235 | 45 | 9 | 916 |
| **Primorsko-notranjska** | 213 | 72 | 17 | 3 | 305 |
| **Osrednjeslovenska** | 349 | 117 | 31 | 6 | 504 |
| **Gorenjska** | 318 | 106 | 25 | 5 | 454 |
| **Goriška** | 336 | 112 | 23 | 4 | 475 |
| **Obalno-kraška** | 188 | 63 | 13 | 3 | 266 |
| **Total** | **3323** | **1138** | **306** | **59** | **4842** |

When looking at table 3.2.1 one can conclude that the current average yearly harvest in 2020 amounts to 4842 Kton d.m. Additionally the exploitation of wood biomass from Slovenia forests is relatively in line with its potentials.

Figure 3.2.1 shows the distribution of primary residues potential form forests.

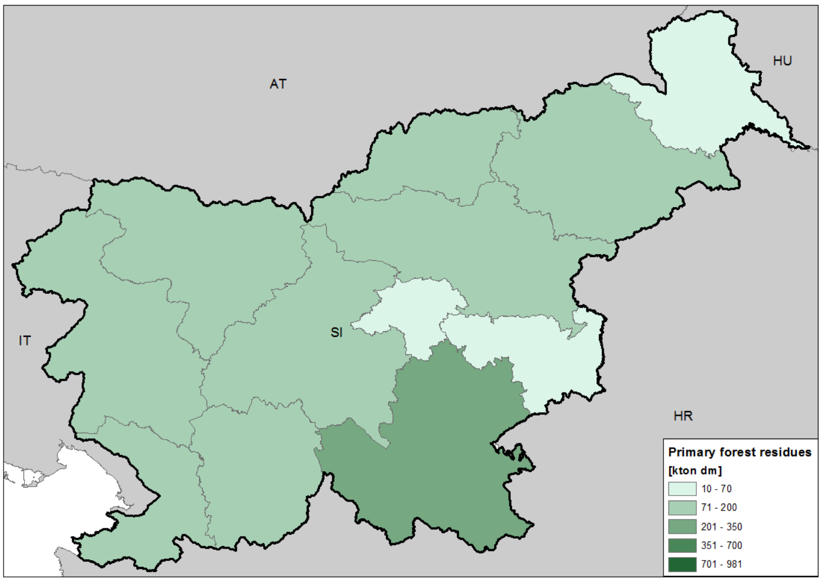



*Figure 3.2.1: Distribution of primary residues potential from forests Kton d.m. (S2BIOM Base potential 2020)*

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

The export of roundwood in 2017 was approximately 3.1 million cubic meters compared to 0.6 million cubic meters of imported roundwood[20]. The movement dynamic in external trade is an important indicator of the processing state and timber use and, consequently, capturing added value to the domestic renewable raw material. The most important exporting countries for Slovenia are Italy and Austria. Primarily low-quality roundwood and firewood is exported to Italy, while primarily coniferous roundwood is exported to Austria [18]. Export and import of roundwood in period from 2008 to 2017 is shown on figure 3.2.2. Slovenia should focus more onto producing value added products by itself, rather than just export the roundwood. It would be beneficial for Slovenian economy in first place, as well as higher amount of carbon sink would be recognized to Slovenia in accordance with LULUCF methodology.

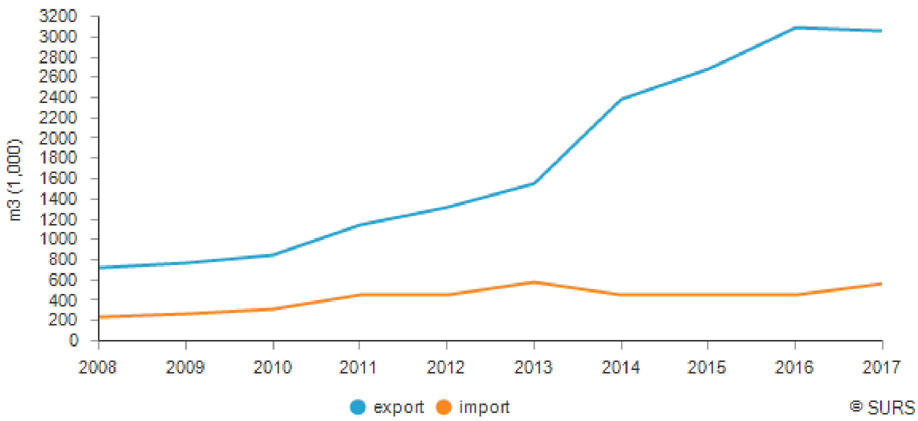



*Figure 3.2.2: Export and import of roundwood, Slovenia, 2017[20]*

## 3.3 Secondary biomass resources from wood processing industries

Table 3.3.1 summarises wood potentials from forest industry. How these were assessed is explained in Annex 2.

*Table 3.3: Secondary biomass potential from forests in Kton d.m. (S2BIOM Base potential 2020)*

| Region | Saw-dust (conifers) | Other residues (conifers) | Residues from industries producing semi-finished wood-based panels | Residues from further wood-processing | Total |
|---|---|---|---|---|---|
| **Pomurska** | 32 | 29 | 2 | 5 | 69 |
| **Podravska** | 55 | 48 | 12 | 25 | 140 |
| **Koroška** | 37 | 34 | 12 | 27 | 111 |
| **Savinjska** | 67 | 61 | 20 | 46 | 193 |
| **Zasavska** | 13 | 11 | 3 | 8 | 35 |
| **Posavska** | 24 | 20 | 7 | 14 | 66 |
| **Jugovzhod Slovenija** | 165 | 70 | 17 | 37 | 288 |
| **Primorsko-notranjska** | 39 | 33 | 7 | 13 | 92 |
| **Osrednjeslovenska** | 61 | 55 | 11 | 26 | 154 |

| Region | Saw-dust (conifers) | Other residues (conifers) | Residues from industries producing semi-finished wood-based panels | Residues from further wood-processing | Total |
|---|---|---|---|---|---|
| **Gorenjska** | 55 | 51 | 9 | 21 | 136 |
| **Goriška** | 59 | 53 | 8 | 19 | 139 |
| **Obalno-kraška** | 34 | 29 | 5 | 11 | 78 |
| **Total** | **642** | **495** | **113** | **252** | **1502** |

According to the data provided by WoodChainManager for the year 2018, the majority of roundwood was processed by sawmill industry (over 1 million m$^3$), followed by the industry of wood composites, mechanical pulp and chemical industry, all of which together processed more than half a million m$^3$. Among large players are also households, which annually consume over 1 million m$^3$ of wood, but it partially derives from non-forest resources. According to the latest research of Slovenian Forestry Institute, strengthening of wood chips industry is evident. In 2017 the aforementioned industry has a turnover of 2.2 million m$^3$ wood chips, which is almost 50 % more compared to 2010. Inputs are mainly residues obtained while cutting forest (36 %), low quality roundwood (32 %), sawmill residues (28 %) and other sources (4 %)[21]. Table 3.3.2 summarises forest derivatives produced in Slovenia in 2018 [21].

*Table 3.4: Forest products in Slovenia (2018[21]).*

| Year: 2018 | Conifers [m$^3$] | Deciduous [m$^3$] | Together [m$^3$] |
|---|---|---|---|
| **Roundwood** | 2,553,000 | 280,000 | 2,833,000 |
| **Wood for pulp and boards** | 659,000 | 366,000 | 1,025,000 |
| **Other industrial wood** | 33,000 | 55,000 | 88,000 |
| **Firewood** | 220,000 | 979,000 | 1,199,000 |
| **Together** | 3,466,000 | 1,680,000 | 5,146,000 |

Figure 3.3.1 offers an insight into a creation of gross value added in field of the woody biomass utilization during the past two decades [2].

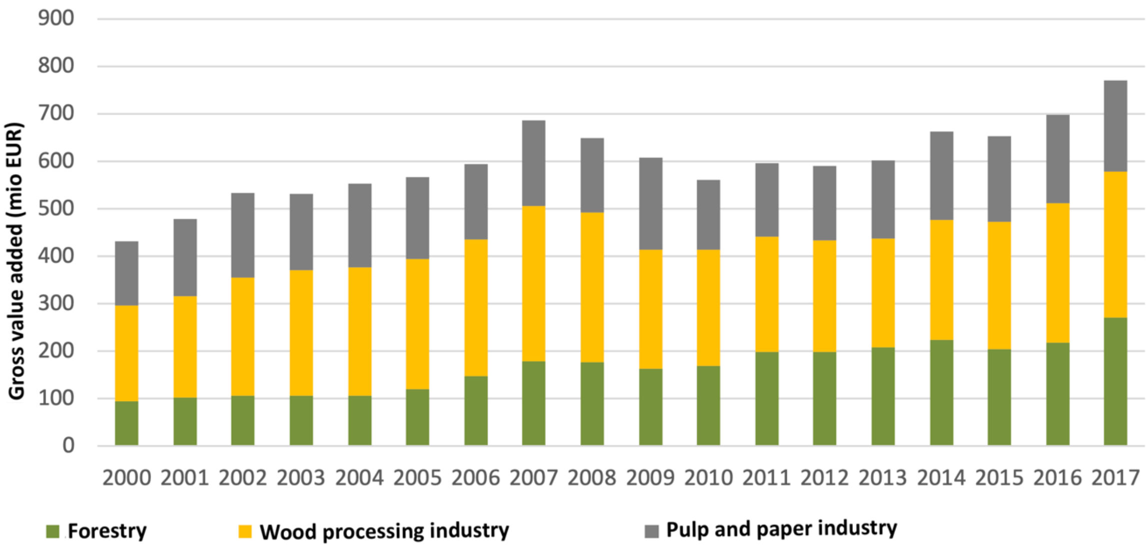



*Figure 3.3.1: Contribution of forestry, wood processing and pulp and paper industry to creation of the gross value added in field of the woody biomass utilization in period from 2000 to 2017[2]*

In period from 2000 to 2017 value added in forestry averaged to 27 % or 166.5 million EUR annually. The importance of forestry is increasing which is also reflected by the value added achieved in 2017. The latter accounted for 271,3 million EUR or 36 % of total value added created in the field of the usage of wood and wood biomass. Despite the increase in the value added, the number of employees within the forestry sector fell from 2,400 to 1,600 in the first decade of the new millennium. However, in the second decade the downward trend stopped. It should be mentioned that observed decrease in number of employees is mainly due to restructuring in management of state-owned forests – instead of prolonging contracts with existing forest-management companies, new entity, namely Slovenian State Forests (SiDG) was formed. The number of employees in companies and sole proprietors is around 1,500 on an annual basis[2].

The highest value added in the area of exploiting wood biomass can be attributed to wood processing and furniture industry. In the period from 2000 to 2017, it averaged to 44 % in the total value added on annual basis. Despite the major stake in the contribution to wood value added, the trend in number of employees has appeared negative. In 2000 the sector employed 23,200 workers. By the end of 2015, the number decreased to 12,300. Interesting as well as encouraging is the data, that the number of employees in the wood processing sector has increased to 13,000 by the end of 2017[2]. However, Slovenia should increase the activity in the wood processing sector, especially because of the present trend of exporting roundwood to e.g. Austria and subsequentially buying back products e.g. plywood, and thus failing to capture value added.

The pulp and paper's industry contribution to the gross value added in the field of usage wood and wood biomass amounted on average to 29 % or 169 million EUR on annual basis (from 2000 to 2017). However, the contribution is decreasing. In 2000 gross value added amounted to 31 %, but later in 2017 that number has dropped to 25 %. Negative trend is also observed when looking at number of employees. In 2000 the sector employed 10,700 workers, reached its minimum in 2013 with only 3,900 employees, but the situation has improved by 2017 when 4,300 workers were employed[2].

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

In terms of relative forest coverage Slovenia is the third in the European Union after Finland & Sweden. Most of its forests are located within the area of beech, fir-beech and beech-oak sites (70 %), which have a relatively high production capacity [17]. 12,624 km length of forest roads offers a good accessibility to this highly abundant biomass resource. According to 2018 annual report on Slovenian forests the possible cut was estimated to be 6.837.356 $m^3$, while the realised cut was 6.060.959, which gives a ratio realised over possible cut of 88.6 % [19]. One of the main issues Slovenian forestry is facing with is highly fragmentised ownership – only 26 % of forest is publicly owned, while other 74 % is privately owned, which together accounts for almost 500 000 owners. Slovenia exports a lot of its wood - the most important exporting countries are Italy and Austria[18]. Mainly the wood is exported as a roundwood and firewood. Only a small fragment is exported as added-value products such as chemicals, pulpwood, fibreboard and particleboard.

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

*Table 3.5: SWOT elements in relation to biomass supply from forestry*

| | |
|---|---|
| **Strengths**<br>• Forestry abundance (58 % of surface is covered by forest)<br>• Good accessibility (forest roads)<br>• Availability of up-to-date data on forests (Slovenian Forest Service, Slovenian Forestry Institute, WoodChainManager) and strong support at sustainable management of forests | **Weaknesses**<br>• High dispersion and fragmentation of forest ownership hampering devoted management<br>• Extensive export of wood instead of creating high value-added products within the county |
| **Opportunities**<br>• Development of innovative and high-added value products<br>• Job creation<br>• Consolidation of local markets<br>• Increased competitiveness of the country | **Threats**<br>• Lack of owners' willingness to mobilise forest feedstock |

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

# 4 Biomass supply: Waste

## 4.1 Introduction

Slovenia is among the countries with the highest percentage of separately collected waste and management of recycling. In 2016, 386 facilities for waste recycling, 180 facilities for backfilling and 10 facilities for waste energy recovery operated in Slovenia. Waste was disposed of in three incineration plants and landfilled at 17 (legal) landfill sites [22].

In 2018 waste was treated in Slovenia according to the following treatment procedures[23]:

- 726,000 tons of municipal waste or almost 71% of total municipal waste generated in Slovenia was collected separately.
- Nearly 8 million tons of waste was recovered through final recovery processes, and just over 349,000 tons of waste was disposed of. 42% more waste was recovered than in 2017 due to a higher amount of recovered construction and demolition waste (more of this waste was used mainly for backfilling than in the previous year). Waste disposal was 10% lower than in 2017.
- 157,000 tons of all types of waste were landfilled, which is just over 1% less than in the previous year. 92% of this waste was landfilled on municipal waste landfill sites, 4% on industrial landfill sites and also 4% on hazardous waste landfill sites. The waste that was landfilled was predominantly mixed municipal waste and residues after mechanical and biological treatment of waste (54% in total), followed by construction and demolition waste (16%) and waste from pulp and paper production and processing (11%). Other types of waste were disposed of in smaller quantities.
- Imports and exports of waste were up compared to 2017; imports by 5%, exports by 6%. In 2018, most of the imported and exported waste was metal waste (56% of all imported and 44% of all exported waste).

Table 4.1.1 summarises waste flows in 2018.

*Table 4.1: Waste flows in Slovenia, 2018[24]*

| YEAR: 2018 | Tons |
|---|---|
| **Non-hazardous and hazardous waste generated - TOTAL** | 8,388,420 |
| **Municipal waste generated** | 1,025,001 |
| **Separately collected municipal waste** | 726,103 |
| **Waste brought from the abroad - import** | 1,110,408 |
| **Recycling of waste - TOTAL** | 3,595,803 |
| **of which composting and treatment in biogas plants** | 324,544 |
| **Waste incineration - use as fuel** | 206,733 |
| **Other waste recovery** | 4,161,878 |
| **Waste disposal on landfill sites - TOTAL** | 157,154 |
| **of which on municipal landfill sites** | 145,045 |
| **Waste incineration with the aim of disposal** | 39,263 |
| **Other final disposal** | 152,982 |
| **Waste delivered to the abroad - export** | 1,090,345 |

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

Figure 4.1.1 presents generated, separately collected and disposed municipal waste on landfill site in Slovenia through the period from 2011 to 2018[23].

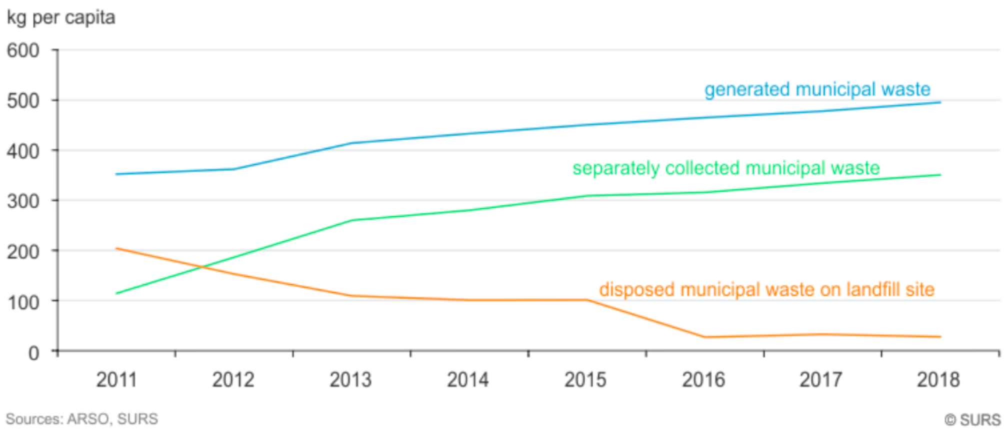



*Figure 4.1.1: Generated, separately collected and disposed municipal waste on landfill site*[23]

Table 4.1.2 summarises waste stream in Slovenia for the years 2017 and 2018[23].

