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

CELEBio

# D.2.1

# Country report: Czech Republic

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| **Publishable executive summary in English** | This country report for the Czech Republic is focused on providing an overall assessment of the current state of the bioeconomy. It is not intended to be an exhaustive look at all aspects of the bioeconomy within the country, but rather the aim is to view these activities in the context of a value chain necessary to bring available biomass to an economic end-user, with the recognition that a systemic approach must be considered. Beyond the assessment of mobilizable biomass, this report examines the local context from their policy, financial and educational aspects, with the backdrop of social and environmental sustainability. The chapters conclude with a SWOT analysis to provide a condensed summary to help guide potential business partners, and also to steer the direction for implementation of a national action plan. |
| **Publishable executive summary in national language** | Tato zpráva o České republice poskytuje celkové vyhodnocení současného stavu českého biohospodářství. Cílem zprávy není podat vyčerpávající shrnutí všech aspektů národního biohospodářství, nýbrž nahlédnout na tyto aktivity v kontextu hodnotového řetězce, který je nezbytný pro zpřístupnění dostupné biomasy koncovému hospodářskému uživateli s uznáním nutnosti využití systémového přístupu. Vedle vyhodnocení mobilizovatelné biomasy zkoumá tato zpráva místní kontext a jeho politické, finanční a vzdělávací aspekty na pozadí společenské a environmentální udržitelnosti. Kapitoly uzavírá SWOT analýza poskytující stručné shrnutí obsahu, jež pomáhá potenciálním obchodním partnerům v orientaci a řídí směr realizace národního akčního plánu. |

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# SUMMARY

This review of the bioeconomy of Czech Republic attempts to examine the available biomass, its current uses, potential gaps in various value chains and status of current bioeconomy.

Czech Republic has a well-developed agriculture industry, with adequate road and rail networks. To make a transition toward more efficient use of biomass, a new mind-set toward long-term environmental and social sustainability will be needed in addition to the current emphasis on economic prosperity. One particular characteristic of the country is its very large farm sizes, which support expansive industrial scale agricultural practices, resulting higher short-term yield of crops at the expense of long-term poor land management. Although, a new law will bring in an era of small farm plots to promote greater diversity in crop selection. The potential availability of agricultural biomass is quite substantial, particularly wheat straw. The low market penetration of organic products, should be seen as an opportunity, as greater customer demand is realize.

Forested land is approximately equally divided in management under the public sector and in private holdings, and major portions of the under-utilized biomass remains in the forestry sector. Two key challenges for the forests are ground water depletion and the infestation of the bark beetle, which will need a concerted effort across the various ministries in government to mitigate these threats. Nevertheless, opportunities exist in the development of new forms of uses for wood biomass, other than for heating and energy sources, such as construction, furniture, and innovative packaging materials.

Czech Republic being a relatively industrialized country has inherent regional strengths in engineering. The machining and digital technology industries are advanced and should be harnessed as a platform for the development of new technologies to facilitate the transition to a green economy. The development of new tools to make farming, forestry and waste management practices more efficient would accelerate the bioeconomy both locally and in other countries.

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# 1 INTRODUCTION

## 1.1 OBJECTIVES AND APPROACH

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

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

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)[1] and was further refined through the execution of interviews with bio-based business developers and other experts. In these interviews, further information was obtained on key factors that guide the choice of setting up bio-based activities in countries. Most of the experts stressed that all the identified factors are important and that a systems 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 to refine the approach.

## 1.2 READING GUIDE

This report is organised in 9 chapters. In chapter 1 (section 1.3) a first description is given of the key characteristics of the country of Czech Republic.

In the chapters 2, 3, and 4 the biomass production including their current uses and opportunities for what biomass can be additionally mobilised, is summarized for respectively the agricultural, forest, and waste sectors. 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

[1] Setting up international biobased commodity trade chains: a guide and 5 examples in Ukraine. Dam, J.E.G. van; Elbersen, W.; Ree, R. van; Wubben, E.F.M. Wageningen : Wageningen UR - Food & Biobased Research (Report / Wageningen UR Food & Biobased Research 1477) - ISBN 9789461739926

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industries and/or used for domestic markets and exports. Subsequently an overview is given of additional biomass potentials that are likely to still be 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.

In Chapter 6 the infrastructure, logistics, and energy sector are described.

Chapter 7 focusses on the innovation potential, particularly in the context of bio-based research and development options. The research and educational infrastructure is described and the potential for developing bio-based start-ups and Public-Private-partnerships will be discussed.

Chapter 8 focusses on the policy framework and describes extensively what regulations, legislation, taxes and tariffs exist of relevance for the development of bio-based production chains. Attention will also be paid to situations where regulation and support measures are actually missing and to which extend the rule of law situation influences the establishment of new bio-based activities.

In Chapter 9 potential financing options related to the development of bio-based production chains are discussed.

## 1.3 Short characterisation of country

Czech Republic is a medium sized country in the EU, according to land surface, with 10.6 million inhabitants (See Table 1). The average income level is just below the average of the EU. The export value expressed in €/capita is still relatively low.

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

| Category | Czech Republic | EU | Unit |
|---|---|---|---|
| **Population** | 10.6 | 512.4 | million (2018) |
| **Area (total)** | 8 | 447 | million ha (2018) |
| **% population in urban areas** | 25.0 | 44.9 | % of total population (2018) |
| **% territory predominantly rural** | 36.8 | 43.8 | % of total territory (2018) |
| **% territory predominantly urban** | 14.5 | 10.7 | % of total territory (2018) |
| **Agricultural Area** | 3.5 | 173.3 | million ha (2016) |
| **Forest area** | 2.67 | 164.8 | million ha (2016) |
| **Population density** | 135 | 115 | n°/km² (2018) |
| **Agricultural Area per capita** | 0.33 | 0.34 | ha/capita(2016) |
| **Forest area per capita** | 0.27 | 0.32 | ha/capita(2016) |
| **GDP/capita** | 19397 | 30 956 | at current prices in 2018 |
| | 27483 | 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*

Czech Republic is land-locked between Germany and Poland in the North, and Austria and Slovakia in the South (see

Figure 1). Czech Republic has a relatively high agricultural area, comprising 3.5 of the 8 million ha total area. Forest area is also nearly 3 million ha. Forests are located mostly closer to the borders of the country, while most of central and southeast Czech Republic is agricultural land. A relatively high percentage of area is rural, and nearly one quarter of the population reside there. Roadways make the two major cities of Prague and Brno very accessible from most parts of the country. Close to 40% of the population live in rural areas, which is similar to the European average. The GDP by purchasing power is similar to the European average, however lower than the average in Euros at current prices. GVA by agriculture, forestry and fishing is higher than the European average.

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

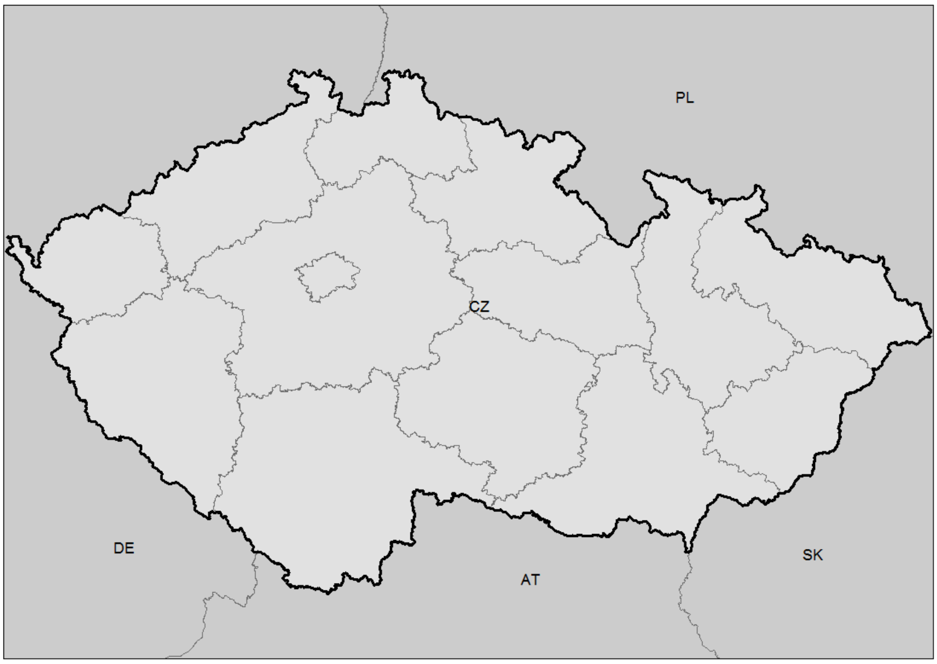


Figure 1 Czech Republic (CZ) and it's bordering countries: Poland (PL), Slovakia (SK), Austria (AT) and Germany (DE)