*Table 4.2: Waste stream in 2017 and 2018, Slovenia*[23]

| Year | 2017 | 2018 |
|---|---|---|
| | tons | |
| **Total waste generated** | 6,172,263 | 8,388,420 |
| **Import of waste** | 1,056,651 | 1,110,408 |
| **Recovery of waste** | 5,602,886 | 7,964,414 |
| **of this recycled** | 3,209,874 | 3,595,803 |
| **of this used for backfilling** | 2,187,962 | 4,115,408 |
| **Disposal of waste** | 390,269 | 349,399 |
| **Export of waste** | 1,030,664 | 1,090,345 |

## 4.1.1 Example of good practice

An example of good practise in the area of waste management is definitely Ljubljana. It is the first European capital to commit to going zero-waste. Since 2002, it has separately collected paper, glass and packaging in roadside container stands. Since 2006, the city has been collecting also biodegradable waste door to door; separate collection of biowaste is set to become mandatory across Europe in 2023, but Ljubljana was nearly two decades ahead of the curve. The development of the most modern plant in Europe for treating biological waste has been a major step towards meeting the city's commitment to a minimum 75% recycling rate by 2025. The Regional Centre for Waste Management (RCERO) opened in 2015 and today services almost a quarter of all Slovenia, uses natural gas to produce its own heat and electricity, processes 95% of residual waste into recyclable materials and solid fuel, and sends less than 5% to landfill. It even turns biowaste into high-quality gardening compost. Prevention, reuse and recycling lead the way. In addition to door-to-door collection, Ljubljana has two household waste recycling centres where citizens can dispose of their rubbish. The one near RCERO Ljubljana is so popular – it gets more than 1,000 visits a day – that the city plans to build at least three more, with another 10 smaller sites in denser areas. Zero-waste stores are an emerging trend in Ljubljana, and the Voka Snaga waste department runs its own packaging-free vending machines for household basics [25].

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

## 4.2 Waste from biological resources

Table 4.2.1. presents findings of S2BIOM project about the potential of biowaste separately collected in Slovenia in 2020. All the measurements are in Kton of dry matter.

*Table 4.3: Biowaste separately collected Kton d.m. (S2BIOM Base potential 2020)*

| Region | Biowaste unseparately collected | Biowaste separately collected | Total |
|---|---|---|---|
| **Pomurska** | 9 | 5 | 14 |
| **Podravska** | 25 | 14 | 39 |
| **Koroška** | 6 | 3 | 9 |
| **Savinjska** | 20 | 11 | 30 |
| **Zasavska** | 7 | 4 | 11 |
| **Posavska** | 6 | 3 | 9 |
| **Jugovzhod Slovenija** | 11 | 6 | 17 |
| **Primorsko-notranjska** | 4 | 2 | 6 |
| **Osrednjeslovenska** | 38 | 20 | 59 |
| **Gorenjska** | 16 | 9 | 24 |
| **Goriška** | 9 | 5 | 14 |
| **Obalno-kraška** | 9 | 5 | 13 |
| **Total** | **160** | **86** | **246** |

The highest potential of biowaste source was assigned to Osrednjeslovenska region (see the table 4.2.1). Since Ljubljana is located in that region, the estimates seem to be logic, because of the high population density in this area a lot of waste is generated. Distribution of biowaste potential across the country is also presented on figure 4.2.1.

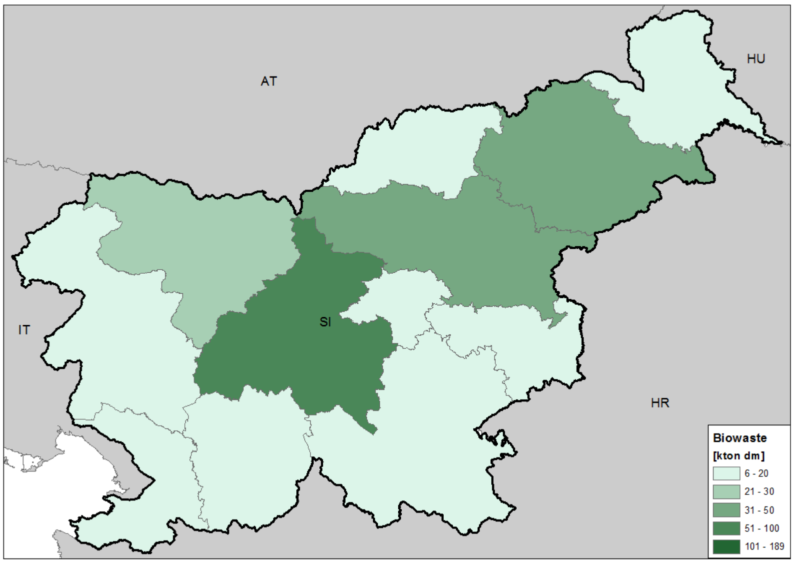



*Figure 4.2.1: Distribution of total biowaste potential over country (Source: S2BIOM)*

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

Table 4.2.2 gives an insight into generation of waste and its treatment in the sector of agriculture, horticulture, aquaculture, forestry and hunting and food preparation and processing for the years from 2016 to 2018. All measurements are in tons[24].

*Table 4.4: Waste generated in agricultural, horticultural, forestry, hunting, fishing and food preparing and processing sector[24].*

| | | | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|
| **Wastes from agricult., horticult., aquacult., forestry, hunt. and fish., food prep. and process.** | Yearly amount with temporary storage - TOTAL (tons) | Non-hazardous, hazardous waste - TOTAL | 99,183 | 79,546 | 99,396 |
| | Waste generated in the current year (tons) | Non-hazardous, hazardous waste - TOTAL | 98,069 | 79,501 | 99,390 |
| | Waste from temporary storage (tons) | Non-hazardous, hazardous waste - TOTAL | 1,114 | 45 | 6 |
| | Treatment - temporarily stored (tons) | Non-hazardous, hazardous waste - TOTAL | 3,033 | 130 | 144 |
| | Treatment - delivered to others in Slovenia (tons) | Non-hazardous, hazardous waste - TOTAL | 96,150 | 79,415 | 98,155 |
| | Treatment - delivered abroad - TOTAL (tons) | Non-hazardous, hazardous waste - TOTAL | ... | ... | 223 |
| | Treatment - delivered abroad - to the EU (tons) | Non-hazardous, hazardous waste - TOTAL | ... | ... | 223 |
| | Treatment - delivered abroad - outside the EU (tons) | Non-hazardous, hazardous waste - TOTAL | ... | ... | ... |
| | Treatment - internal recovery, disposal - TOTAL (tons) | Non-hazardous, hazardous waste - TOTAL | ... | ... | 874 |

Based on observations from table 4.2.2, one can conclude that majority of biowaste produced in the aforementioned sectors, stays within the country.

Postconsumer wood includes all kinds of wooden material that is available at the end of its use as a wooden product, like packaging materials (e.g., pallets), demolition wood, timber from building sites, and used furniture. The quality of the postconsumer wood determines the possibilities to utilize postconsumer wood for material applications beyond combustion with energy application. Potentials of the post-consumer wood for the year 2020 were assessed in the scope of the S2BIOM project. Table 4.2.3 summarises the major findings.

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

*Table 4.5: Hazardous and non-hazardous post-consumer wood Kton d.m. (S2BIOM Base potential 2020)*

| Region | Hazardous post-consumer wood | Non-hazardous post-consumer wood | Total |
|---|---|---|---|
| **Pomurska** | 1 | 3 | 4 |
| **Podravska** | 2 | 8 | 10 |
| **Koroška** | 0 | 2 | 2 |
| **Savinjska** | 1 | 6 | 8 |
| **Zasavska** | 0 | 2 | 3 |
| **Posavska** | 0 | 2 | 2 |
| **Jugovzhod Slovenija** | 1 | 4 | 4 |
| **Primorsko-notranjska** | 0 | 1 | 2 |
| **Osrednjeslovenska** | 3 | 12 | 15 |
| **Gorenjska** | 1 | 5 | 6 |
| **Goriška** | 1 | 3 | 4 |
| **Obalno-kraška** | 1 | 3 | 3 |
| Total | **11** | **51** | **62** |

Figure 4.2.2 shows the distribution of total post-consumer wood potential over the country.

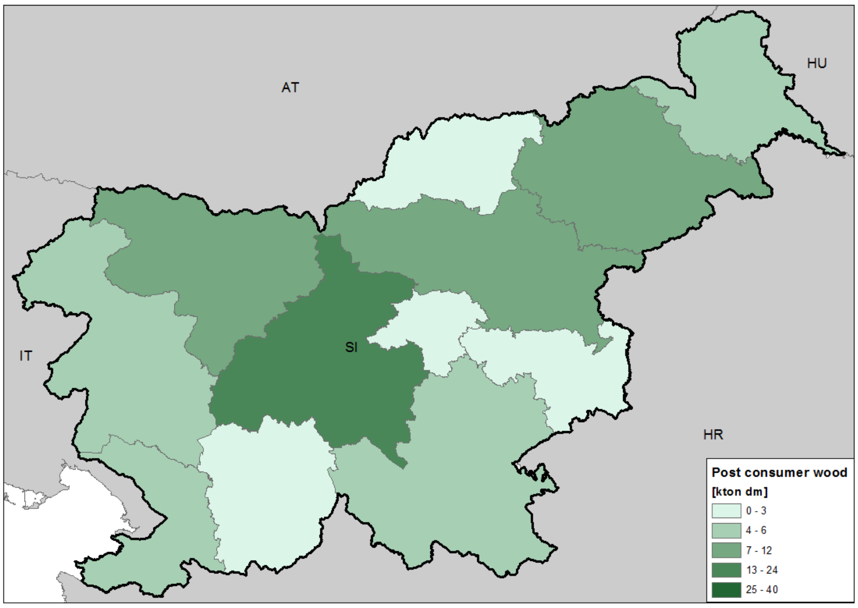



*Figure 4.2.2: Distribution of total post-consumer wood potential over the country*

Another important source of biowaste in Slovenia is food preparation and processing sector. Sources that generated food waste in 2018 are described in table 4.2.4. Additionally, the table gives an insight into treatment of that waste. Based on data obtained, it can be concluded that most of the food waste is recovered in biogas plants.

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

*Table 4.6: Food waste generation by source and treatment, Slovenia, 2018[24]*

| YEAR: 2018 | Tons |
|---|---|
| **Food waste generated - TOTAL** | 139,856 |
| • **in production activities (incl. primary)** | 10,839 |
| • **in distribution and food stores** | 13,763 |
| • **in food services** | 42,071 |
| • **in households** | 73,182 |
| **Food waste treatment - recovery in biogas plants** | 66,255 |
| **Food waste treatment - recovery in composting systems** | 40,878 |
| **Food waste treatment - biological stabilisation** | 29,859 |
| **Food waste treatment - other treatment** | 2,864 |

Table 4.2.5 summarises amounts of certain groups of municipal waste (with the focus on biological waste) generated in Slovenia in 2018[24].

*Table 4.7: Amounts of municipal waste in relation to its biologic origin, Slovenia, 2018[24]*

| YEAR: 2018 | Tons |
|---|---|
| **PACKAGING WASTE** | |
| • **Paper and cardboard packaging** | 83,803 |
| • **Wooden packaging** | 22,696 |
| **SEPARATELY COLLECTED FRACTIONS** | |
| • **Paper and cardboard** | 113,397 |
| • **Biodegradable kitchen, canteen waste** | 62,579 |
| • **Wood as a waste** | 33,835 |
| **GARDEN AND PARK WASTE** | |
| • **Biodegradable waste** | 98,848 |
| • **Soil and stones** | 411 |
| **OTHER MUNICIPAL WASTE** | |
| • **Waste from markets** | 9 |
| • **Waste from sewage cleaning** | 22 |

Based on observations from table 4.2.5, one can conclude that separately collected biowaste sources ("paper and cardboard", "biodegradable kitchen, canteen waste" and "wood as a waste") for the year 2018, if summed together, amounted to 209,811 tons. The results coincide relatively well with S2BIOM's estimated potential of separately collected biowaste in 2020 which is 246,000 tons (see the table 4.2.1).

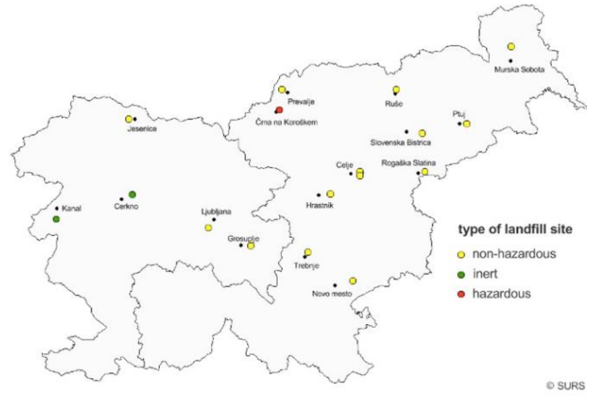
This project received funding from the BBI JU under the EU Horizon 2020 research and innovation programme under grant agreement No.838087

## 4.3 Current waste treatment and unused potentials estimates

The following facilities operated in Slovenia in 2016[22]:

- 386 facilities for waste recycling, where almost 2.9 million tons of waste was recycled (52.3% of all waste generated this year in Slovenia)
- 180 facilities for waste recovery with backfilling, where 1.3 million tons of waste was recovered (23.8% of all waste generated this year in Slovenia)
- 10 facilities for waste incineration for the purpose of energy recovery, where 231 thousand tons of waste was utilized for energy (4.2% of all waste generated this year in Slovenia)
- 3 facilities for waste incineration for the purpose of waste disposal, where 37 thousand tons of waste was removed (0.7% of all waste generated this year in Slovenia)

In 2016 there were 17 operating landfill sites in Slovenia, of which 14 for non-hazardous waste, two for inert waste and one for hazardous waste. Twelve landfill sites were in eastern Slovenia and five in western Slovenia (shown on figure 4.3.1)[22].




Sources: ARSO, GURS

*Figure 4.3.1: Operating landfill sites, Slovenia, 2016[22]*

Table 4.3.1 compares data on waste treatment facilities and amount of waste treated in years 2014 and 2016[22].

*Table 4.8: Waste treatment facilities and amount of waste treated, Slovenia, 2014 and 2016[22]*

| | **2014** | | **2016** | |
|---|---|---|---|---|
| | Number of facilities | Amount of waste treated (1,000 tons) | Number of facilities | Amount of waste treated (1,000 tons) |
| **Facilities for waste recovery - TOTAL** | 559 | 4,846 | 576 | 4,417 |
| ***facilities for waste recycling*** | 354 | 2,753 | 386 | 2,876 |
| ***facilities for backfilling*** | 189 | 1,824 | 180 | 1,310 |
| ***facilities for incineration with energy recovery*** | 16 | 269 | 10 | 231 |
| **Facilities for waste disposal - TOTAL** | 21 | 319 | 20 | 157 |
| **facilities for waste disposal with incineration** | 3 | 35 | 3 | 37 |
| **landfill sites** | 18 | 284 | 17 | 138 |

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

### 4.3.1 RCERO Ljubljana – the most modern Regional Waste Management Centre in Europe

The RCERO Ljubljana project involves upgrades to regional waste management facilities serving 37 municipalities in central Slovenia. It is made up of three sub-projects: a new landfill area; a treatment plant for leachate, which is liquid that has percolated through solid matter and contains constituents of that matter; and waste treatment facilities.

The new landfill area has been in use since 2009, the leachate treatment plant started operating in January 2011 and the waste treatment facilities were completed in October 2015. The amount of waste processed at the new facilities that end up in landfill is below 5 % – the rest is recycled for use by industry as raw materials or as an energy source.

RCERO Ljubljana performs mechanical biological treatment of two types of waste: biological waste collected separately, and mixed municipal waste. Waste is also taken in bulk and sorted. The facilities can process 150,000 tonnes of mixed waste and over 20,000 tonnes of biological waste a year.

The aim of the treatment is to reduce the quantity of waste going into landfill, to separate waste which can be recycled or incinerated in incineration plants, such as metal and glass, and to produce compost from biological waste for use in gardening and landfill maintenance. It involves mechanical separation of mixed municipal waste followed by preparation of solid fuel, and breaking down of biodegradable municipal waste and fermentation of separately collected biological waste to produce biogas.

Each year, the facilities produce 60,000 tonnes of solid fuel, 35,000 tonnes of digestate (material remaining following the breakdown of mixed municipal waste), 6,000 tonnes of wood, 7,000 tonnes of compost and 25,000 tonnes of waste that can be recycled to generate raw materials. They also generate 17 000 megawatt hours (MWh) of renewable electrical energy and 36,000 MWh of heat energy from biogas. The energy generated is used in the facility and some of the equipment in the administrative building is made from waste materials.

The waste treatment facilities, located near Ljubljana, are among the most modern in Europe and the biggest of their kind in Slovenia in terms of budget and capacity. Owing to the advanced technologies used, the project has helped to cut surface and groundwater contamination by water leaching from landfill, greenhouse gas emissions, particularly methane, and odours from the decomposition of biodegradable waste. It has also brought about a six-fold reduction in waste ending up in landfills[26].

A third of Slovenia's population, some 700,000 people, now have a long-term solution to their waste management issues. Given the number of municipalities involved, the project is a good practice example in terms of cooperation among local authorities[26].

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

## 4.4 Summary and conclusions in relation to SWOT elements

Slovenia is among the countries with the highest number of separately collected waste and management of recycling. It separately collected almost 71 % of all municipal waste and manage to recycle more than 42 % of all waste generated in 2018. In 2016, 386 facilities for waste recycling, 180 facilities for backfilling and 10 facilities for waste energy recovery operated in Slovenia. Waste was incinerated in three incineration plants and landfilled at 17 (legal) landfill sites [22]. During the past 10 year, Slovenia has managed to constantly decrease disposed waste on landfill site. Ljubljana is also the first European capital to commit to going zero-waste. The development of the most modern plant in Europe for treating biological waste (RCERO) has been a major step towards meeting the city's commitment to a minimum 75% recycling rate by 2025. RCERO Ljubljana performs mechanical biological treatment of two types of waste: biological waste collected separately, and mixed municipal waste. It can process over 20 000 tonnes of biological waste per year[26]. The aim of the treatment is to reduce the quantity of waste going into landfill, to separate waste which can be recycled or thermally treated in incineration plants, such as metal and glass, and to produce compost from biological waste for use in gardening and landfill maintenance. It involves mechanical separation of mixed municipal waste followed by preparation of solid fuel, and breaking down of biodegradable municipal waste and fermentation of separately collected biological waste to produce biogas[26]. Each year, the facilities produce 60,000 tons of solid fuel, 35,000 tons of digestate (material remaining following the breakdown of mixed municipal waste), 6 000 tonnes of wood, 7,000 tons of compost and 25,000 tons of waste that can be recycled to generate raw materials. The facility also generates 17,000 MWh of renewable electrical energy and 36,000 MWh of heat energy from biogas[26].

*Table 4.9: SWOT analysis in relation to waste sector in Slovenia*

| | |
|---|---|
| **Strengths**<br>• Awareness and willingness of citizens to separately collecting waste<br>• Presence of the most modern regional waste management centre in Europe (RCERO) | **Weaknesses**<br>• Lack of better capabilities to treat broader spectrum of waste |
| **Opportunities**<br>• Development of innovative and high-added value products<br>• Job creation<br>• Increased competitiveness of the country<br>• Reduction of landfill costs<br>• Extension of landfill's lifetime | **Threats**<br>• Waste accumulation |

# 5 Bio-based industries, products and markets

## 5.1 Current bio-based industries

In addition to other industrial sectors, domestic chemical industry is particularly inclined towards going bio-based. Aquafil[27], for example, has long been looking into alternative polyamide textile resource sourcing, initially by recycling, while it is lately also coordinating the project EFFECTIVE[28], where materials are being sources as bio-derived. In this view, the EFFECTIVE project aims to demonstrate first of its kind and economically viable routes for the production of bio-based polyamides and polyesters from sustainable renewable feedstock towards fibres.

The company Helios[29] has traditionally been using lipid-sourced resin materials, which are applied for coatings. Today, Helios Resins produces over 60,000 tons of liquid resins annually, including coating resins, composite resins, polyester resins for isolation and polyester polyols for PU flexible foams. In addition to the latter, Helios has been looking into other drop-in or outperforming precursors, which could be implemented in resins. Here, acrylates, various furan derivatives and sugars are being tested at different TRLs in existing commercial formulations.

Melamin is a company that is very dedicated to developing various bio-based materials, primarily from bio-alcohols. It supplies resins for paper, construction, wood, rubber, and the lacquer industry; impregnated decorative paper for the furniture industry, and impregnated materials for footwear manufacturing. Melamin is presently implementing a project to develop 100% carbon-based bio-sourced resin. In general, its primary aim is to apply labelled green bio-methanol, bio-formaldehyde, bio-butanol, *etc.* for their commercial formulations.

The company Tanin[30,31] is producing various wood-derived chemicals, such as furfural, tannin, extractives or others. They are a global leading company, selling plant extracts for various uses, from technical extracts for leather industry to natural extracts, used for animal nutrition and food (oenology). In 1980s Tanin focused especially on animal nutrition. Their longstanding portfolio has been recognised as containing interesting building blocks, which can be deemed as the intermediates to various bio-based products, which are increasingly sourced.

Generally, domestic plastic manufacturers[32] (mostly SMEs) represent a rather substantial force to be reckoned for in future bio-based transition. Additional sectoral companies include Krka, as well as Lek, which enter bio-industries though biotechnological drug production, Navodnik and Plastika Skaza, as some of the most leading representatives of the aforementioned plastics producers, as well as Acies Bio, as one of the prominent successful start-ups, dealing primarily in the biotechnological building blocks through fermentation (for example whey).

### 5.1.1 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.

### 5.1.2 Commercial biorefineries

There are **no commercial bio-refineries** in Slovenia, which is the most outstanding barrier to a more bio-based (domestic) industry at large. SiDG[34] is managing state-owned forests, while the announcement of BSW[35] seems to be one of possible future opportunities to unlock waste biomass bio-refining in addition to potential intermediate (mobile) bio-refineries.

### 5.1.3 Regional bio-based initiatives

SRIP Circular Economy[36] is in the lead, of which CEL.CYCLE[37] is the largest research, development and innovation project; Bridge2Bio is performing the mapping of bio-economy, linked also to BIOEAST, *etc.*

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

There are **no international flagship bio-based projects** at present, as mapped by the Bio-based Industries Consortium.

EFFECTIVE[28] is the only demonstrational project, which is coordinated by a Slovenian partner, specifically, Aquafil. Polyamides (Nylon) and polyesters are two of the most widespread families of polymers, with applications spanning from garments, carpets and sportswear to automotive parts, packaging materials, fishing products, electric and electronic components. In recent years, the developers of such large-volume products have started to increase their interest in the production of green products at affordable prices, which implies not only the use of bio-based materials but also the application of strategies that ensure a sustainable end-of-life of the products. In this view, the EFFECTIVE project aims to demonstrate first of its kind and economically viable routes for the production of bio-based polyamides and polyesters from sustainable renewable feedstock towards the obtaining of fibres and films with enhanced properties, market competitiveness and increased sustainability.

AGRIMAX[38] is having Gospodarsko Interesno Združenje Grozd Plasttehnika as a partner, as well as one of its demo sites/locations in Slovenia. Around a third of all food produced globally is wasted each year. This waste occurs throughout the whole value chain, from farmers to consumers. However, there are significant amounts of valuable compounds contained in the wasted food that could and should be recovered.
The AGRIMAX project is designed to establish the technical and economic viability using bio-refining process on waste from crops and food processing to deliver new bio-compounds for the chemical, bio-plastic, food, fertilisers, packaging and agriculture sectors.

SUSFERT[39], the third demonstrational project, is introducing the aforementioned Acies Bio company as a partner. SUSFERT will develop multifunctional fertilisers for phosphorus and iron supply. Phosphorus is essential for crop production but is currently based on non-renewable resources. The SUSFERT project will develop sustainable new sources for novel fertilisers to partly or fully replace existing sources. Specifically, it will reduce non-renewable phosphorus in fertilisers by 40 per cent, replace synthetic chelates for iron fertilisation, replace synthetic controlled release coatings and produce four compound fertilisers.

Last but not least, the aforementioned CEL.CYCLE[37] is the largest research, development and innovation project, which includes Slovenian partners exclusively. Partners in this programme aim to discover full potential of integrated and cascade use of biomass through comprehensive research and by systematically collecting and recording findings. The project intends to develop and optimise new, sustainable technologies and procedures to lead us to useful biomass components, which can be later used as environmentally acceptable and renewable materials and products. Whatever biomass residue should remain at the end of it all, we will convert it into energy. Various research-production circles interconnect within this programme. They create new value

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

chains with a common goal – optimal material utilisation of biomass throughout the circuit. Mastery knowledge base of research institutions intertwines with production/manufacturing competences of industry through entire process, from developing fundamental knowledge to industrial application. Partners from industry actively participate as early as initial phase of basic research by supplying relevant information about what results they expect and what is essential for the knowledge to be applicable in the industry. By doing so we can ensure that the search for new findings is focused on needs and demands, clearly stated by the industry as end user, thus allowing for successful market uptake and following principles of closed materials loops. All mentioned above demands a tight partner cooperation, high level of trust and creativity as well as open communication at all stages of process and between all value chains. CEL.CYCLE is developing the cascade use of biomass, industrial symbiosis, and circular economy.

## 5.3 Future Biomass valorisation options

In Slovenia, the „Technologies for sustainable biomass transformation and new bio-based materials" are a part of the „Networks for the transition to circular economy". „Networks for the transition to circular economy" are 1 of 9 S4 (Slovenia's Smart Specialisation Strategy)[40] Priority Areas. The Priority Area is coordinated by a national cluster-like entity, Strategic Research and Innovation Partnership (SRIP) Networks for the transition into circular economy.

Respectively, **bio-refining is of interest**. In terms of relative forest coverage, Slovenia is the third in the European Union after Finland & Sweden. Existing chemical industry is strong (at least 25% among 1st 20 companies considering revenue or employees). There´s an interest to increase bio-based product share (European Bioeconomy in Figures 2008 – 2015, BIC, 2012, BIC, 2018).

But there are weaknesses present. The European „Valley of death", the model of risk profile for companies of innovation processes, is opting for a PPP approach. A Slovenian (additional) „Valley of death" is due to lacking basic/commodity chemicals. Consequently, a **large-scale biomass bio-refinery may not be optimal** for Slovenia.

Consequently, **a local** (hence smaller) **bio-refinery concept** may be **more appropriate for Slovenia** (shown on figure 5.3.1).

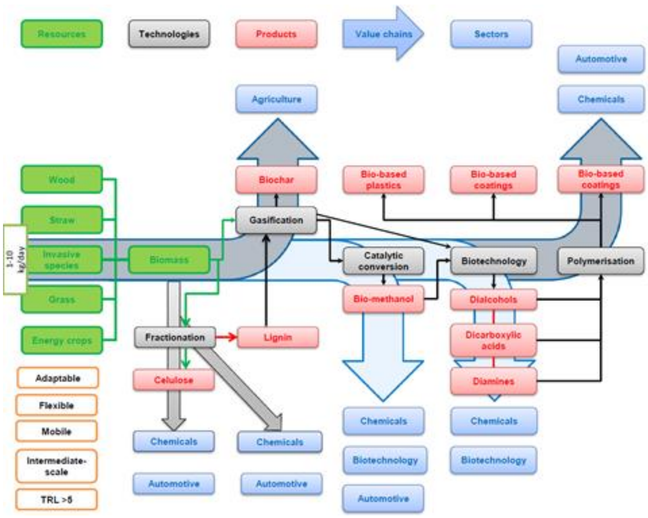



*Figure 5.3.1: Bio-refinery concept suitable for Slovenia. Source: National Institute of Chemistry*[41]

The options to address the latter are to implement a **mobile bio-refinery concept**, moving according to specific resource availability (1), retrofitting the only existing fractionation at the Pulp and Paper Institute[42] (2), or executing a **greenfield pre-treatment investment** at one of existing/future sawmill operations or paper industry companies, which would be the primary cellulose up-takers, followed by chemistry. This would also unlock a potential to bridge the bio-based value chain from the resource to products, be it chemical or agricultural.

## 5.4 Summary and conclusions in relation to SWOT elements

In addition to other industrial sectors, domestic chemical industry is particularly inclined towards going bio-based. Spectrum of bio-based product is quite broad, covering polymers for textile industry, various coatings, resins, wood-derived chemicals, plant extracts, biological drugs etc. One of the most vital issues impeding extension of bio-based industry is lack of commercial bio-refineries in Slovenia. In fact, there is not a single one biorefinery.

A few regional bio-based initiatives are already in place, among whom SRIP Circular Economy is in the lead, while CEL.CYCLE is the largest research, development and innovation project; beside CELEBio also Bridge2Bio is performing the mapping of bio-economy, the latter is also linked to the BIOEAST etc. However, there are no international flagship bio-based projects at present or even domestic at high TRLs. According to future biomass valorisation the bio-refining is much of an interest. A Slovenian (additional) „Valley of death“ is due to lacking basic/commodity chemicals. Consequently, a large-scale biomass bio-refinery may not be optimal for Slovenia. Better fit seems to be achieved by local (hence smaller) bio-refinery concept.

The main SWOT analysis findings considering the bio-based industries, products and markets are summarised in table 5.4.1.

*Table 5.1: SWOT analysis of bio-based industries, products and markets in Slovenia.*

| | |
|---|---|
| **Strengths**<br>• Abundant biomass resources / willing industrial partners | **Weaknesses**<br>• Middle of bio-chemicals/materials value chain missing / very high-CAPEX technologies |
| **Opportunities**<br>• Companies with strong bio-based interests / state-of-the-art chemicals or plastic production | **Threats**<br>• Loss of competitive market advantage / not developing own bio-based processes (buying them) |

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

# 6 Infrastructure, logistics and energy sector

## 6.1 Existing industrial hubs and harbours

The port of Koper is the only Slovenian port which handles cargo. It is a part of the Trans-European Transport Network (TEN-T). Since it carries out transport and logistics activities of national and wider regional importance, it is considered to be one of the most important connecting transport platforms in Slovenia. Its strategic geographical position is extremely favourable for supplying markets in Central and Eastern Europe[43].

Some business performance highlights of Luka Koper Group – a company managing the Port of Koper (for the business year 2018)[44]:

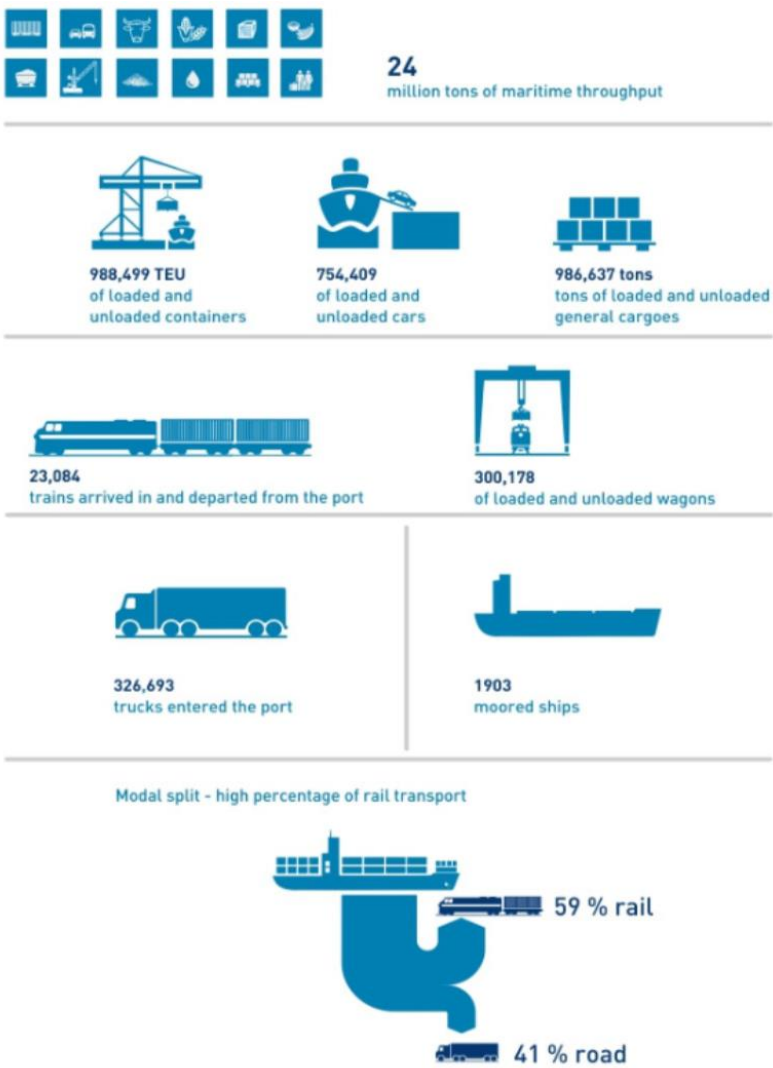



*Figure 6.1.1: Highlights of Luka Koper Group's business year 2018*[44]

No inland waterways exist in Slovenia[45].