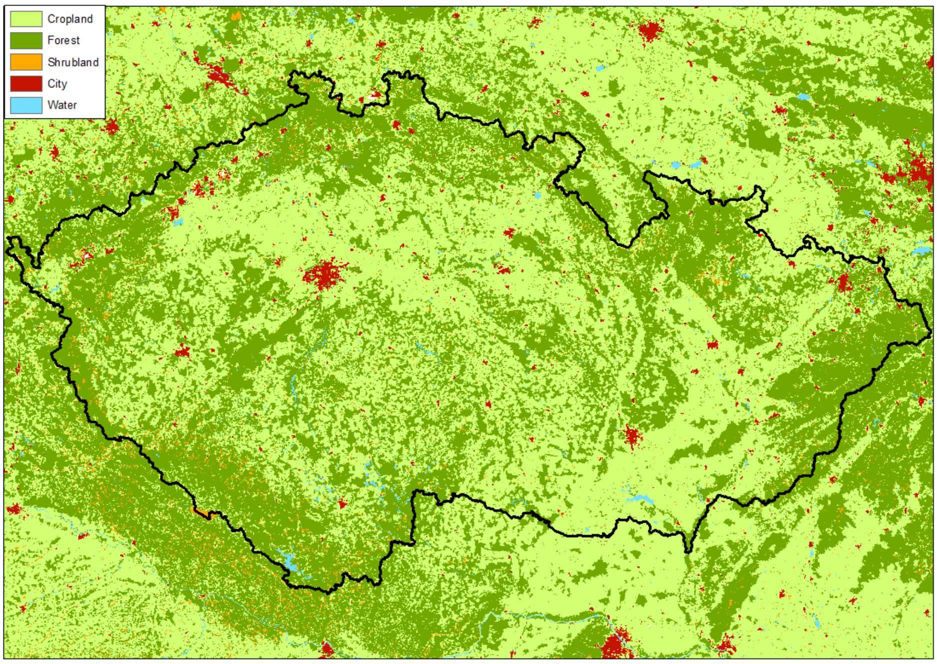


Figure 2 Main land cover distribution over Czech Republic

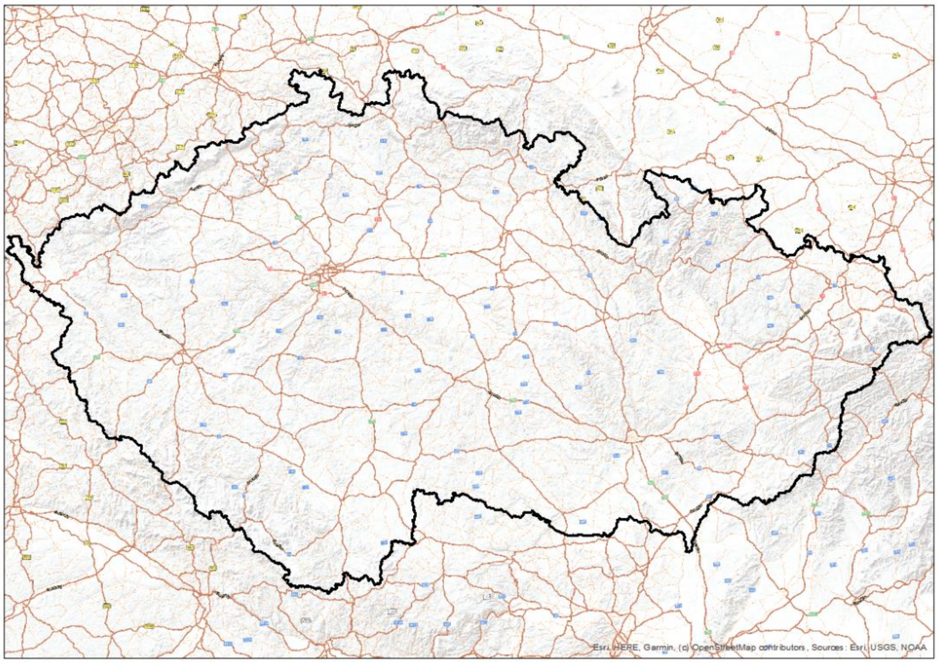


Figure 3 Major Roadways in Czech Republic

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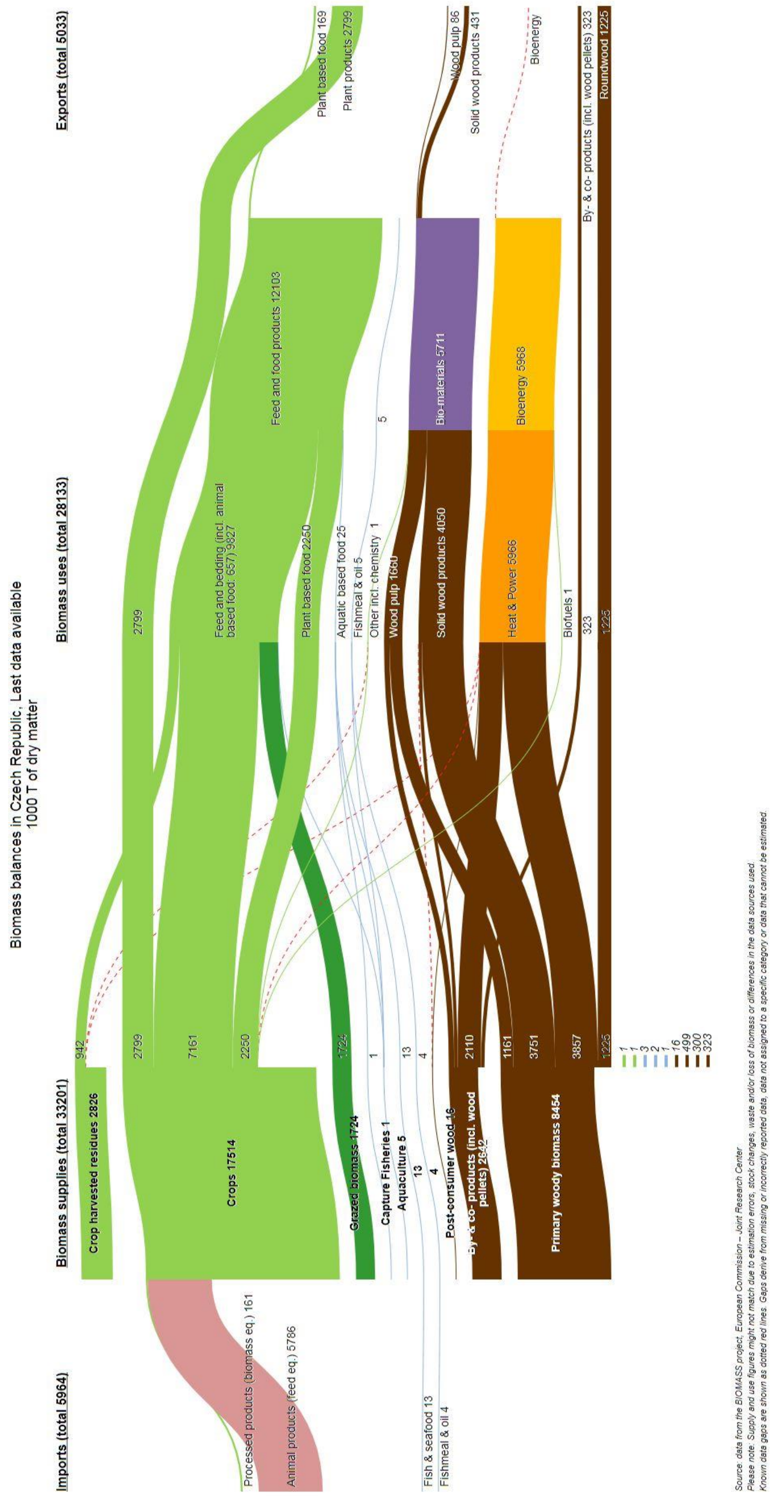