Large scale bio-based production chains require transportation of large volumes of materials, i.e. the supply of biomass and the export of (intermediate) products. The only cheap options for transportation of large volumes are waterways and railways. Experts indicated that hubs are essential for establishing successful biorefineries. Using the results of the project "Methodology for defining and gathering business zones and entities of innovative environment in Slovenia" we were able to map the current industrial hubs in Slovenia with constrains on size of industrial zones (15 ha or more) and distance to the nearest freight railway track (up to 1 km)[46].

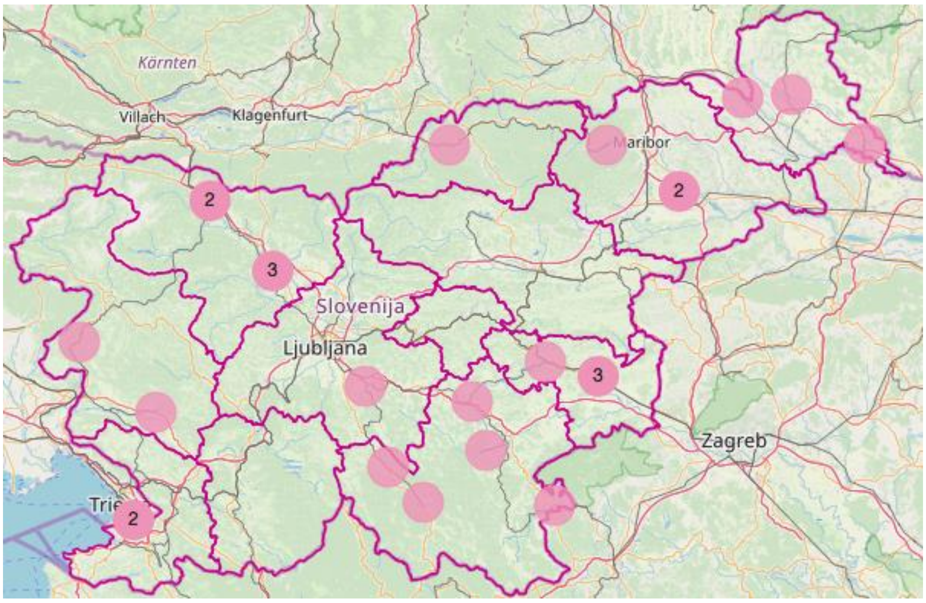



*Figure 6.1.2: Current industrial zones in Slovenia that are more than 15 ha large and are less than 1 km distant from the freight railway track[46]*

Industrial zones illustrated on figure 6.1.2 are also listed in table 6.1.1 with respect to corresponding municipality[46].

*Table 6.1: Current industrial zones in Slovenia, larger than 15 ha and distant less than 1km to the nearest freight railway track[46]*

| Name of the entity | Municipality |
|---|---|
| **Acroni** | Jesenice |
| **Bivje Jug** | Koper |
| **Bussines zone Jug** | Grosuplje |
| **Bussines zone Novoles** | Straža |
| **Industrial zone Gornja Radgona** | Gornja Radgona |
| **Industrial zone Talum** | Kidričevo |
| **Industrial zone Brezina** | Brežice |
| **Industrial zone Lendava** | Lendava |
| **Industrial zone Lepovče** | Ribnica |
| **Industrial zone LIK I, II, III** | Kočevje |
| **Industrial zone Ptuj** | Ptuj |
| **Industrial zone Rosalnice** | Metlika |
| **Industrial zone Sevnica** | Sevnica |
| **Industrial zone Trebnje** | Trebnje |
| **Craft-industrial zone Hrpelje** | Hrpelj-Kozina |
| **Industrial zone Anhovo – south** | Kanal |

| | |
|---|---|
| **Business zone Goričane** | Medvode |
| **Business zone Mirce** | Ajdovščina |
| **Business zone pri Vipapu** | Krško |
| **Business zone Vrbina** | Krško |
| **Business zone Ruše – TDR (RU26)** | Ruše |
| **Business zone ZGO (ex iron works Ravne)** | Ravne na Koroškem |
| **Radovljica Gramoznica Graben** | Radovljica |
| **Sava Labore** | Kranj |
| **Savska cesta** | Kranj |
| **North craft-industrial zone – SOIC I., II. And III.** | Murska Sobota |

## 6.2 Existing railways

The rail network in Slovenia is owned by the state and consists of 1,208 kilometres of track. The Infrastructure Agency is responsible for the construction, upgrading, renovation and maintenance of the public railway infrastructure, while the management thereof is carried out by the company Slovenske železnice – Infrastruktura, d.o.o. The company Slovenske železnice – Potniški promet, d.o.o., transports approximately 15 million passengers per year with around 525 trains and the company Slovenske železnice – Tovorni promet, d.o.o., transports almost 21.3 million tonnes of goods per year (2017)[47,48].

The railway network in Slovenia is divided into major and regional tracks in terms of traffic volume, economic importance and the interconnecting role. Railway infrastructure is further divided by the number of tracks into single-track railway where trains run on the same track in both directions and double-track railway where each track is intended for a particular direction[49]. Table 6.2.1 summarises length of railway tracks.

*Table 6.2: Length of railway tracks*[49]

| Length of tracks | km |
|---|---|
| **Total length of tracks** | 1,207.70 |
| **Length of double-track railway** | 333.54 |
| **Length of single-track railway** | 874.16 |
| **Length of major tracks** | 607.79 |
| **Length of regional tracks** | 599.91 |
| **Length of electrified tracks** | 605.30 |

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

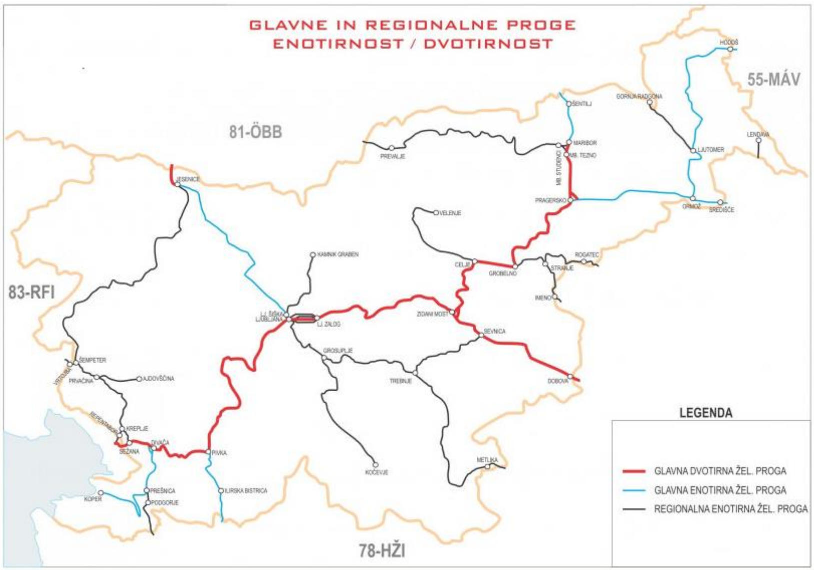



*Figure 6.2.1: Map of the main and regional tracks, single / double track railways. Main double track railway is marked by red, main single track railway by blue and regional single track railway by black[49].*

All the major railways, with exception of junctions with foreign railway, are electrified by a single DC system with a nominal voltage of 3 kV[49] (shown on figure 6.2.2.)

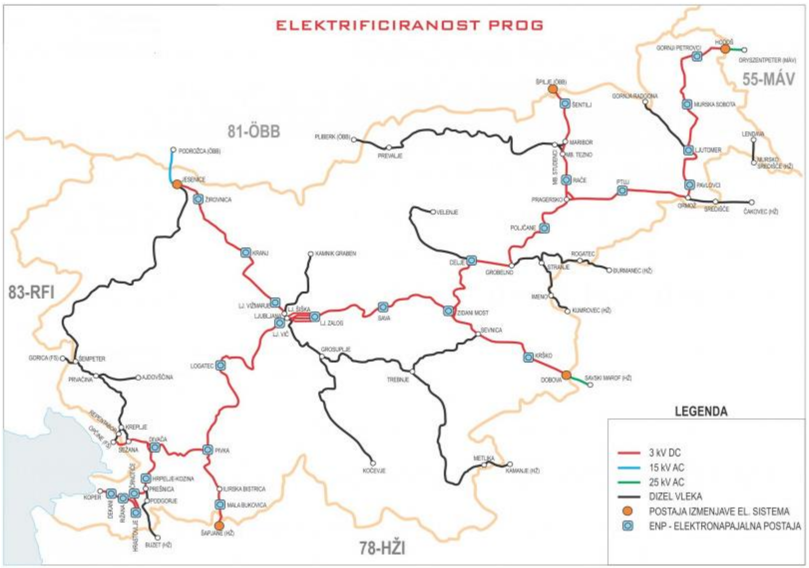



*Figure 6.2.2: Map of the electrified railways. 3 kV system is marked with red. By black are marked railway tracks that are not electrified [49].*

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

With the respect of the permissible mass load on tracks by freight wagons, the tracks are categorized according to the permissible axle and permissible length load. The permissible axel load is the maximum mass, in tonnes, that can be applied to the one axle of a railway vehicle on a given track, regardless on its total number of axles. The permissible load per running meter is the maximum mass in tonnes that be applied to one running meter of railway vehicle on a given track[49] (shown on figure 6.2.3).

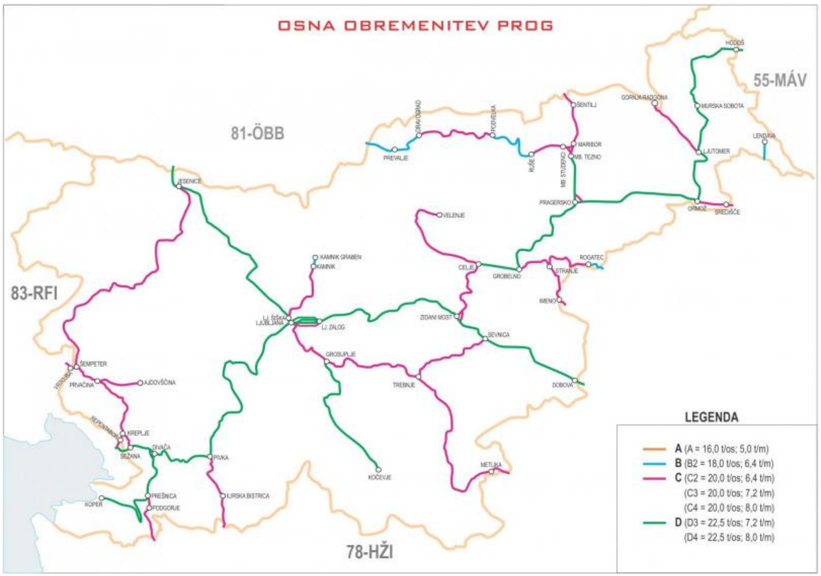



*Figure 6.2.3: Tracks with the respect of the permissible axle (ton/axle) and length load (ton/m). Tracks marked with green are limited to max permissible load of 22.5 tons per axle or 8 tons per meter. Tracks marked with purple are limited to max permissible load of 20 tons per axle or 7.2 tons per meter [49].*

## 6.2.1 Current investments in railway network

**Building the second track Divača-Koper is currently the most extensive infrastructural project in Slovenia**. The second track will improve the connection between Slovenian cargo port of Koper with the interior of the country, as well as with wider European rail network [50].

The existing Divača-Koper railway line was built over half a century ago. At that time, it enabled the development of the Port of Koper and provided a connection from the Slovenia coast to its hinterland. The line's capacity is currently stretched to the limits. In 2018 Slovenia started building second track from Divača (inland) to port of Koper. The estimated construction time is 7 years and the estimated value of the entire project is EUR 1.194 billion[50].

The Second track is a part of the Trans-European Transport Network (TEN-T network). The territory of the Republic Slovenia is crossed by two corridors of the core network, an integral part of which is also Divača-Koper line:

- The Baltic-Adriatic corridor (Poland-Italy)
- The Mediterranean corridor (Spain-Ukraine)

The Second track will increase the capacity in mobility between the only Slovenian port, Slovenian hinterland, and countries of Central and Eastern Europe:

- 231 trains per day (existing line and second track) instead of current 90 trains per day.
- 43.4 million tonnes transport capacity per year (existing line and second track) instead of current 14 million tonnes per year.

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

The second track is also in strategic interest of neighbouring countries and entire Europe, as the existing track represents a bottleneck on two core European railway corridors[50].

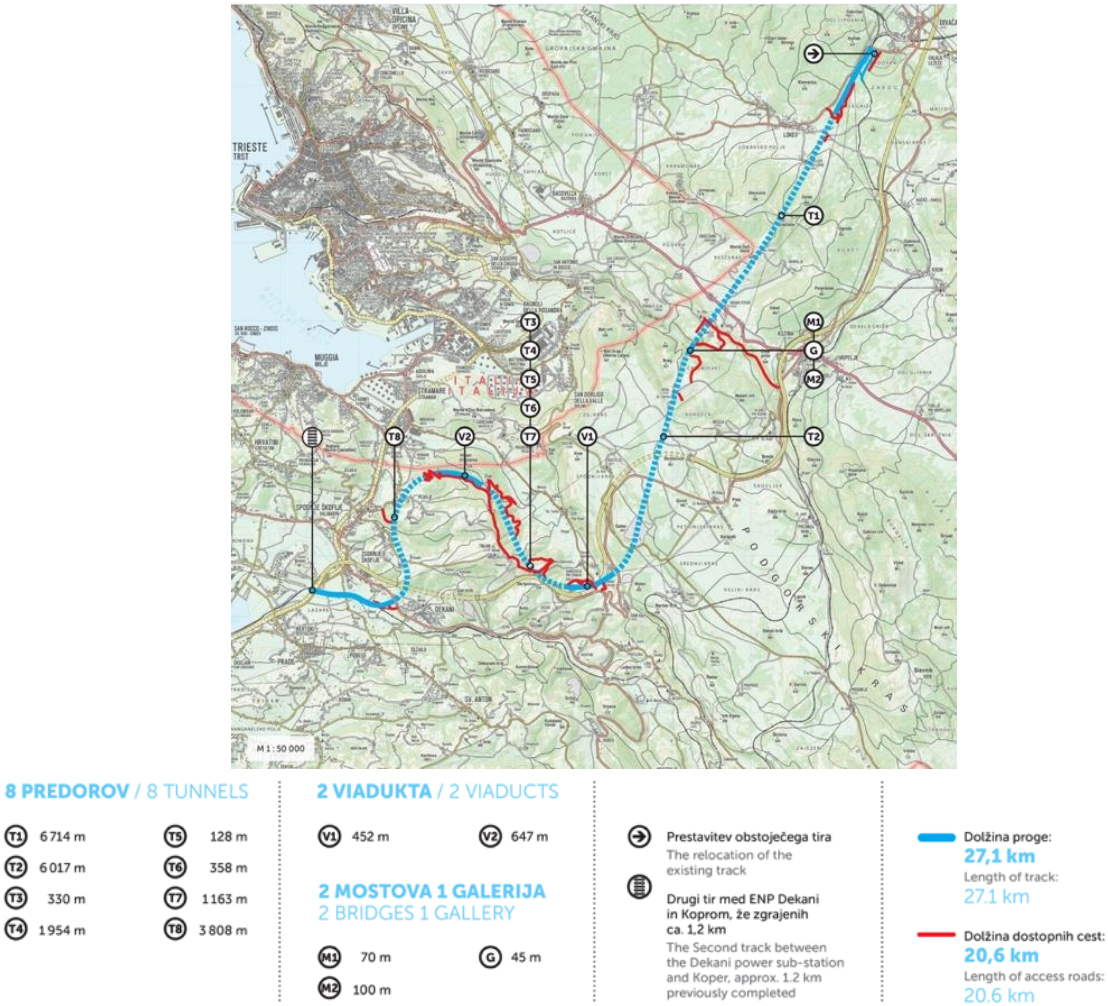



*Figure 6.2.4: Second railway track from Divača to Koper[50]*

One of the priority programme tasks in the field of rail traffic is the implementation of the Transport Development Strategy in the Republic of Slovenia until 2030 and of the Resolution on the National Programme for the Development of Transport in Slovenia until 2030. In this context, special emphasis is placed on the development of pan-European priority rail corridors and the associated absorption of EU funds to co-finance projects[47].

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

## 6.3 Existing road infrastructure

Two important European traffic roads cross Slovenia's territory:

- **5th Pan-European transport Corridor** which links Lisbon via Barcelona and Ljubljana to Kiev (connects Southern, Central and Eastern Europe)
- **10th Pan-European transport Corridor** which links Munich via Jesenice and Ljubljana to Belgrade and Istanbul (connects Central and South-eastern Europe and Asia)

In the past 30 years, Slovenia has heavily invested in construction and improvement of the road network. The most important and the most congested part of the road network is the motorway cross, which was completed in 2011. Its brunch A1 runs from Maribor to Koper (the so called Slovenik) and the second branch A2 runs from Jesenice to Brežice (the so called Ilirika) – both shown on figure 6.3.1 [51].

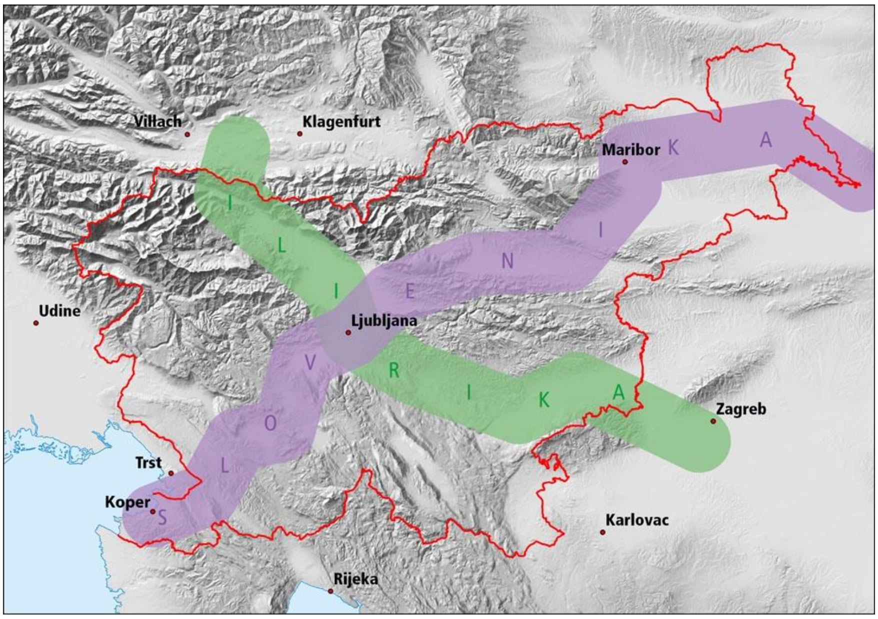



*Figure 6.3.1: Slovenian motorway cross[51]*

Slovenia has approximately 39,000 kilometres of public roads. The public road network is divided into state roads owned by the State and municipal roads owned by municipalities. The total length of state roads is more than 6,500 kilometres (see the table 6.3.1). The management, maintenance and development of main and regional roads and the cycle network fall under the responsibility of the Slovenian Infrastructure Agency (DRSI), while the Motorway Company of the Republic of Slovenia (DARS) manages, maintains and plans the development of motorways and expressways [52].

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

*Table 6.3: Insight into length of state roads [53]*

| Year | SUM (state roads) [km] | Motorways and expressways [km] | Main roads [km] | Regional roads [km] | Connections to motorways and to expressways [km] | Connections to main roads [km] | Connections to regional roads [km] |
|---|---|---|---|---|---|---|---|
| **2018** | **6540** | 623 | 800 | 5117 | 165 | 8 | 13 |
| **2017** | **6534** | 618 | 800 | 5117 | 164 | 8 | 13 |
| **2016** | **6530** | 610 | 807 | 5113 | 163 | 8 | 9 |
| **2015** | **6536** | 610 | 807 | 5119 | 163 | 8 | 9 |
| **2014** | **6545** | 607 | 811 | 5127 | 162 | 8 | 8 |
| **2013** | **6545** | 607 | 811 | 5127 | 162 | 8 | 8 |
| **2012** | **6559** | 607 | 811 | 5142 | 163 | 8 | 7 |
| **2011** | **6551** | 607 | 809 | 5136 | 161 | 8 | 8 |
| **2010** | **6551** | 607 | 809 | 5136 | 161 | 8 | 8 |

Municipal roads are managed by municipalities and include local roads (more than 13,000 km) and public paths (more than 18,500 km)[52]. Road goods vehicles registered in Slovenia carried 85 million tonnes of goods in 2018. The majority of carried goods belonged to groups of goods mining and quarrying (29%) and products of agriculture, forestry and fishing (12%) [54].

In accordance with the plan of investments in transport infrastructure for 2018–2023, most of the funds are allocated for the construction of new sections and bypasses, road reconstruction and the arrangement of roads through settlements. The funds intended for bridge structures, geotechnical measures and the establishment of cycle routes throughout Slovenia have also been substantially increased[52].

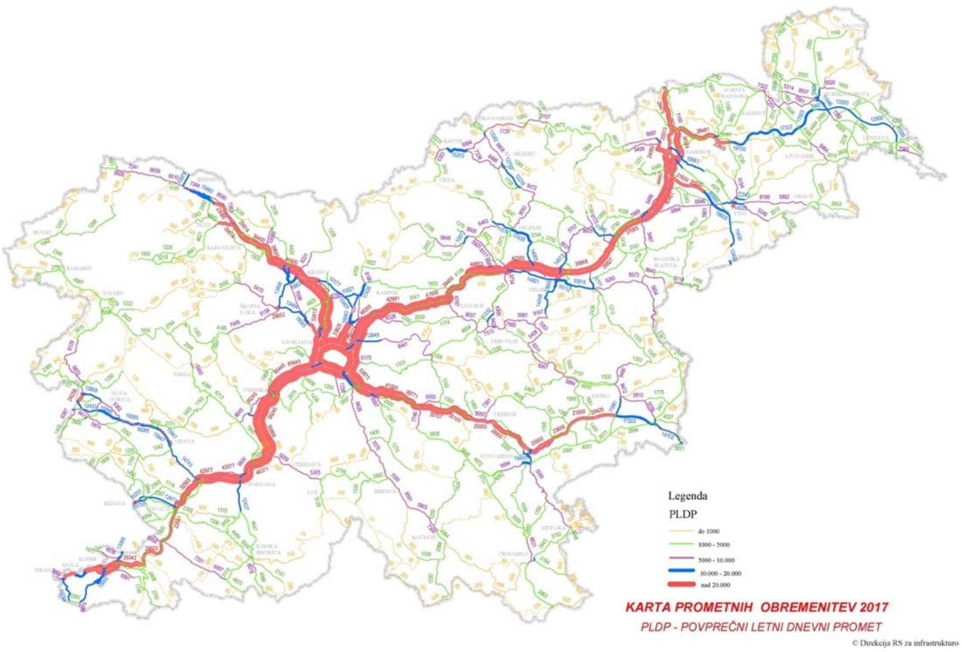



*Figure 6.3.2: Map of Slovenian road network with the respect of the traffic load. The most traffic loaded is motorway cross marked with red[53].*

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

## 6.4 Energy sector

Table below summarises data on Slovenian energy sector, obtained during S2BIOM project. The Data capitalises on Eurostat's base in 2013.

| Category | Slovenia | EU average | Unit | Assessment | Similar countries |
|---|---|---|---|---|---|
| **Energy** | | | | | |
| **Primary energy consumption** | 3.25 | 3.22 | toe/capita (2012) | Medium | ES, FR, PL, SI, SK, ME |
| **Energy dependence** | 47.1 | 55.4 | % | Medium | |
| **Renewable energy share** | 21.5 | 17.9 | % | Medium | |
| **GHG emissions** | 9.20 | 9.47 | ton $CO_2$-eq/capita | Medium | |
| **Renewable energy (RE)** | | | | | |
| **Bioenergy in RE** | 61 | 69 | % | Medium | FR, SI |
| **Bioenergy in total energy** | 10.7 | 10.6 | % | Medium | |
| **Energy infrastructure** | | | | | |
| **Biofuels prod. Capacity** | 0.002 | 0.051 | ton/capita | Low | |
| **CHP** | 7.1 | 17.3% | % gross electricity generation | Low | |
| **District heating** | 753 | 7,404 | km | | |
| | 0.4 | 0.3 | m/capita | medium | |
| **CHP = Combined Heat and Power, GDP = Gross Domestic Product; GHG = Greenhouse Gas; LSU = Livestock units; MSW = Municipal Solid Waste, PPS = Purchasing Power Standard, RE = Renewable energy; UAA = Utilised agricultural area** | | | | | |

Slovenia's priority 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. In light of this, the most important renewable energy source in Slovenia is considered to be wood and its by-products. With smart management of Slovenian wood and deploying cutting edge technologies in this field, it would be attainable to first extract as many high-added value products as possible and later on burn what remains to get the heat and energy. In this fashion Slovenian wood has a potential of fuelling energy sector, pulp & paper sector, chemical industry, civil engineering sector (eco- bio-based material production and construction) etc. Simultaneously Slovenia would reduce dependency on imported sources, increase energy security, and boost employment and development in rural areas[55,56].

According to Statistical Office of Republic of Slovenia, in 2017 the share of renewable energy sources was 16 %. This amount of renewable energy was further composed of 52 % of energy produced by wood, 30 % of hydro energy, 5 % of geothermal and solar energy and 5 % of waste and biomass [6].

Biogas production in Slovenia is growing in small increments and it is currently behind national goal of 35 MW energy production (cogeneration system for heat and power) by 2020. Main sources for biogas production in the region are: agricultural waste, organic waste on municipal landfills, biodegradable waste from food processing industry, waste from public utilities and organic kitchen waste. Parallel to biogas use in the energy sector, Slovenia is yet to see increase in biogas or biofuel use in transport sector[56].

There are minimal efforts to introduce grass-based (e.g., Miscanthus giganteus) biomass for producing briquettes and pellets for heating. Its production is on very small scale and not widely popular due to competition with arable land for food or animal feed production[56].

The current use of biomass for individual heating is high, especially in small cities and rural areas, but the biomass is mainly used in inefficient individual heating systems. Most district heating is based on large scale fossil driven district heating networks. Although there are only a few RES (renewable energy resources) driven small-scale district heating networks in Slovenia today, the development of small scale district heating networks is a part of the Slovenian national energy plans and strategies. It is supported in a range of national tools like DOLB subsidies and supports schemes for small scale cogeneration plants. The main barriers are low awareness of positive impacts of centralised small-scale DH (especially higher efficiency and less pollution with hard particles) of the general population, problematic legislation for above 1 MW district heating networks, existing use of biomass or individual heating, low price of heating oil and natural gas. Practically no small-scale district cooling or district heating projects in Slovenia exist (data form 2016). There are mainly large-scale district heating systems in larger cities. Only a handful of small scale district heating systems in Slovenia is using RES [57].

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

## 6.5 Summary and conclusions in relation to SWOT elements

Port of Koper is a part of the Trans-European Transport Network (TEN-T). Its strategic geographical position is extremely favourable for supplying markets in Central and Eastern Europe. It is well connected to the Slovenian railway network. Currently the most extensive infrastructural project in Slovenia is focusing on building the second railway track (from Divača to Koper), which will reinforce the connection between port of Koper with interior of the country, as well as with wider European network. Two priority railway freight corridors cross Slovenia: the Baltic-Adriatic Corridor (RFC 5) and the Mediterranean Corridor (RFC 6). Slovenia's territory is also crossed by two important road corridors, namely the 5$^{th}$ Pan-European transport Corridor (links Lisbon via Barcelona and Ljubljana to Kiev) and 10$^{th}$ Pan-European transport Corridor (links Munich via Jesenice and Ljubljana to Belgrade and Istanbul). Slovenia possesses 1,207.70 km of railway tracks and approximately of 39,000 km of public roads. Slovenia has more than 12,000 km of forest roads, which becomes relevant in sense of accessibility and mobilisation of biomass.
Slovenia's priority 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. In light of this, the most important renewable energy source in Slovenia is considered to be wood and its by-products. According to Statistical Office of Republic of Slovenia, in 2017 the share of renewable energy sources was 16 %. This amount of renewable energy was further composed of 52 % of energy produced by wood, 30 % of hydro energy, 5 % of geothermal and solar energy and 5 % of waste and biomass.

Table 6.5.1 summarises SWOT elements of Infrastructure, logistics and energy sector of Slovenia.

*Table 6.4: SWOT analysis of Infrastructure, logistics and energy sector of Slovenia*

| Strengths | Weaknesses |
| --- | --- |
| • Well-developed motorway network<br>• Established positions in EU hinterland transport<br>• Access to the sea<br>• Flat land around port of Koper (room for warehousing development)<br>• Strong position rail transport in freight | • Poor quality of state road transport<br>• In some areas obsolescent rail network<br>• Lack of inland waterway network<br>• Lack of inland road/rail logistic terminals |
| **Opportunities** | **Threats** |
| • Central position of the Slovenia on TEN corridors (Baltic-Adriatic and Mediterranean corridors)<br>• Established strong position of rail (esp. in freight transport)<br>• **Currently building second track which will link Slovenian cargo port of Koper with the interior of the country, as well as wider European rail network (future freight transport capacity will be more than tripled)**<br>• Co-ordination with other ports (Trieste, Rijeka, Venice) | • Worrying condition of the state road network<br>• Condition of the rail network<br>• Increased congestion in Ljubljana<br>• Competition from other corridors (Croatia, Italy)<br>• Competition from other ports (Rijeka, Trieste, Venice) |

# 7 Skills, education, research and innovation potential

## 7.1 Research infrastructure

The most relevant research infrastructure equipment, related to bio-based industrial development may be found at the Pulp and Paper Institute[42], National Institute of Chemistry[41] and Faculty of Chemistry and Chemical technology (University of Maribor)[58], which are either leading CEL.CYCLE[37] or SRIP Circular Economy[36]. Other relevant hubs include University of Maribor, Faculty of Mechanical Engineering, Slovenian National Building and Civil Engineering Institute, and University Of Ljubljana, Faculty of Mechanical Engineering, leading individual CEL.CYCLE Sections (composites, construction, energetics…).

Considering the equipment of Pulp and Paper Institute[59], the latter spans from the laboratory to pilots.
Pulp and Paper Institute, with its Laboratory and the Pilot equipment represents the only papermaking infrastructure centre in the area of SE Europe. The papermaking laboratory is divided in four testing sections: mechanical-physical, graphical, chemical and microbiological testing and together with pilot equipment (pilot papermaking machine, pilot coating machine and calendaring machine) covers the entire paper production process. Laboratory equipment enables the study and characterization of input materials, the characterization of paper and paper products, waste water, solid waste and the evaluation of the production process. The developed and implemented analytical methods in the different areas of testing ensure solutions for different complex challenges related to the surface, optical, printing and other specific properties of the materials.

Considering the equipment of National Institute of Chemistry, the latter primarily relates to the production of various bio-based chemicals/materials (D13, D07, D09…)[41]. Research is oriented towards the development of new technologies and products, which will help to ensure the long-term development of Slovenia and which are internationally relevant. Industry is an important partner to the Institute in these endeavours. There are a number of Slovenian companies with whom the Institute has entered into close long-term cooperation, as well as a number of well-regarded foreign companies. From a financial point of view, this kind of cooperation represents 20% of the income of the Institute. The National Institute of Chemistry is also making infrastructure available through KET4CP project[60].

The EU-funded project KET4CleanProduction (KET4CP) sets its strategic objectives on helping SMEs to solve their clean production challenges and - as a result - to stay sustainable, innovative and competitive. By encouraging the use of advanced manufacturing technologies and related key enabling technologies (KETs) their production processes are supposed to be upgraded towards a more energy- and material- efficient state.

Faculty of Chemistry and Chemical technology (University of Maribor) is largely invested in separations[61].
Companies, such as Acies Bio also offer the access to pilot equipment operations on a commercial basis.
Combining all key aspects of microbial technology development under one roof is this one of Acies Bio key advantages for rapidly and efficiently generating value of our clients' R&D assets. Interdisciplinary research teams rapidly transfer new findings and successful approaches among production strain improvement, media and bioprocess development, scale up and DSP/isolation development, assuring fastest progress towards final goals. They ensure that all important parameters are considered throughout different stages of the development process, reducing project management burden on the clients' side and assuring timely and professional delivery of milestone targets and products. The list of equipment, available at Acies Bio, is mapped by the Pilots4U project, noting infrastructure.

The InnoRenew CoE[62] is an independent research institute, formally established in the year 2017 in the frameworks of the project InnoRenew CoE. At the InnoRenew CoE they are conducting research about renewable materials and sustainable buildings, and we are transferring our scientific knowledge into industrial practice. They focus our research activities on innovative and interdisciplinary approaches of wood and its use. Their international team of professionals and scientists have diverse areas of expertise, are active with their Living Laboratory, and are available for everyone who may need it in their work.

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

Slovenian Forestry Institute[63], while not having abundant research infrastructure, has the access to the largest resource map within country. It is a public research institute of national importance, which conducts basic and applied research on forests and forest landscapes, forest ecosystems, wildlife ecology, hunting, forest management, and other uses of the resources and services forests provide.

## 7.2 Education infrastructure

As bio-economy is in Slovenia treated under the umbrella of circular economy activities, the most relevant education infrastructure is being developed by the Competence Centres for Human Resources Development "KOC – Kompetenčni Center Krog"[64], which includes numerous relevant stakeholders. KOC – Kompetenčni Center Krog relates to the planned operation of the SRIP Circular Economy, which represents an innovation cluster. It is an eco-system consisting of independent stakeholders (total 93, including the Styrian Chamber of Commerce) such as small, medium and large enterprises, R&D and education institutions, as well as non-profit and non-governmental organizations supporting innovative activity, capacity sharing, sharing of knowledge and experience, and effective contribution to knowledge transfer, networking, dissemination, cooperation & networking between companies & other stakeholders. Companies involved in KOC, which are members of the SRIP, operate predominantly in the vertical recycling value chain, using waste as new sources of raw materials and illustrating processes and technologies of turning waste into new sources in the direction of closing the loop, that is, 'zero waste'.