Figure 4 Biomass flows in Czech Republic (top) and EU-28 (bottom) JRC Sankey diagrams of biomass flows[3]

[3] Gurría Albusac, Patricia; Ronzon, Tévécia; Tamošiūnas, Saulius; López Lozano, Raul; García Condado, Sara; Guillén Garcia, Jordi; Cazzaniga, Noemi; Jonsson, Klas Henrik Ragnar; Banja, Manjola; Fiore, Gianluca; Camia, Andrea; M'barek, Robert (2017):

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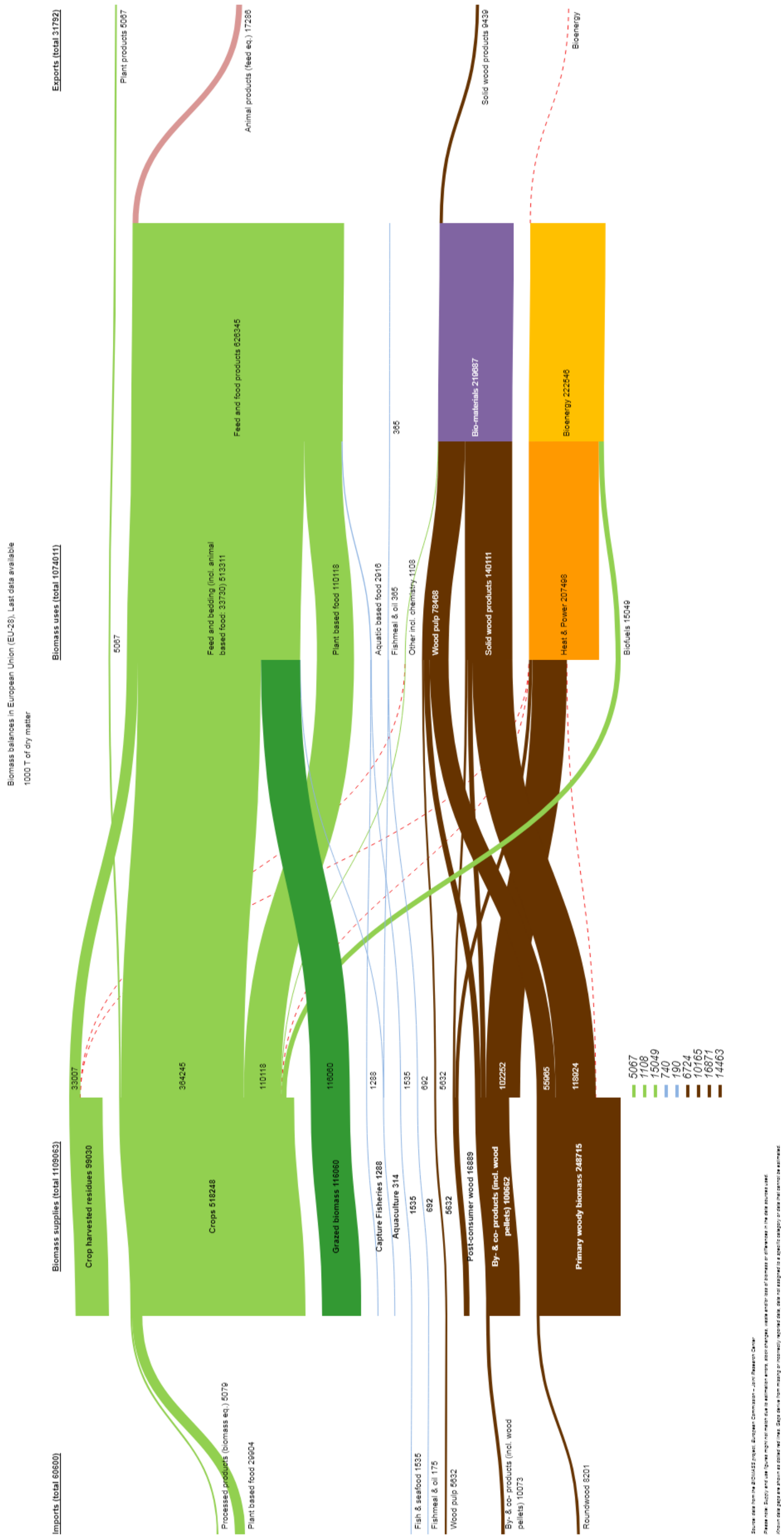


Biomass uses and flows. European Commission, Joint Research Centre (JRC) [Dataset] PID: http://data.europa.eu/89h/34178536-7fd1-4d5e-b0d4-116be8e4b124

Explanation of Sankey diagram

The Sankey biomass diagram is split into biomass supply (shown on the left of the diagram) and biomass uses (right portion of the diagram). Each of these areas shows different categories: agriculture, forestry and fishery (supply), as well as feed and food, biomaterials, bioenergy, and direct exports for each sector (uses). All supply and uses of biomass have been converted to Ktons 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

Figure 5 Explanation of Sankey diagram

From the Sankey diagram for Czech Republic (Figure 4) the following main observations can be made. The main biomass supply produced in Czech Republic is from crops (17.5 Mton d.m.) and primary woody biomass from forests (8.5 Mton d.m.). Most of the cropped and grazed biomass is used for food and feed production (12.1Mton d.m.), and the woody biomass is mainly used for heating and power (5.67 Mton d.m.) and biomaterials (5.7 Mton d.m.). A small amount of the woody biomass is exported as wood pulp and solid wood products (0.5 Mton d.m.). Some of the crops are exported as plant based food or plant products (2.8 Mton d.m.).

Imports consist mostly in volume of animal products (5.79 Mton). The Sankey diagram also shows that the cropped harvested residues are quite significant (2.83 Mton d.m.), but much less than half is used as feed or bedding while for the other part it is not clear what it is being used for. This however is similarly the case for the whole EU Sankey diagram.

The production of biomaterials and bioenergy is much smaller then food, feed and plant products and practically all based on woody biomass supply, according to Figure 4.

# 2 BIOMASS SUPPLY: AGRICULTURE

## 2.1 INTRODUCTION

In this chapter the agricultural biomass production and its main uses is described. A distinction will be made between the main economic products produced and their main process chains and residual biomass potentials from primary production and availability as by-products of the food processing industries. The residual biomass sources, certainly the ones from primary sources are indeed abundant, however, external events such as changing climatic conditions and droughts make it difficult to predict the mobilizing potential. In addition to presenting the main biomass production, attention is also paid to the importance and the structure of the agricultural sector and to the main environmental challenges associated with agriculture in Czech Republic. Barriers to the sustainable mobilization will also be discussed together with potential ways of overcoming these barriers.

## 2.2 CHARACTERISATION OF CURRENT AGRICULTURAL SECTOR

The agricultural sector in Czech Republic is generally quite comparable to the European average. The proportion of agricultural employment in 2017 was the same (3.9%), and the agricultural area per capita is similar to the European average (see Table 2). The crop (59%) and livestock (41%) outputs are also similar to the European average.