At University of Ljubljana, there is a number of engineering (e.g. pharmaceutics, chemical engineering, mechanical electrical engineering) and applied life science studies (e.g. wood processing, food technology, biotechnology) that provide a solid knowledge basis for bio-based R&I and industries. There is however only one elective master course on Bioeconomy, which takes place at the Biotechnical Faculty. It introduces the key principles of industrial organisation in circular bioeconomy (eg. cascading use of biomass, industrial symbiosis, role of biorefineries) to the students of applied life sciences, and thus extending their set of skills and career opportunities. The University of Ljubljana is also a part of the BioEnergyTrain[65] project where nearby TU Graz also developed very complementary (study) programmes.

Bioenergy is a particularly important field in this respect as it is at the cross-roads of several important European policies, from the Strategic Energy Technology Plan Roadmap on Education and Training (SET-Plan) to the European Bioeconomy Strategy to European Food Safety and Nutrition Policy. European development in this prioritised field is stalled due to a lack of qualified personnel, a lack of cohesion and integration among stakeholders, and poor linkage between professional training and industry needs. To address these problems, BioEnergyTrain brings together fifteen partners from six EU countries to create new post-graduate level curricula in key bioenergy disciplines, and a network of tertiary education institutions, research centres, professional associations, and industry stakeholders encompassing the whole value chain of bioenergy from field/forest to integration into the sustainable energy systems of buildings, settlements and regions. The project fosters EU cooperation to provide a highly skilled and innovative workforce across the whole bioenergy value chain, closely following the recommendations of the SET-Plan Education Roadmap. At the University of Maribor, the Master's programme Chemical Engineering is the one, which is mostly relevant to bio-economy (among others).

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

## 7.3 Environment for start-ups

Slovenia faces more than a few **challenges** in the realm of start-up company culture, as well as environment. Considering bio-economy, EIT Climate-KIC Accelerator[66] is one of the most sought for options available.
EIT Climate-KIC Accelerator is the only EU acceleration programme focused on climate impact by cleantech commercialisation.

Technology Park Ljubljana also offers some prospective options, often within various granted projects.
They are largest innovation ecosystem for commercialization of knowledge and technology in SE Europe.

Last but not least, ABC Accelerator[67] offers some opportunities, primarily in the field of (bio)energy.
Through eit InnoEnergy, it is possible to boost the success rate of start-ups or power the growth of scale-ups and SMEs in the field of sustainable energy and/or energy efficiency.

## 7.4 Public private partnerships

SRIP Circular Economy[36], the **Strategic Research and Innovation Partnership – Networks for the transition into circular economy** is a connection of Slovenian business subjects, educational and research institutions (RDI), non-governmental organisations and other interested parties, in collaboration with the state, aiming to establish new value chains according to the economic principles of closed material flows. The vision of the SRIP – Circular economy is to sustainably increase the efficiency and competitiveness of the domestic economy in the transition into circular economy. The long-term effect of the SRIP – Circular economy involves contributing to the recognisability of Slovenia as a circular economy hub that will set the reference standard for top professionals and foreign investors through its knowledge, R&D infrastructure, breakthrough technologies and services, as well as its regulatory support environment.
GOALS:
1) Long-term public-private partnership
2) Improvement of the material efficiency index / productivity from 1.07 (2011) to 1.5 (2020)
3) Establishment of new value chains with closed material flows
4) New business models

By meeting the set goals, all the members of the SRIP – Circular economy will also contribute to the fulfilment of the goals of the Slovenian Smart Specialisation Strategy (S4), i.e. to boost Slovenia's competitiveness in global markets by increasing the added value per employee, the share of knowledge-intensive and high-tech exports in total exports, and overall entrepreneurial activity.

## 7.5 Summary and conclusions in relation to SWOT elements

The most relevant research/development infrastructure equipment, related to bio-based industrial development may be found at the:

- **Pulp and Paper Institute**; the latter spans from the laboratory to pilots. With its Laboratory and the Pilot equipment represents the only papermaking infrastructure centre in the area of SE Europe.
- **National Institute of Chemistry**; the latter primarily relates to the production of various bio-based chemicals/materials
- **Faculty of Chemistry and Chemical technology (University of Maribor)**; the latter has largely invested in separations.

Research is in general oriented towards the development of new technologies and products, which will help to ensure the long-term development of Slovenia and which are internationally relevant. At the InnoRenew CoE (H2020 Teaming centre), an independent research institute, they are conducting research about renewable materials and sustainable buildings, with an aim to later transfer their scientific knowledge into industrial practice. They focus on research activities of innovative and interdisciplinary approaches of wood and its use. Another important player is Slovenian Forestry Institute. Although it doesn't have abundant research infrastructure, they do have an important access to the largest resource map within the country.

The most relevant education infrastructure, among others also related to the bio-based industry, is being developed by the Competence Centres for Human Resources Development – KOC. It is an eco-system consisting of independent stakeholders (total 93, including the Styrian Chamber of Commerce). Its aim is to properly equip manpower with knowledge and skills required by the latest trends in industry. To some extent also University of Ljubljana and University of Maribor are engaged in education relevant to foster bio-economy in Slovenia (chemistry, biology, engineering, *etc.*).

Among the players that are creating stimulating environment for start-ups (which in fact is quite modest), should be mentioned:

- EIT Climate-KIC Accelerator
- Technology Park Ljubljana
- ABC Accelerator

In a field of PPP, SRIP should be considered. SRIP is **Strategic Research and Innovation Partnership – Networks for the transition into circular economy**. Its vision is to rise the recognisability of Slovenia as a circular economy hub that will set the reference standard for top professionals and foreign investors through its knowledge, R&D infrastructure, breakthrough technologies and services, as well as its regulatory support environment. It's a cluster-like national stakeholder.

The main SWOT analysis findings considering the existence of infrastructure/environment are summarised in a table 7.5.1.

*Table 7.1: SWOT analysis of Skills, education, research and innovation potential of Slovenia*

| | |
|---|---|
| **Strengths**<br>• Highly-skilled engineering professionals are educated, which are very flexible or adaptable | **Weaknesses**<br>• Little medium TRL (3–6) research/development infrastructure, slowing down development. |
| **Opportunities**<br>• Setting up pilots in order to speed up development, as the rest is mostly available | **Threats**<br>• The loss of engineers due to brain drain migration or competitiveness due to PPP pilots lacking |

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

Slovenia does not have a strategy for the purpose of fostering bioeconomy, however there are regulations, developmental goals and priorities that are encompassed in the nation strategy called the Slovenian Smart Specialization Strategy (S4). It directs the use of funds in the context of Operational Programme for the execution of the European cohesion policy for the 2014-2020 period. The S4 also applies to other funds and instruments of the developmental policy. An important document is "Transition signpost towards a green economy (2018)"[68] (Slo. "Kažipoti prehoda v zeleno gospodarstvo (2018)"), which is more recent and up to date. It deals with bioeconomy as an integral part of the circular economy; another noteworthy program is the Rural Development Program. [68]

There are several other frameworks that serve as a general support for bioeconomy in Slovenia, and they include both funding from the EU, as well as from the Ministries. [69]

### 8.1.1 Slovenian Smart Specialization Strategy (S4) (2015)

This strategy focuses on the concentrating of the developmental investments in the field of research and development, innovation, industrial policy and other recognized high-priority fields, with sustainability being the common denominator.

Bioeconomy is not explicitly stated and mentioned in the Slovenian Smart Specialization Strategy, but the Strategy refers to it implicitly on multiple high-priority fields (shaded fields; see Table 8.1.1 below). [69]

*Table 8.1: High-priority fields of the Slovenian Smart Specialization Strategy (S4, 2015)*

| **Healthy living and working environment** | **Natural and traditional resources for the future** | **Industry 4.0** |
|---|---|---|
| • Smart cities and communities<br>• Smart buildings and forest-wood chain homes | • Network for the transition to circular economy<br>• Sustainable food production<br>• Sustainable tourism | • Factories of the future<br>• Health – medicine<br>• Mobility<br>• Development of materials as products |

The Strategic development and innovation partnerships (Slo. "Strateška razvojno-inovacijska partnerstva") or SRIP have been formed based on the S4 Strategy. They pertain to all nine of the high-priority fields of S4 and their purpose is to foster the cooperation of stakeholders from the economy, knowledge institutions, NGOs and politics, in order to coordinate and direct the investments into strengthening competences and abilities, forming development initiatives and entering into international value chains – in other words, forming clusters. SRIP have formed Action Plans, that are the product of the cooperation between stakeholders about the directives, goals and investments in the respective fields.

The only SRIP partnership that explicitly includes the field of bioeconomy in its Action Plan is the »Networks for transition into circular economy« - where the field of bioeconomy is not defined in the broader sense (as is the case in the EU's Bioeconomy Development Strategy), but in a more technical sense (»bio-based economy«). SRIP »Networks for transition into circular economy« has defined three goal fields of technology:

1) technologies for biomass processing and development of new bio materials;
2) technologies for the use of secondary raw materials and the reuse of waste,
3) energy retrieval from alternative sources.

The order of importance of these goals for the development of bioeconomy is in that order. Two main goal indicators were defined: improvement of the material efficiency of the economy and new value chains with closed material loops. [68]

The S4 strategy included 656 million euro per year of private and public development investments for the three-year period 2016-2018. Aside from these financial incentives, there are also tax reliefs; companies creating profit are entitled to a tax relief equal to 100 % of the value of their R&D investments – this way the companies have an edge with their R&D activities, while reducing their tax base by the value of the cost of the R&D investment[40].

### 8.1.2 Transition signpost towards a green economy (2018)

This document is the result of raising awareness and thorough consultations on recognising the opportunities Slovenia has to transition into a circular economy. It summarises the strategic directives and connections between certain measures, namely the Action Plans of SRIP (see above). The priority areas of measures are: sustainable resource management, green growth of the economy, green goods and services, green budget reform, sustainable urban development, green public sector, training and green practices in agriculture.
Agriculture and forest-wood chain are two main areas of focus of this document. It is mentioned that main points for farming are a gap in biological waste treatment, an opportunity in stimulating self-sufficiency and replacing fossil fuels with biomass; for the forest-wood chain the main messages are that there is a good technological knowledge of the companies in the field, good data support (the Slovenian Forestry Institute), and many opportunities, from the furniture industry, green public contracts, to nanotechnology. [68]
Currently, at the time of writing, the Resolution "Our food, countryside and natural resources after 2021" is in the process of being passed. This resolution is about the national program on the strategic directives of the development of the Slovenian agriculture and food industry. [70]

### 8.1.3 Rural Development Program (2014-2020)

The Rural Development Program (RDP) has several priority areas that address the issue of bioeconomy; it mentions the potential of using biogas and biomass as a renewable source, but it also warns about the danger of excessive energetic exploitation of the forest. Forest wood is defined as a product that is often used inappropriately and in a way that yields too little added value and as a carbon sink. It states that investments in the production of biogas from biological waste from agriculture is justified.
Alongside the conventional use of agricultural and forest biomass, RDP addresses only the last step in the cascade use of biomass, that is energy production. In the future it would be wise to expand the activities in order to bring on effects that come with a more ambitious cascade biomass use. [68]

### 8.1.4 General support framework

*Research and Innovation Strategy of Slovenia (2011 -2020)*

- the main prerogative in implementing reforms is due to the fact that Slovenia has recognised that the world will face shortages of natural resources such as energy, food and water, and major threats associated with climate change. These challenges call for critical reflection and investigation of the causes of this situation, and require above all a change of lifestyle and changes in our socio-economic behaviour.

*Slovenian Industry Policy (2014-2020)*

- emphasises the challenges of creating food, human health and battling ageing. Priority technological fields are considered to be biotechnology and other related technologies. agro-industry and sustainable food production is considered to be one of key industrial sectors when dealing with these issues.

*Sustainable urban strategies of municipalities,*

- focused on rethinking agri-food production in small and medium-sized towns.

*The government framework program for the transition to a green economy (www.vlada/zeleno.si)*

- emphasizes green economy as Slovenian long-term strategic direction and an opportunity for the development of new green technologies, create green jobs, more efficient management of natural resources, promotion and development of Slovenian knowledge. [69]

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

## 8.2 Summary and conclusions in relation to SWOT elements

Bioeconomy is not the central topic of any specific Slovenian framework or policy. There are, however, several national and EU frameworks that touch on the topic of bioeconomy: Slovenian Smart Specialization Strategy (S4) (it focuses on sustainability and fosters SRIP partnerships amongst various stakeholders from the entire value chain), Transition signpost towards a green economy (emphasises the opportunities Slovenia has to transition into a circular economy, mostly pertaining to agriculture and forest-wood chains) and the Rural Development Program (mentions the conventional use of agricultural and forest biomass, as well as energy production). There are also some far more general support frameworks for bioeconomy: Research and Innovation Strategy of Slovenia, Slovenian Industry Policy, Sustainable urban strategies of municipalities and the Government framework program for the transition to a green economy.

Following table 8.2.1 summarises SWOT elements of Bioeconomy Policy Framework of Slovenia.

*Table 8.2: SWOT analysis of Bioeconomy Policy Framework of Slovenia*

| | |
|---|---|
| **Strengths**<br>• The measures that are present are specific in the field of bioeconomy<br>• Simply mentioning bioeconomy in policies of agriculture etc. is progress, because it shows the understanding that these sectors play a role in Slovenia's transition into a circular economy<br>• There is a growing awareness that structural changes in policies are need for the development of bioeconomy | **Weaknesses**<br>• No explicit legislative bioeconomy support and stimulation, only measures that contribute to bioeconomy development<br>• Most measures rely on voluntary pledges from the private sector<br>• Limited resources for possible measure implementation<br>• A lack of a circular agricultural policy<br>• A lack of financial incentive/ subsidies to foster bioeconomy development |
| **Opportunities**<br>• Future policies should focus on clusters: pairing innovation centres with industry and state<br>• Policies for improved biomass managing, increase in the use of forest wood and stimulation of the use of recognized certificates<br>• Removing administrative issues, e.g. via voucher schemes (proposed in Poly4EmI, 2014) | **Threats**<br>• No new and bioeconomy-specific policies and legislation (status quo)<br>• Ignoring of the raising awareness of the need for structural change in policy<br>• Continuous relying on voluntary pledges from companies |

# 9 Financing

## 9.1 Introduction

Pro-business climate in Slovenia manifests as a growing recognition of the importance of FDI (Foreign direct investment in Slovenia) as a source of fixed capital formation to economic growth and performance. This was translated into the government commitment to actively encourage inward investment by streamlining the investment promotion agencies and offering special investment incentives. Under the cost-sharing schemes designed to attract serious investors, funding is available to investors whose projects will build on Slovenia's key selling points: well-developed infrastructure and supporting industries, and clusters of specialised suppliers.
The overall supply chain costs are low in Slovenia thanks to its strategic geographical position at the heart of the market with 500 million customers without any customs and duties, equally convenient to serve east and south-east Europe, as well as Asia.
A database of sectors and companies to target, leasehold and freehold locations to develop, was created by SPIRIT InvestSlovenia, so that potential investors are able to find answers or receive an in-depth customised response to their questions on investing in Slovenia. [71]
Slovenia has international agreements with many other states on tax exemption and preventing double taxation of income and assets of non-nationals. They can apply for this exemption in order to reduce the payment of the tax on income that comes from Slovenia. [72]

Slovenia has a great potential for fostering bioeconomy, mainly because of the high potential for exploitation of solid biomass, namely forest wood. According to the Slovenian Forestry Institute, the potential of wood biomass in Slovenia is around 450.000 tonnes of forest wood per year. [56]
For that reason, there are several policies and general support framework that provide Ministry funding, although not enough to fully realise this potential. Apart from Ministry funding, there is also EU funding for fostering bioeconomy development, including ESIF and H2020.
Ministry funding is provided from policies and strategies, mentioned above under the title General Support Framework; these are the Research and Innovation Strategy of Slovenia (2011-2020), the Slovenian Industry Policy (2014-2020), Sustainable Urban Strategies for Municipalities, the Government Framework Program for the Transition to a Green Economy and SRIP. The latter, also describes above, means that the Ministry of Economy and the Ministry of Labour disburse funds for cluster formation under the domain of S4. These SRIP funds amount to 25 million euro for the program period.
ESIF, which is EU funding, provides resources for research and innovation and it relates to the Slovenian Smart Specialisation Strategy (S4). For the Thematic Objective no. 1 (TO1), which is titled Research, Development and Innovation, over 210 million euro is allocated for the financial period, however no allocations for particular S4 domains have been reserved as the disbursement of funds relates to tendering procedures. There are three domains of S4 that relate to bioeconomy: 2.1 Circular Economy; 3.1 SI Industry; 4.0 Factories of the Future. In the TRL3-6 call (Ministry of Science) it was assured that one project per S4 domain would be funded, but the same is not true for TRL6-9 (Ministry of Economy); for this segment there is no such provision and projects are selected regardless of the S4 domain. [69]
For the domain 2.1 Circular economy, a cluster exists called SRIP Circular Economy. It has 60 members spanning across six focus areas, including Biomass and Alternative Raw Materials. [36]

The Rural Development Program is a crucial source of investment support in the field of use of agricultural biomass. In the field of mobilising forest-wood biomass this support comes from the Program of the Action Plan for enhancing Competitiveness of the Forest-wood chain in Slovenia by 2020. In the field of energy efficiency and renewable energy development, the main authority or source of funding is Ekosklad (Eng. "Eco-fund"). [68]

In terms of funding of the stages of development, there are some evident gaps; Getting innovations up to TRL 4 and providing a laboratory proof of concept generally does not present a major difficulty, however getting them from TRL 4 to TRL 6 is often a financial obstacle. Industrial proof of concept testing is needed for this step, and this is a costly procedure, which can in some cases deter industrial partners.
Another gap is getting innovations from TRL 6 to TRL 9, i.e. to the market. This is also an expensive step, as it requires resources for marketing and launching the product.

A different obstacle, which can also hinder product development is that sometimes the most innovative and novel technologies have the most difficulty in finding financing for industrial proof of concept and on.
A possible solution to bridge these gaps is fostering cluster formation. Pairing innovation centres with the right industry partners can benefit both parties and speed up the process in a safe and reliable way. [69]

## 9.2 Summary and conclusions in relation to SWOT elements

Slovenia has a great potential for fostering bioeconomy, but the realization of this potential ultimately depends on the financing. Slovenian government has started offering special investment incentives: cost-sharing schemes designed to attract serious investors, as well as promoting the well-developed infrastructure and supporting industries, and clusters of specialised suppliers.
Ministry funding is provided from policies and strategies, whereas EU funding provides resources for research and innovation.
Throughout the stage of development, there are some gaps in available funding, i.e. financing for getting products from TRL 4 to 6 and from TRL 6 to the market.

Table 9.2.1 summarises SWOT elements of Financing of bioeconomy of Slovenia:

*Table 9.1: SWOT analysis of Bioeconomy Financing of Slovenia*

| **Strengths** | **Weaknesses** |
|---|---|
| • Educated labour force, language skills and willingness to learn<br>• Areas of excellence in academia and industrial research<br>• Streamlined investment promotion and incentives<br>• Increase in demand for bio-based products in export-oriented companies (e.g. automotive industry) | • Finding funds for the transition from TRL 4 to TRL 6<br>• Finding funds for the transition from TRL 6 to market<br>• Small scope of international projects, platforms, networks that are based in specific measure<br>• Weak investment activity in processing activities in the direction of transitioning to bio-based alternatives<br>• 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<br>• Better use of available EU funding in the field of bioeconomy<br>• Promoting cluster formation<br>• Regional resource connecting (RDI, production, logistics) | • Stagnant or reduced Government funding and use of EU funds<br>• Possible risky nature of investment<br>• A lack of agencies providing equity and loans for bio-based initiatives |

# References


1. Studies on the TEN-T Core Network Corridors and Support of the European Coordinators: BALTIC-ADRIATIC CORRIDOR - Final Study Report, https://ec.europa.eu/transport/sites/transport/files/bac_corridor_study.pdf; Accesed on November 9, 2019
2. Poročilo o stanju na trgu lesnih proizvodov v Sloveniji. http://wcm.gozdis.si/strokovni-prispevki/porocilo-o-stanju-na-trgu-lesnih-proizvodov-v-sloveniji; Accessed on November 9, 2019.
3. SiStat - SURS, https://pxweb.stat.si/SiStatDb/pxweb/en/30_Okolje/; Accessed on November 10, 2019
4. EC: Statistical Factsheet - Slovenia (June 2019).
5. Republic of Slovenia Statistical Office. Stat'O'Book. Statistical Overview of Slovenia 2018, https://www.stat.si/StatWeb/File/DocSysFile/10179/STATOBOOK_2018.pdf; Accessed on November 1, 2019
6. S2BIOM - Benchmarking Factsheets. https://s2biom.wenr.wur.nl/web/guest/data-downloads; Accessed on November 13, 2019.
7. Eurostat - Agriculture. https://ec.europa.eu/eurostat/web/agriculture/data/database; Accessed on November 13, 2019.
8. Zrakić M, Hadelan L, Prišenk J, Levak V, Grgić I. Tendencije proizvodnje kukuruza u svijetu, Hrvatskoj i Sloveniji. *Glas zaštite bilja*. 2017. doi:10.31727/gzb.40.6.9
9. SURS: Number of trees and gross area by training systems and fruit varieties, Slovenia, 2017. https://pxweb.stat.si/SiStatDb/pxweb/en/30_Okolje/30_Okolje__15_kmetijstvo_ribistvo__04_rastlinska_pridelava__04_15P65_popis_sadovnjakov_2012/15P6510S.px/; Accessed on November 12, 2019.
10. Poročilo o stanju kmetijstva, živilistva, gozdarstva in ribištva - Agricultural institute of Slovenia. https://www.kis.si/Porocila_o_stanju_v_kmetijstvu_OEK/; Accessed on November 15, 2019
11. S2BIOM - D1.6 A spatial data base on sustainable biomass cost supply of lignocellulosic biomass in Europe - methods & data sources. https://www.s2biom.eu/en/publications-reports/s2biom.html; Accessed on November 14, 2019.
12. S2BIOM - Task 9.3.2: Strategic case study Assessment of biomass production potential from short rotation crops (SRC) on unused agricultural land for use in biomass power plants in Croatia. https://s2biom.wenr.wur.nl/doc/S2biom---T932---SCS-Croatia---report.pdf; Accessed on November 13, 2019.
13. Strategija izkoriščanja biomase iz kmetijstva in gozdarstva ("Agriculture and forestry biomass exploitation Strategy"). 2011;http://arhiv2014.skupnostobcin.si/fileadmin/sos/datoteke/pdf/Barbara/PREDLOGI_PREDPISOV/Kmetijstvo/Strategija_biomasa_priloga.pdf; Accessed on November 16, 2019
14. Scarlat N, Dallemand J-F, Fahl F. Biogas: Developments and perspectives in Europe. *Renew Energy*. 2018;129:457–472.
15. Food processing industry in Slovenia in 2017. https://www.nasasuperhrana.si/wp-content/uploads/2018/09/brosura-zpi_ENG_v2.1.pdf; Accessed on November 14, 2019.
16. S2BIOM - Tools for Biomass Chains. https://s2biom.wenr.wur.nl/web/guest/biomass-cost#_48_INSTANCE_bNEOGMUfuY37_%3Dhttps%253A%252F%252Fs2biom.wenr.wur.nl%252Fbiomasscostsupplyviewer%252Findex.html%253Fmode%253Dcost%2526; Accessed on November 14, 2019.
17. Slovenia forest service. http://www.zgs.si/eng/slovenian_forests/forests_in_slovenia/forestation_and_variety_of_forests/index.html; Accessed on November 6, 2019
18. Wood flows. http://wcm.gozdis.si/en/wood-flows-and-prices; Accessed on November6, 2019
19. Zavod za gozdove Slovenije. Poročilo Zavoda za Gozdove Slovenije o gozdovih za leto 2018. http://www.zgs.si/fileadmin/zgs/main/img/PDF/LETNA_POROCILA/2018_Porocilo_o_gozdovih.pdf; Accessed on November 6.
20. Roundwood export and import, Slovenia 2017. https://www.stat.si/StatWeb/gl/News/Index/7660; Accessed on November 6, 2019
21. Trg gozdnih lesnih sortimentov v Sloveniji v 2018. http://wcm.gozdis.si/strokovni-prispevki/trg-gozdnih-lesnih-sortimentov-v-sloveniji-v-2018; Accessed on October 23, 2019
22. Infrastructure for waste management, Slovenia, 2016. https://www.stat.si/Statweb/En/News/Index/7501; Accessed on November 8, 2019
23. Waste, Sloveina, 2018. https://www.stat.si/StatWeb/en/News/Index/8419, accessed on November 8, 2019
24. SiStat. https://pxweb.stat.si/SiStat; Accessed on November 13, 2019
25. From recycling to zero waste: how Ljubljana rethought its rubbish. https://www.theguardian.com/cities/2019/may/23/zero-recycling-to-zero-waste-how-ljubljana-rethought-its-rubbish; Accessed on November 7, 2019.
26. Upgraded waste management facilities for central Slovenia. https://ec.europa.eu/regional_policy/en/projects/slovenia/upgraded-waste-management-facilities-for-central-slovenia; Accsed on November 13, 2019
27. Aquafil Slovenia. https://www.aquafil.com/where-we-are/slovenia/; Accessed on November 13, 2019.
28. BBI: Project EFFECTIVE. https://www.bbi-europe.eu/projects/effective; Accessed on November, 2019.
29. Helios Slovenia. https://www.helios-group.eu/; Accesed on November 13, 2019.
30. Tanin Sevnica. http://www.tanin.si/; Accessed on November 13, 2019.

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


31. Tanin Sevnica - bio-based. http://www.tanin.si/2_biobased; Accessed on November 13, 2019.
32. Grozd Plasttehnika Slovenia. http://giz-grozd-plasttehnika.si/index.php/en/; Accessed on November 13, 2019.
33. SRIP HRANA. https://www.gzs.si/srip-hrana/vsebina/english; Accessed on November 13, 2019.
34. SiDG. https://www.sidg.si/index.php/o-sidg/poslanstvo/about-sidg; Accessed on November 13, 2019.
35. BSW Slovenia. https://www.bsw.co.uk/locations/slovenia; Accessed on November 13, 2019.
36. SRIP Circular Economy. https://srip-circular-economy.eu/; Accessed October 10, 2019
37. CELL.CYCLE. https://celkrog.si/?lang=en; Accessed on November 13, 2019.
38. AGRIMAX. https://www.bbi-europe.eu/projects/agrimax; Accessed on November 13, 2019.
39. SUSFERT. https://www.bbi-europe.eu/projects/susfert; Accessed on November 13, 2019.
40. Slovenska Strategija Pametne Specializacije (S4). 2017.
41. National Institute of Chemistry. https://www.ki.si/en/; Accessed on November 13, 2019.
42. Pulp and Paper Institute. http://icp-lj.si/?lang=en; Accessed on November 13, 2019.
43. Kiriazids T, Kiriazidis T. Maritime transport. In: *European Transport: Problems and Policies*. ; 2018:76-89. doi:10.4324/9780429447693-5
44. Annual report of Luka Koper Group. https://www.luka-kp.si/eng/annual-reports, Accessed on October 7, 2019. Published 2018.
45. ECORYS. Study on Strategic Evaluation on Transport Investment Priorities under Structural and Cohesion funds for the Programming Period 2007-2013: Country Report Slovenia. 2006.
46. Poslovne cone in subjekti inovatinvnega okolja. http://178.238.236.24/cone/client/; Accessed on November 14, 2019
47. Rail transport. https://www.gov.si/en/policies/transport-and-energy/rail-transport/; Accessed on October 3, 2019.
48. Railway transport, Slovenia, 2017. https://www.stat.si/StatWeb/en/News/Index/7523, Accessed on October 7, 2019.
49. Železniška infrastruktura. https://www.gov.si/teme/zelezniska-infrastruktura/, Accessed on October 7, 2019.
50. Building the second track - a new railway line from Divača to Koper. http://www.drugitir.si/en; Accessed on October 3, 2019.
51. Prometna lega in prometne povezave. https://eucbeniki.sio.si/geo9/2629/index4.html; Accessed on October 13, 2019
52. Road transport. https://www.gov.si/en/policies/transport-and-energy/road-transport/; Accessed on October 6, 2019.
53. Cestna infrastruktura. https://www.gov.si/teme/cestna-infrastruktura/; Accessed on October 6, 2019.
54. Road goods transport, Slovenia, 2018. https://www.stat.si/StatWeb/pr/News/Index/8074; Accessed on October 7, 2019.
55. Energy industry sector. https://www.gov.si/en/policies/transport-and-energy/energy-industry-sector/; Accessed on October 7, 2019.
56. Anteja EGG d.o.o. *Country Report Slovenia, DanuBioValNet, Interreg*. http://www.interreg-danube.eu/approved-projects/danubiovalnet/outputs?page=3; Accessed on October 6, 2019
57. Heating and cooling in Slovenia. https://www.coolheating.eu/en/slovenia.html; Accessed on October 7, 2019.
58. Faculty of Chemistry and Chemical Engineering, University of Maribor. https://www.fkkt.um.si/en; Accessed on November 13, 2019.
59. Pulp and Paper Institute - infrastructure. http://icp-lj.si/institut/infrastructure/?lang=en; Accessed on November 13, 2019.
60. KET4CP. https://www.ket4sme.eu/; Accessed on November 13, 2019.
61. Faculty of Chemistry and Chemical Engineering - separations. https://www.fkkt.um.si/en/node/542; Accessed on November 13, 2019.
62. InnoRenew CoE. https://innorenew.eu/; Accessed on November 13, 2019.
63. Slovenian Forestry Institute. http://en.gozdis.si/home/; Accessed on November 13, 2019.
64. Competence Centres for Human Resources Development. http://www.sklad-kadri.si/en/human-resources-development/competence-centers-for-human-resources-development/; Accessed on November 13, 2019.
65. BioEnergyTrain. http://www.bioenergytrain.eu/; Accessed on November 13, 2019.
66. EIT Climate-KIC Accelerator. https://www.climate-kic.org/programmes/entrepreneurship/accelerator/; Accessed on November 13, 2019.
67. ABC Accelerator. https://abc-accelerator.com/; Accessed on November 13, 2019.
68. Lovec M, Juvancic L, Mesl M. Družbeni kontekst prehoda v biogospodarstvo / Social context of the transition into bioeconomy. BRIDGE2BIO.
69. Brkanovic S. Case Study Report [Slovenia]. Mapping the EU Member States' / regions' Research and Innovation plans & Strategies for Smart Specialisation (RIS3) on Bioeconomy.
70. SPIRIT - Invest Slovenia. https://www.investslovenia.org/; Accessed on October 10, 2019.
71. International Taxation - Tax Exemptions. https://www.fu.gov.si/en/taxes_and_other_duties/areas_of_work/international_taxation/; accessed on the 10th of October.
72. Hoepffner N, Garcia-Conando S. Biomass production, supply, uses and flows in the European Union. *EU Publ*. 2018.
73. Biomass production, supply, uses and flows in the European Union. https://publications.europa.eu/en/publication-detail/-/publication/358c6d4b-1783-11e8-9253-01aa75ed71a1/language-en/format-PDF/source-search; Accessed on November 13, 2019

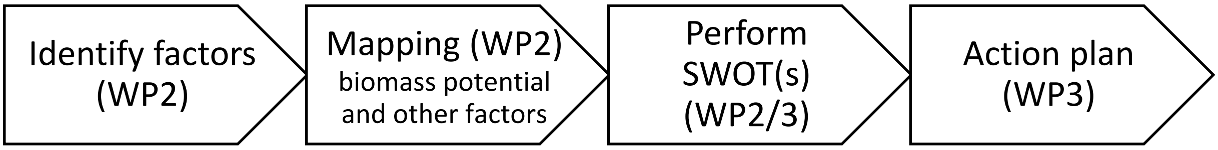
This project received funding from the BBI JU under the EU Horizon 2020 research and innovation programme under grant agreement No.838087

# 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

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

# 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

To consult and download biomass cost-supply data from the S2BIOM toolbox see: https://s2biom.wenr.wur.nl/web/guest/biomass-supply#_48_INSTANCE_nYA0VqOhoRGM_%3Dhttps%253A%252F%252Fs2biom.wenr.wur.nl%252Fbiomasscostsupplyviewer%252Findex.html%253Fclassic%2526

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:

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

*Table A.1: Overview of agricultural residual biomass potential types and considerations*

| | 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 A.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 | Mobili-sation |
|---|---|---|---|---|---|
| **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.<br>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.<br><br>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:<br>Site productivity<br>-Soil and water protection: ruggedness, soil depth, soil surface texture, soil compaction risk<br>-Biodiversity (protected forest areas)<br>-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:<br>-Site productivity<br>-Soil and water protection: ruggedness, soil depth, soil surface texture, soil compaction risk<br>-Biodiversity (protected forest areas)<br>-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 | None |

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

| | | | | | |
|---|---|---|---|---|---|
| | | | | Roundwood) in period 2010-2014) subtracted from UP4. | |
| **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 <u>excl. for pulp and paper and board industry</u> (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 A.3: Overview of potentials calculated for biowaste and wood waste*

| |
|---|
| **<u>Technical potential</u>**<br>The Technical potential represents the amount of biomass assuming only technical constraints and a minimum of constraints by competing uses.<br>In case of biowaste no constraints are considered in the technical potential.<br>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. |
| **<u>Base potential</u>**<br>This is the sustainable technical potential, considering currently agreed sustainability standards.<br>In case of biowaste the base potential equals the technical potential.<br>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. |
| **<u>User defined potential</u>**<br>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.<br>In case of biowaste no user-defined potentials have been developed.<br>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. |

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

## 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'). 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 Table A.4.