In terms of soil nutrient balance however, the nitrogen is much higher than in Europe (98 compared to 51 kg of nutrient per ha of agricultural land). The most striking difference compared to Europe is the average farm size (130 ha/holding) compared to the 16.6 ha on average in Europe. Not surprisingly the percentage of holdings under 5 ha is low (18.7% compared to 62.6% in Europe).

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Table 2 Key characteristics[4] for the agricultural sector in Czech Republic

| Category | Czech Republic | EU Average | Unit |
|---|---|---|---|
| Agriculture in % of total employment | 3.9% | 3.9% | % of total employment 2017 |
| Agricultural area per capita | 0.33 | 0.34 | ha/capita |
| Cereal yield | 9.3 | 5.2 | t/ha |
| Crop output in total output | 59% | 56% | % of total agricultural output value (2018) |
| Livestock output in total output | 41% | 44% | % of total agricultural output value (2018) |
| Agricultural income (2010=100) | 142 | 121 | Index 2010=100 (2018) |
| Livestock density | 0.51 | 1.02 | LSU/ha UAA |
| High input farms | 28% | 29% | %/ total farms 2016 |
| Low input farms | 28% | 39% | %/ total farms 2016 |
| Gross nutrient balance nitrogen | 98 | 51 | kg of nutrient per ha (average 2011- 2015) |
| Gross nutrient balance phosphorus | -2 | 1 | kg of nutrient per ha (average 2011- 2015) |
| Irrigated utilised agricultural area | 0.7% | n.a. | % of UAA 2016 |
| HNV farmland | 21% | 32% | % of agricultural land |
| Soil erosion | - | 2.4 | tonnes/ha/yr 2012 |
| Average farm size | 130.2 | 16.6 | ha UAA/holding (2016) |
| % of agr. holdings < 5 ha | 18.7% | 62.6% | %/total no. of holdings |

HNV= High Nature Value

A long-term problem of agricultural landscape are large land blocks which were created in the 2nd half of the 20th century as a result of intensification of agriculture and the growth of a single crop over wide areas, through the programmes of collectivization under the managed economy era. Such farming has led to soil degradation, compaction, erosion, loss of nutrients, loss of organic matter

[4] Source S2BIOM, Benchmarking factsheets (https://s2biom.wenr.wur.nl/web/guest/data-downloads) updated with https://ec.europa.eu/agriculture/statistics/factsheets_en) and additional Eurostat data (https://ec.europa.eu/eurostat/web/agriculture/data/database)

and accumulation of harmful substances (from agricultural and industrial activities).[5] The fact that the average land block size is so high has many implications for the Czech agriculture. While in some respect this characteristic can be beneficial from a short-term economic point of view (e.g. easy accessibility with heavy machinery, easy application of fertilizers), long-term over intensification leads to erosion, compaction of the soil and to other negative effects. This can result in lower yields over time. Rapidly worsening characteristics of the soil were indeed reported by the Research Institute for Soil and Water Conservation, an organisation established under the Ministry of Agriculture.[6] Similarly, Czech Globe, an environmental think tank which initiated a project 'Intersucho' on detailed droughts monitoring[7], reports more than 60% of arable land being hit by exceptional or extreme droughts since 2015. These droughts affected the yield of the farmers as well as their willingness to provide biomass. This low willingness of the farmers is also confirmed by the questionnaires in the chapter 2.3.1. The quality of the soil is also negatively affected by erosion. On heavily eroded soils, the yields drop by up to 75% and land prices are reduced by up to 50%. Soil in the climatic conditions of the Czech Republic is threatened primarily by water and wind erosion. Suggested within the summary on agroforestry, is the utilization of waste biomass from wood for production of fortified fertilizers (elaborated in Section 3.5).

Water erosion is a threat to soil as it removes soil particles from the upper (most fertile) parts of soil (topsoil) and deposits them in other locations, i.e. causes soil loss. The reduced thickness of the soil profile and disturbed soil structure significantly reduce the soil's ability to retain water. Water erosion in the Czech Republic threatens in the long-term the areas with the most valuable, high-quality soil (the Elbe basin and the Morava valley), where the largest share of soil are at an extreme risk (potential loss of soil particles at 10.1 tonnes/ha/year, and more; Figure 6) is located. In 2017, a long-term potential soil loss (G) threatened 56.7% of the agricultural land, in 17.8% it was an extreme threat.

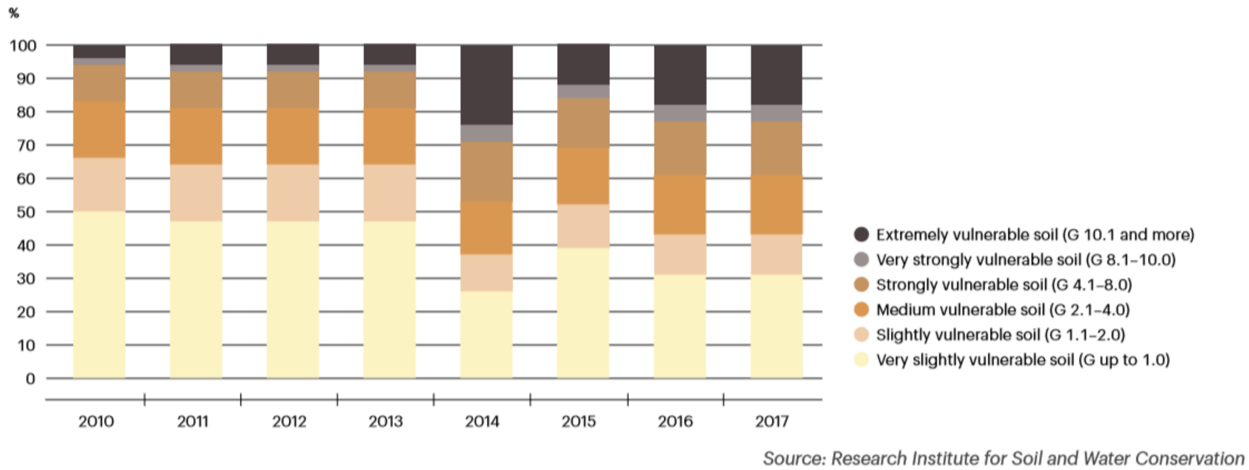


Figure 6 Development of potential vulnerability of farmland to water erosion in the Czech Republic, expressed as a long-term soil loss [%], 2010–2017[8]

5 See https://www.mzp.cz/C125750E003B698B/en/state_of_the_environment_reports_documents/$FILE/OPZPUR-Report_CZ_Environment_2017-20190116.pdf
6 See http://eagri.cz/public/web/file/611976/SVZ_Puda_11_2018.pdf (only in Czech)
7 See https://www.intersucho.cz/en/?from=2020-01-03&to=2020-01-31&current=2020-01-26
8 The jump in the area of extremely vulnerable land in 2014 is due to a change in the methodology of calculating the potential vulnerability of farmland to water erosion in the Czech Republic. See, https://issar.cenia.cz/

The Ministry of Agriculture is partially reacting to the large block sizes, through a new measure. From 2020 onwards, cultivation of single crop monocultures are limited to only 30 ha in order to diversify agricultural landscapes. Intensive debate is also being held between the government and the individual farmers on the eligibility and degree of compensation for droughts and other external events. Many subsiding schemes for water retention and for enhancing the soil quality (e.g. crop rotation) exist, however, they seem to be ill-effective considering the reports on droughts and lowering soil quality. Finally, it should be noted that more than 70% of the Czech soil is rented, leading to a limited responsibility of the tenant for the soil quality. This makes it difficult to incentivize the farmers to protect the soil and increase sustainability standards.

Since 2000, an upward trend has been noticeable in consumption of industrial fertilizers with fluctuations in the individual years. While in the years 2011–2014 this development stagnated, in 2015 there was again a significant increase in consumption, mainly due to prolonged drought and lack of nutrients in the soil.

Overall, a bioeconomy strategy is currently missing, which is an essential starting point for the Czech bioeconomy to evolve in a sustainable direction. As many studies are confirming, local conditions are paramount to providing guidelines to the local farmers and processing plants and a detailed regional scoping of the climatic conditions and soil quality is necessary (Stella et al., 2019)[9]. This strategy should also reflect the RED II guidelines on correct biomass removal (mainly straw) to achieve the advanced biofuels targets[10], as well as dedicated cropping of biomass on unused, abandoned and degraded lands.

### 2.2.1 Crop production

When looking at the production of crops for existing food and feed uses, the Czech Republic production is within an average position at EU levels, with 11.3 Mt dry matter production. The most important crops in Czech Republic are cereals, green harvested crops (maize and other forage crops), sugar and starchy crops and oil crops, e.g. rape. Permanent crops cover a relatively small percentage of the cropping area, particularly in comparison to the majority of EU countries.

[9] Estimating the contribution of crop residues to soil organic carbon conservation. Tommaso Stella, Ioanna Mouratiadou, Thomas Gaiser, Michael Berg-Mohnicke, Evelyn Wallor, Frank Ewert and Claas Nendel. 2019. Environmental Research Letters, 14: 9.

[10] See https://www.efi.int/projects/rediibio-red-ii-sustainability-criteria

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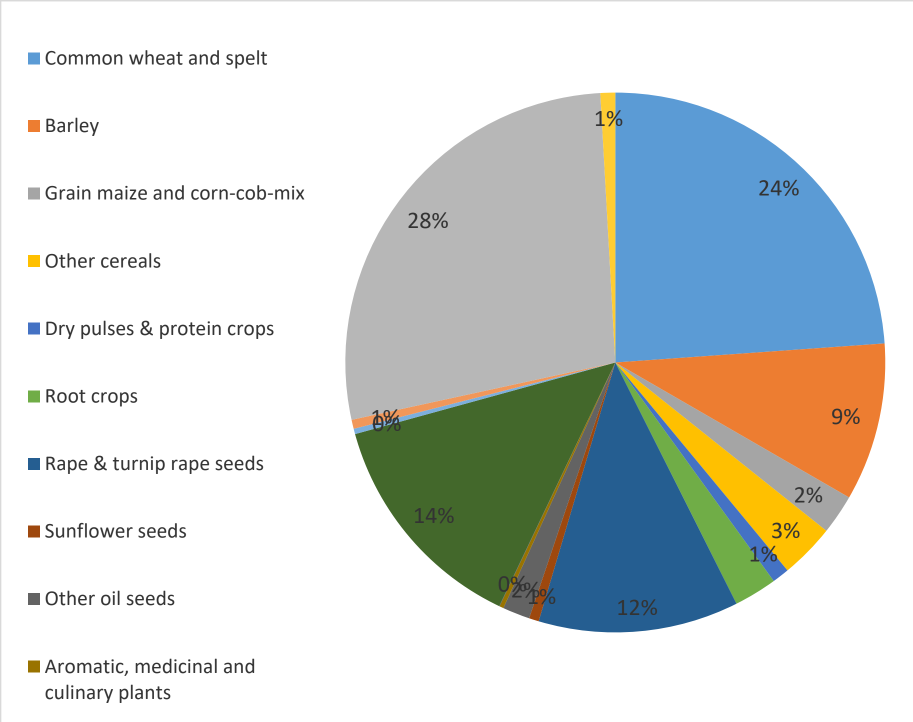


Figure 7 Main crops and land uses in Czech Republic[11]

[11] Source Eurostat, data 2016 (accessed July 2019)

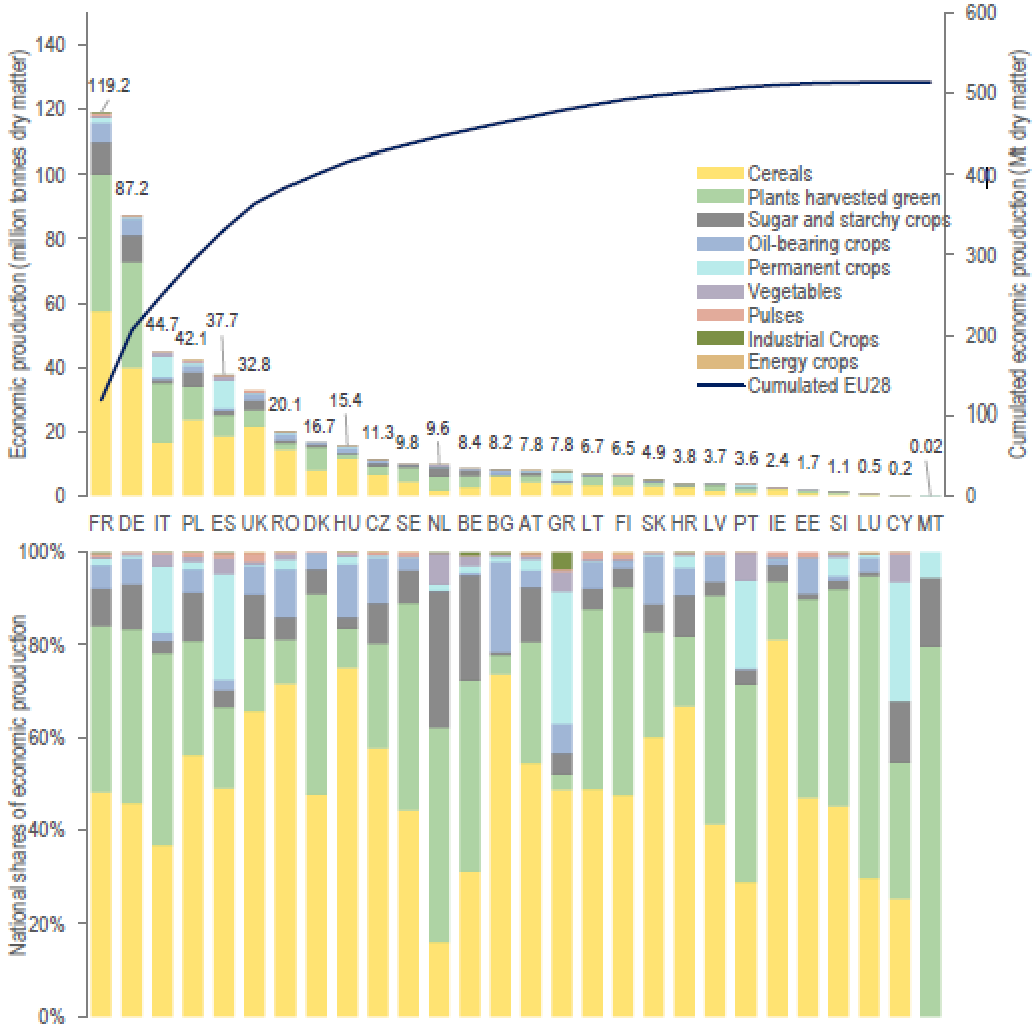


Figure 8 Economic production (top panel) from the main crop groups per member state, expressed in Mton of dry matter per year; and the shares at national level (bottom panel).
Average values over the reference period 2006-2015. Extracted from Camia et al. 2018.

Zednicek et al., 2020[12] identifies the main utilization pathways of biomass using material flow analysis (see Figure 9). The majority of the biomass (approximately 6 Mton of economic and 4 Mton of residual production) is directed towards animal food production where the biomass is used either as feed or as animal bedding. The animal bedding consumption is estimated mainly on the number of livestock and on the stabling practices. Animal feed consumption is based on the animal food production and feed conversion ratios as reported by (Lesschen, Van den Berg, Westhoek, Witzke, & Oenema,

[12] Zednicek, Pavel. (2020). Towards Circular Bioeconomy in the Czech Republic: the identification of sustainable business cases for agricultural residues (Master's thesis, Utrecht University, Utrecht, Netherland). *Manuscript in preparation.*

2011)[13]. Mainly grains are used as a feed. More than 3.5 Mton is used in the plant food production (derived from consumption reported by CSO[14] and from imports and exports).