*Table A.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 | In wheat processing 20% to 25% wheat offals (Kent et al., 1994). Wheat bran represents roughly 50% of wheat offals and about 10 to | None |

| | | | |
|---|---|---|---|
| | cereals per EU country | 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. | |

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.

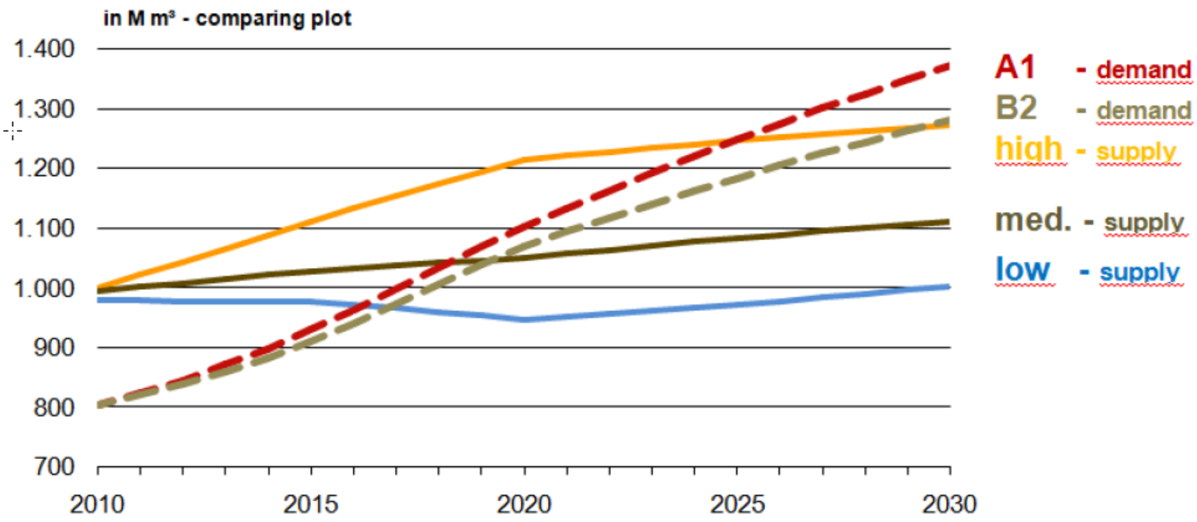
To come to a regional distribution of the cereal bran potentials in every S2BIOM country 2 assumptions were made:

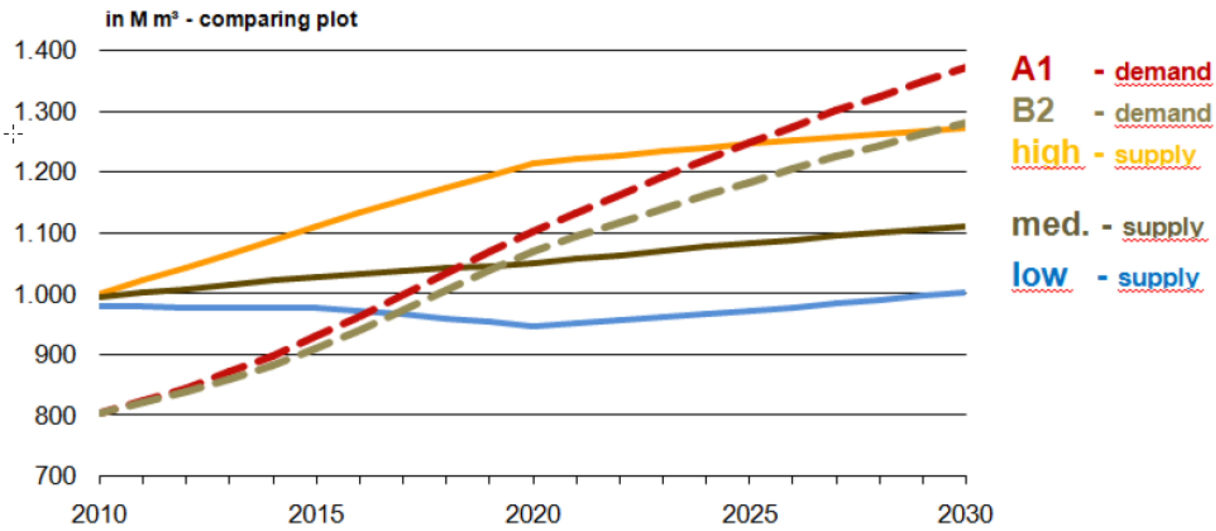
1) The bran based on the net domestic production (=domestic production – exports) is distributed regionally according to cereal production area share.
2) The cereal bran based on processing of imported biomass is distributed over largest (port) cities per country as it is expected that processing industries 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.

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

## 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 Figures A.1 and A.2).




*Figures A.1and A.2: Future development of demand and supply as projected by the EU-Wood project for different scenarios (Mantau, 2010). Source EUWood 2010*

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

*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 A.3 and A.4).*

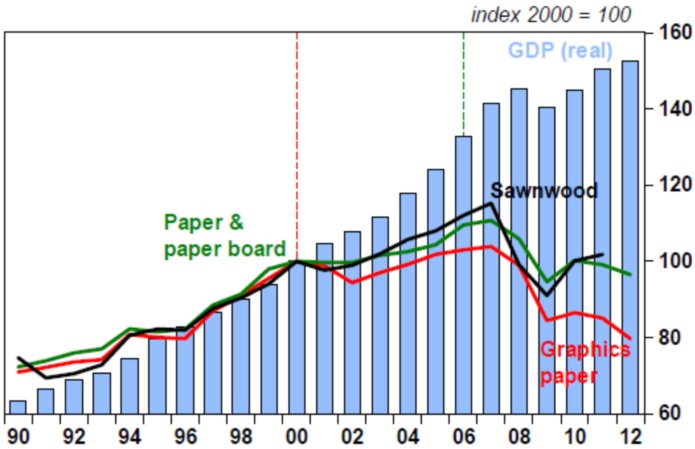



**Figure 2.1.2.** EU GDP (real) and forest products consumption index over the period 1990-2012 (2000 = 100). (Forest products data from FAO; GDP data from IMF, Gross domestic product based on purchasing-power-parity (PPP) valuation of country GDP).

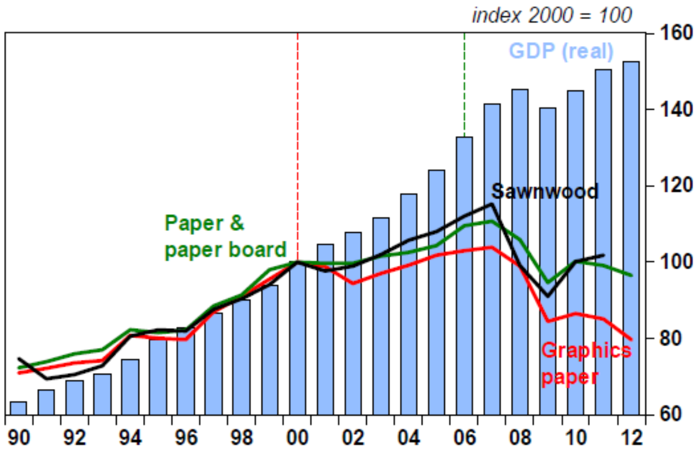



**Figure 2.1.2.** EU GDP (real) and forest products consumption index over the period 1990-2012 (2000 = 100). (Forest products data from FAO; GDP data from IMF, Gross domestic product based on purchasing-power-parity (PPP) valuation of country GDP).

*Figure A.3 and A.4: EU GDP and forest products consumption index*[1]

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 A.5 and A.6 show for sawn wood and panels that the S2BIOM data for 2012 are close to EFSOS II reference scenario projections 2010.

[1] 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?

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

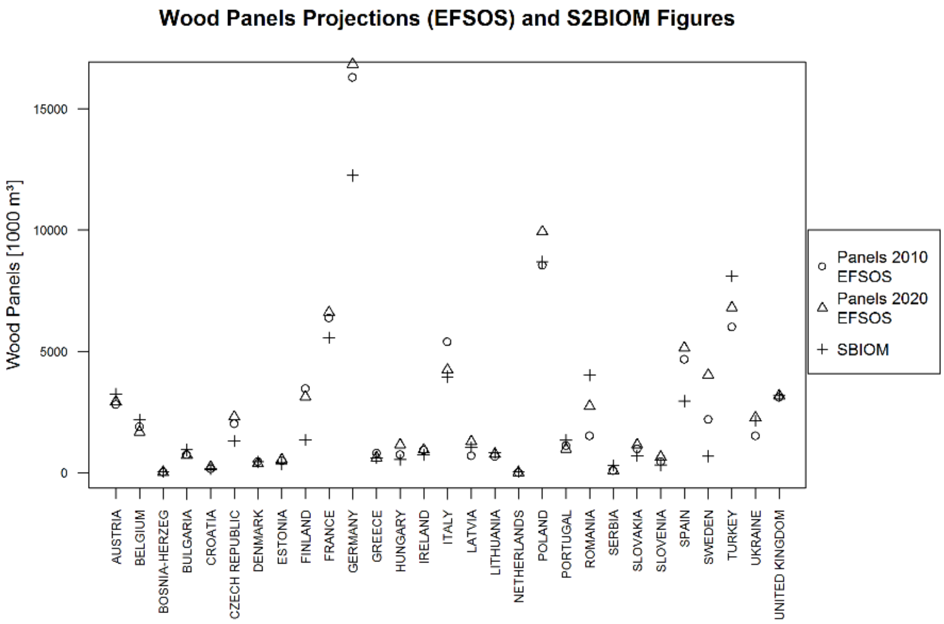



*Figure A.5: Wood panel production, EFSOS 2 reference scenario projections, and S2BIOM 2012 estimates*

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.

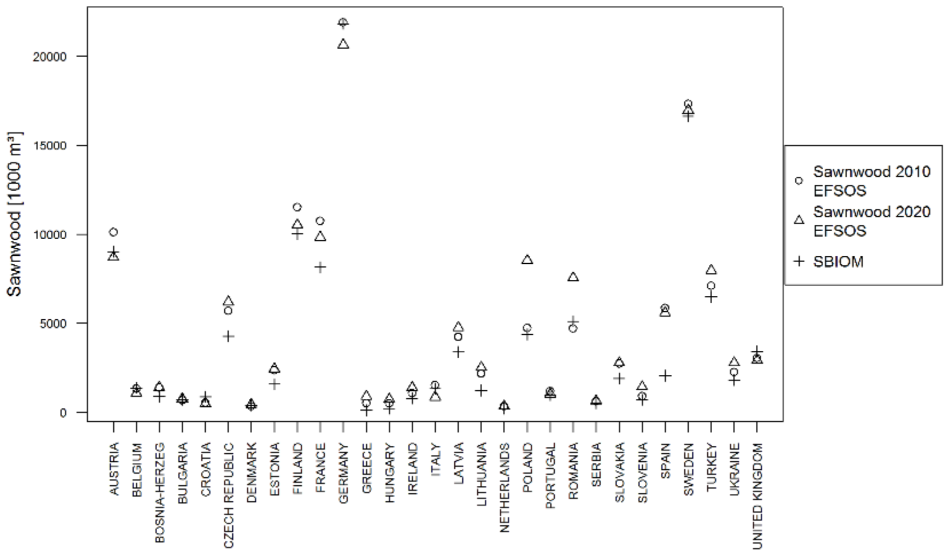
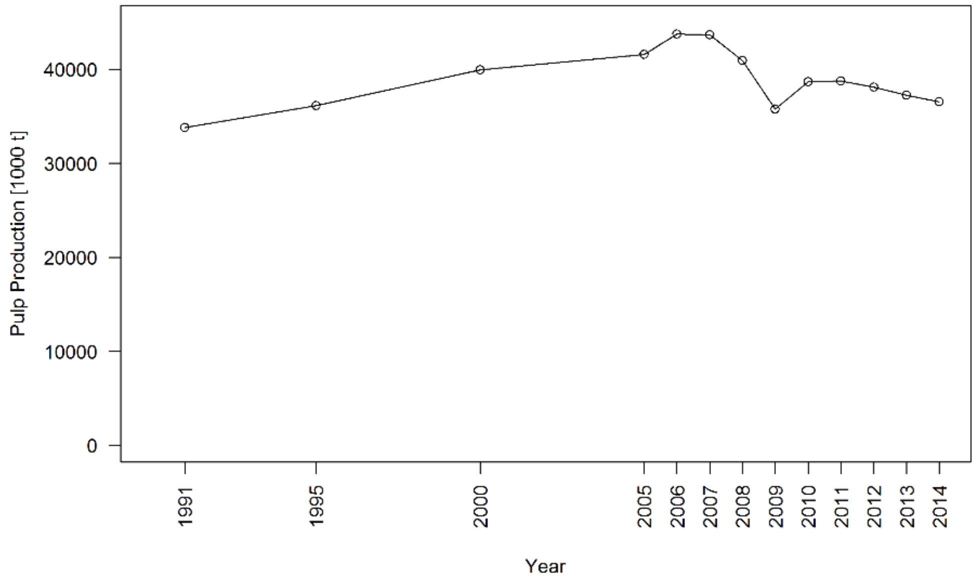



*Figure A.6: Sawnwood production, EFSOS 2 reference scenario projections and S2BIOM 2012 estimates*

The visualisation of the figures from the "Historic Statistics" report of CEPI on pulp and paper production are shown in Figure A.7. 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.




*FigureA.7: Development of Pulp production, CEPI data*

The approach used is summarised by category in Table A.5.

*Table A.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 |

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

## 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:

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

$$PCW_{\text{base potential}} = PCW_{\text{energy}} + PCW_{\text{disposed}}$$

in which:

$PCW_{\text{recovered}}$ = PCW used for materials like panels and chipboards
$PCW_{\text{energy}}$ = PCW used for energy production
$PCW_{\text{disposed}}$ = 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[2]). 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[3], 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.

[2] 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
[3] 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.

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

## 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.

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.

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

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

Σ NPv = sum of NPVs

n = number of years

i = the interest rate (set to 4%)

The cost also allows for national differentiation of cost according to main inputs having national specific prices levels. The is 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 bio-based 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

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

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 Figure A.8.

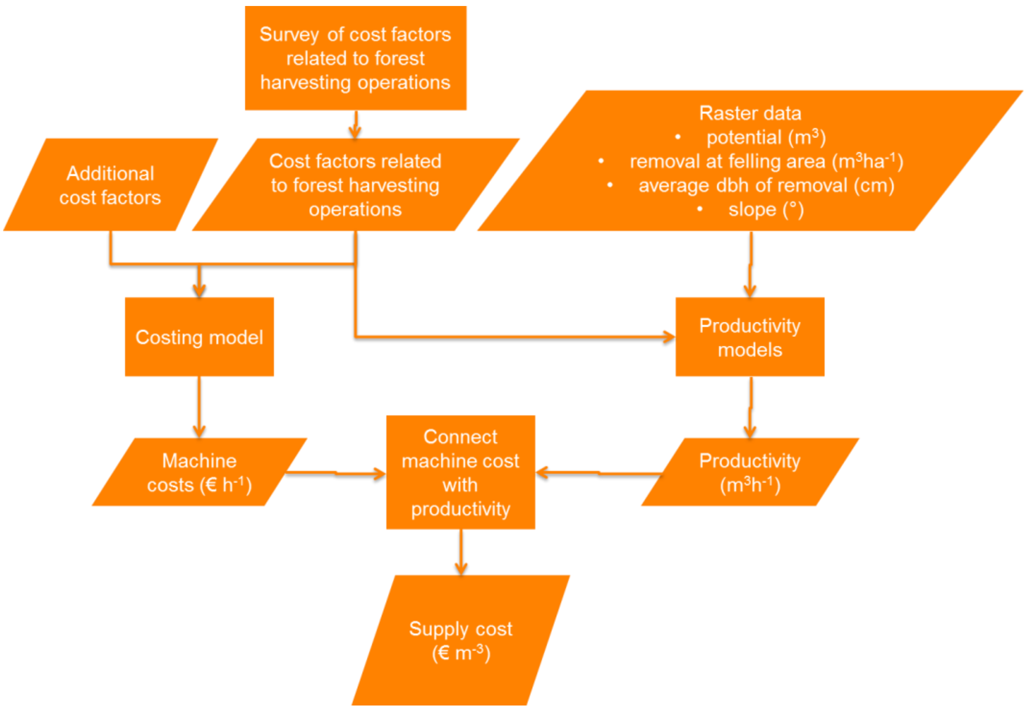



Figure A.8 General work flow of the forest biomass cost calculations

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

**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.