Currently, less than 1 Mton is used in technical use, i.e. combustion or biofuel production. The biofuel production consumes around 650 Kton of biomass with rapeseed and sugar beet as the main feedstocks. There are two major incineration plants of straw in the Czech Republic, one in Kutná Hora consuming around 70 Kton of straw annually and one in Jindřichův Hradec with similar supply. Next to this, small straw pellet mills are estimated on around 20 Kton annually. Insulation or the production of construction materials out of straw[15] is limited in the Czech Republic, with an estimation of maximum 10 Kton annually. Overall the technical use is thus estimated at maximum 200 Kton of straw.

Fruits and Vegetables are the main imported commodities with 0.74 Mton and 0.65 Mton of biomass resources[16]. Conversely, cereal grains form the majority of the exported biomass (around 2 Mton of dry matter exported). The Czech Republic also has a large network of biogas plants (more than 500; see Chapter 6), with maize as the main feedstock crop (around 1 Mton). Pastures are rather limited source of biomass (less than 1 Mton in dry matter).

Tertiary residues mainly in the form of food waste and human waste are also relevant with an annual production of around 0.8 Mton of food waste[17] and 0.219 Mton of human waste (mainly in the form of sludge).

[13] Greenhouse gas emission profiles of European livestock sectors
Author links open overlay panel. J. P. Lesschen, M. van den Berg, H. J. Westhoek, H. P. Witzke, O.Oenema. Animal Feed Science and Technology. 2011. 166–167, 16-28.
[14] See https://www.czso.cz/csu/czso/food-consumption-2017
[15] See https://www.ekopanely.com/contact/
[16] When not explicitly mentioned the weight is reported in standard humidity and purity
[17] Foodwaste estimates are based on per capita waste production and crosschecked with the amount ratio of organic waste in the municipal waste. See: https://www.europarl.europa.eu/news/en/headlines/society/20170505STO73528/food-waste-the-problem-in-the-eu-in-numbers-infographic

Table 3 Availability of primary crop (economic) and residual biomass. Extracted from Zednicek et al., (2020)

| | *Crop* | *Area* [ha] | *Economic Yield* [t/ha] | *Economic Yield* [Mt] | *Residue Yield* [t/ha] |
|---|---|---|---|---|---|
| Cereals | Wheat | 819690 | 5.4 | 4.43 | 5.9 |
| | Rye | 25355 | 4.74 | 0.12 | 4.7 |
| | Barley | 324724 | 4.95 | 1.61 | 4 |
| | Oat | 42821 | 3.56 | 0.15 | 4.1 |
| | Triticale | 37851 | 4.55 | 0.17 | 5.2 |
| | Grain Maize | 81851 | 5.98 | 0.49 | 8.9 |
| | **Sum** | **1332292** | | **6.97** | |
| Sugar Crops | Potatoes | 22889 | 25.5 | 0.58 | 2.2 |
| | Sugar Beet | 64760 | 57.5 | 3.72 | 5.5 |
| | **Sum** | **87649** | | **4.31** | |
| Oil seeds | Rapeseed | 411802 | 3.43 | 1.41 | 8.6 |
| | **Sum** | **411802** | | **1.41** | |
| Arable Fodder Crops + Grassland | Green & Sillage Maize | 224105 | 29.84 | 6.69 | 0 |
| | Perenial Fodder Crops | 193199 | 5.5 | 1.06 | 0 |
| | Permanent Grassland | 971791 | 2.52 | 2.45 | 0 |
| | Sum | 2300348 | | 10.20 | |

Table 3 provides more detailed information on the individual crop production. It covers the area, economic (primary crop at standard humidity) and residue (secondary biomass as dry mass) yield of the most common agriculture crops which jointly constitute more than 95% of the total gricultural

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production (also see

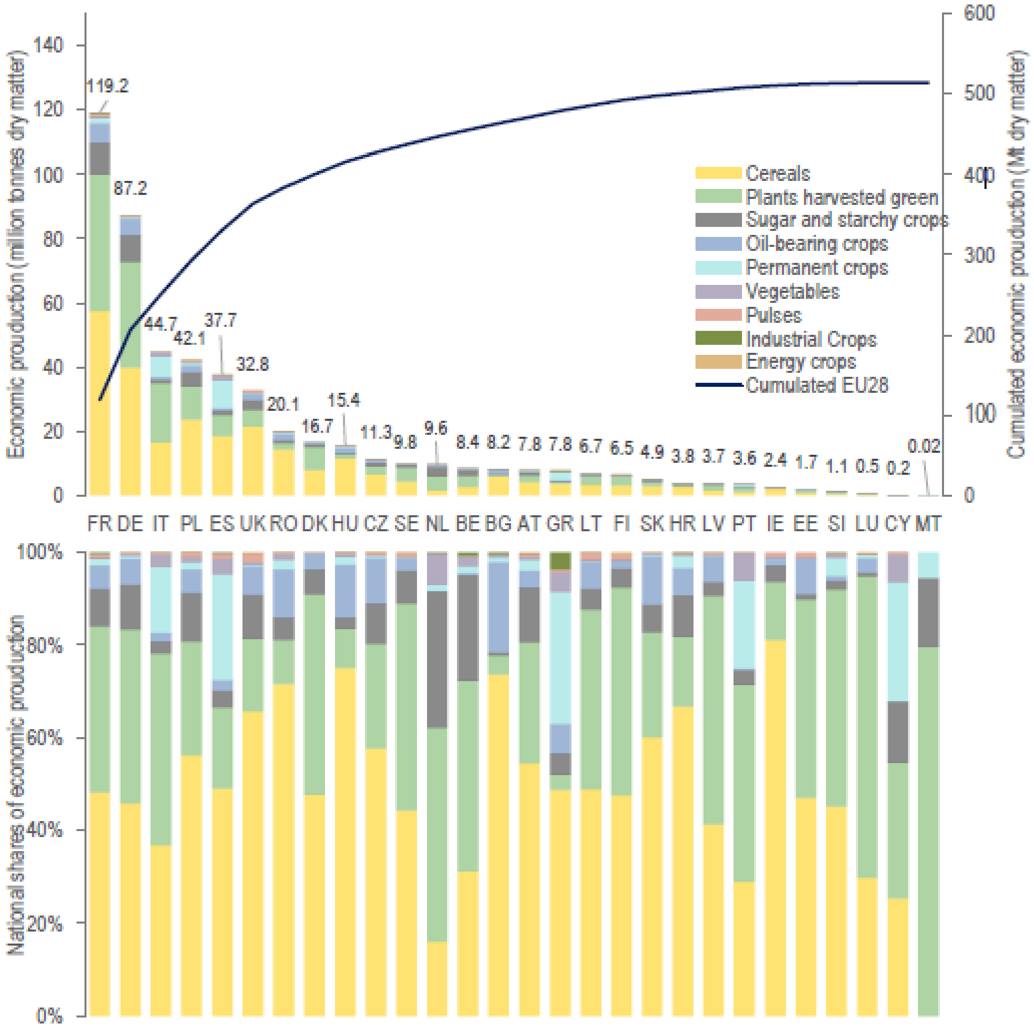


Figure 8).

The specific area of crop production and the respective economic yield are extracted from the Czech Statistics Office (CSO). Residue yields are based on an up-to-date Joint Research Centre (JRC) publication by Garciá-Condado et al., 2019[18] using empirical models which also include inter-annual variability of crop production.

[18] Assessing lignocellulosic biomass production from crop residues in the European Union: Modelling, analysis of the current scenario and drivers of interannual variability. Sara García-Condado Raúl López-Lozano Lorenzo Panarello Iacopo Cerrani Luigi Nisini Antonio Zucchini Marijn Van der Velde Bettina Baruth. 2019. Global Change Biology Bioenergy. 11: 6, 809-831.

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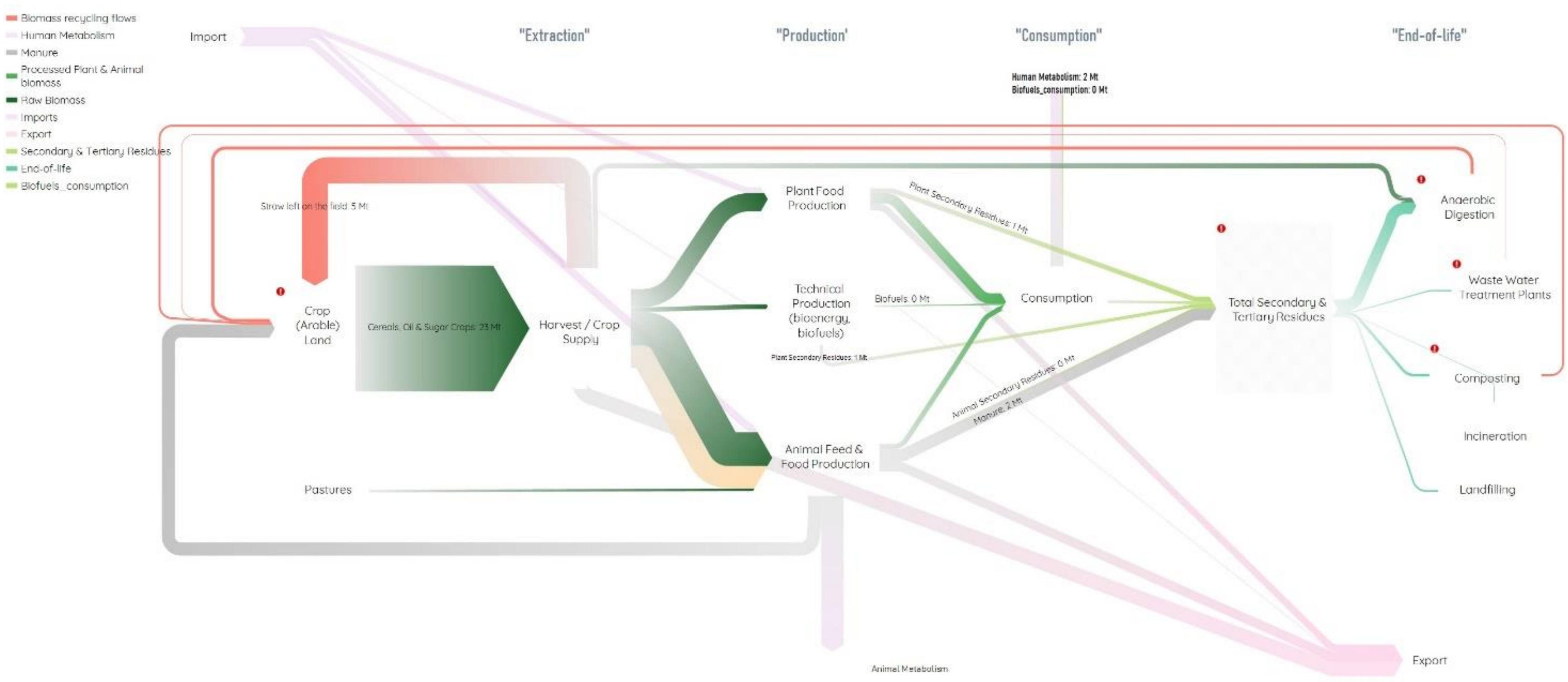



Figure 9 Material Flow Analysis of the main agricultural biomass types (in kton) as reported by Zednicek et al. (2020)

The green arrows shows the flows of raw biomass types (e.g. grains or seeds). The "Total Secondary & Tertiary Residues" symbolizes a node of other-than post-harvest residues. The red arrows shows the biomass returning back to the economy.

### 2.2.1.1 Cereals

Cereals constitute the majority of the agricultural production in the Czech Republic. The total economic yield is 7 Mton and the residue yield 7.36 Mton of dry matter. Average yield of cereals is around 4.8 Mton/ha with maize and wheat as the highest yielding crops. Around 60% of the agricultural land is covered by cereals with wheat and barley as the main crop types. Cereal straw is the most abundant source of residual biomass covering more than 65% of the primary residual production (the rest being oil crops straw) (Camia et al., 2019). Straw is mostly used as animal bedding or as a fertilizer (ploughing back into the field). Based on Zednicek et al. (2020) around 2 Mton of the economic cereal production is exported, and another 2.4 Mton are used as animal feed. Approximately 200 Kton are used in the technical cycles, either in incineration plants or by smaller SME's (e.g. construction materials). Part of the cereal production is used as a feedstock into biogas plants (mainly maize).

### 2.2.1.2 Oil crops

The main oil crop in the Czech Republic is rapeseed. While the consumption of sunflower (mainly as a vegetable oil) is abundant, the majority of it is imported and the sunflower production constitute less than 1% (less than 47 Kton) of the overall agricultural production. Rapeseed is cultivated on around 411 thousand ha and the annual economic production is 1.41 Mton. Due to the large residue production per hectare, rapeseed straw is an abundant primary residue (approximately 3.5 Mton). Based on Zednicek et al., (2020), approximately 500 Kton of oil seeds is manufactured as an edible vegetable oil. More than 600 Kton is directed towards biofuel production and around 300 Kton is exported. During the manufacturing of rapeseed into oil, an estimated 40% efficiency of oil production is derived from the seed, and the resulting 60% forms a secondary residue which is mostly used as a feed, as well as a portion to produce glycerine as a by-product. At present the substantial yield of secondary residues or rapeseed straw remain unclear as to their use, and present a case of mobilizable biomass, if it is commercially accessible.

### 2.2.1.3 Sugar crops

Potatoes and sugar beet are the most common sugar crops. Sugar beet and potatoes are cultivated on 64 thousand ha and on 23 thousand ha, respectively. While the area covered is around 5% of the overall agricultural land in the Czech Republic, due to its high yield (57 tons/ha, 25.5 tons/ha for sugar beet and potatoes, respectively) the harvest is significant. Around 3.72 Mton of sugar beet and 0.6 Mton of potatoes has been harvested in 2019. With approximately 0.41 Mton/year, sugar crops are less relevant in terms of their post-harvest residues production. Sugar beet is mostly used as a feedstock in a sugar processing industry. Imports of sugar beet is rather insignificant (less than 0.1

Mton) and export is mainly in the form of a commodity as a sugar (around 350 Kton). Part of the harvested sugar beet (around 0.6 Mton) is used as a feedstock into the ethanol production.

Potatoes production is around 0.6 Mton and the import is quite significant (approximately 0.2 Mton). Based on the consumption as given by the CSO, the majority of potatoes (0.7 Mton) are directly consumed, with a limited portion being used in the starch industry. The residual production is more significant in the processing industry rather than as a post-harvest residue.

### 2.2.2 Permanent crop production

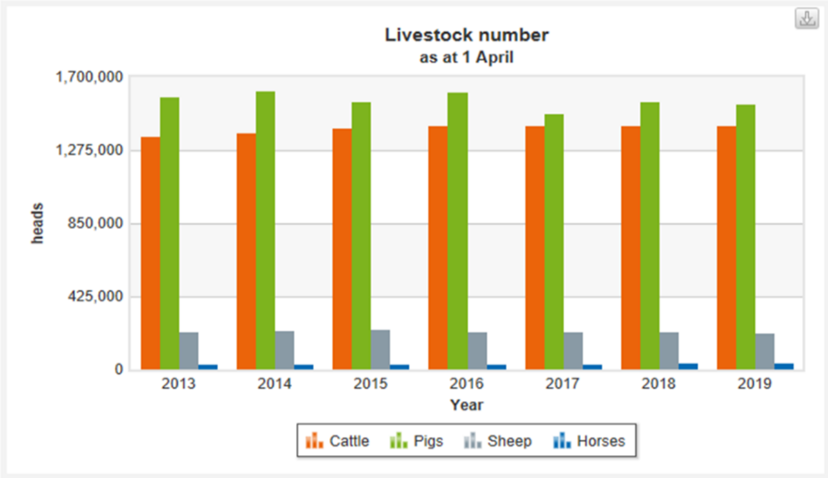
Considering other biomass sources, permanent crops are a slightly less relevant type of biomass in the Czech Republic. The majority of the permanent crop production is covered by grassland which occupy around 970 thousand ha, a significant proportion to the overall agricultural land (more than 10%). The yield per hectare on these areas is 2.52 ton/ha with an overall annual harvest of 2.4 Mton. The majority (more than 80%) of the permanent grasslands are reported as the Less Favourable Area (LFA) according to Land Parcel Identification System (LPIS)[19]. Hop fields and vineyards are additional permanent crops with a coverage of 4.3 and 19.6 thousand ha, respectively. The Czech Republic is the fourth largest producer of hops and this crop has a long tradition together with barley processing for beer production. The vineyards are mainly in the South Moravian region, which is suitable for these purposes due to higher temperatures and drier soil.

### 2.2.3 Livestock production

Livestock production is a significant sector of agriculture with more than 1.5 million pigs and 1.4 million heads of cattle farmed in 2018 (see Figure 10).

The CSO reports the stock of poultry as more than 23 million heads with chickens covering most of the output. Cattle older than 2 years counts for approximately half of the overall cattle production. With respect to the meat production (see Table 4) pork is the most common meat type (288 Kton) followed by poultry (260 Kton) and beef (137 Kton). While for cattle the self-sufficiency is high and even large part is exported, for pigs it is only around 50% and more than 350 ktons of pig meat is imported annually. Milk is a highly relevant commodity in the Czech Republic with more than 3 Mt of milk produced in 2018. Out of this production more than one third is exported.

[19] See http://eagri.cz/public/web/file/214061/publikace_mze_A4_rozvoj_venkova_ENG_FINAL.pdf




Data source: Public database CZSO

Figure 10 Livestock Numbers (2013-2018)

The feed demands are calculated from the feed conversion ratios (FCR) as reported by Lesschen et al., (2011)20. The FCR is expressed as the mass of dry weight feed consumed per mass of product produced. The latter is reported by the CSO and the feed demands can thus be easily estimated. Cattle production which is either connected to beef meat or milk is the most feed intensive sector of animal food production. Around 3.7 Mton and 1.4 Mton of feed was consumed for milk production and beef meat production, respectively. Pork meat production is responsible for around 0.9 Mton of feed consumption. The pork production/feed consumption is however less accurate with respect to the consumption of pork as large part is being imported.

[20] Greenhouse gas emission profiles of European livestock sectors
Author links open overlay panel. J. P. Lesschen, M. van den Berg, H. J. Westhoek, H. P. Witzke, O.Oenema. Animal Feed Science and Technology. 2011. 166–167, 16-28.

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

Table 4 Livestock Production and Feed Conversion (2018)

| | Production in carcass weight[t] | Production in live weight [t] | Feed Conversion Ratio | Feed Demands (Mt) |
|---|---|---|---|---|
| Cow's Milk | 3078000 | 3078000 | 1.2 | 3.69 |
| Beef | 71181 | 136667 | 19.8 | 1.41 |
| Pork | 210910 | 288076 | 4.1 | 0.86 |
| Poultry | 164261 | 260084 | 3.3 | 0.54 |
| Eggs | 76 | 76 | 2.8 | 0.00 |
| | | | **Total** | **6.51** |

Generally, there has been a steady decrease of the livestock count from 1990 by more than 35%. This is also associated with lower application of manure on the fields which has decreased from 1990. The CSO only reports the consumption of manure and not the overall production. We have therefore estimated the manure production based on the livestock count and average manure production. In dry weight around 2.2 Mton is produced (Table 5). At standard humidity, we estimate around 25 Mton of manure production annually. The CSO reports 13 Mton as an application onto the field. We assume the rest being directed towards the large biogas plants network where silage maize and manure are the most common feedstocks.

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Table 5 Livestock Numbers and Manure Production (2018)

| | Number | Manure t/DJ | Dry weight % | Mton/year | Mton/year dry matter |
|---|---|---|---|---|---|
| **Cattle** | 1,415,770 | 19 | | 18.54 | 1.83 |
| Cattle aged up to 6 months | 233,175 | 13.5 | 7% | 1.02 | 0.08 |
| Cattle aged over 6 months up to 12 months | 182,580 | 14.5 | 11% | 1.31 | 0.14 |
| Cattle aged between 1 and 2 years | 315,795 | 14.5 | 10% | 4.30 | 0.43 |
| Cattle of 2 years and over | 684,220 | | 10% | 11.91 | 1.19 |
| **Pigs** | 1,557,218 | 12 | | 5.52 | 0.37 |
| Piglets, less than 20 kg of l. w. | 460,584 | 12 | 6% | 0.22 | 0.01 |
| Young pigs, 20 and less than 50 kg of l. w. | 381,601 | 21 | 7% | 0.64 | 0.04 |
| Pigs for fattening (incl. cull boars and sows) | 578,257 | 12 | 7% | 3.89 | 0.25 |
| Breeding pigs (50 kg l.w. and over) | 136,776 | 10 | 8% | 0.77 | 0.06 |
| **Poultry** | 23,572,784 | 7 | 30% | 0.44 | 0.00 |
| Chickens | 22,428,355 | - | - | 0.00 | 0.00 |
| Hens | 7,989,588 | - | - | 0.37 | 0.11 |
| Roosters | 259,773 | - | - | 0.37 | 0.11 |
| Geese | 19,834 | - | - | 0.00 | 0.00 |
| Ducks | 780,767 | - | - | 0.00 | 0.00 |
| Turkeys | 343,828 | - | - | 0.00 | 0.00 |
| | | | **Total** | **24.49** | **2.20** |

## 2.2.4 Fisheries and aquaculture

The Czech Republic is landlocked country which the recreational fisheries; aquaculture and inland commercial fisheries is organized.

Recreational fisheries includes the performance of fishing rights in the fishing grounds of the Czech Republic, which are enacted by Fisheries Act No. 99/2004 on fish farming, fishing rights, fishing inspections, protection of marine fishing resources and act amendments and by Decree No. 197/2004 of the Fishery Act. Recreational fisheries consists of the management of river systems and water bodies in such a way as to preserve stable, species-divers and age-rich fish communities. In the Czech republic, more than 2 thousand fishing grounds representing an area of almost 42 thousand ha, while recreational fisheries is engaged in about 350 thousand fishermen. Fishing grounds are divided into non-trout and trout. Recreational fishermen catch about 4,000 tons of fish from the fishing grounds every year.

Fish farming (aquaculture) in the Czech Republic is carried out mainly in ponds, from which about 90 % of the total fish production is produced. Fish farming is carried out on an area of 42,000 ha. Fish are also farmed in traditional flow-through aquaculture systems designed mainly for salmonid fish breeding, including modern aquaculture recirculation systems. The average fish production in the Czech Republic is around 20,000 tons, with 89 % of production being common carp (Cyprinus carpio). In 2017, imports of fish and fishery products were valued at USD 362 million and exports USD 204 million. Estimated per capita fish consumption amounted to about 8.9 kg in 2016.[21]

Although generally not well known, ornamental fish (koi carp, goldfish, garden-pond fish and tropical aquarium fish species) have a very significant place in total aquaculture production of the Czech Republic. Based on production figures, the Czech Republic is among the largest world producer and exporter of freshwater ornamental and aquarium fish.

## 2.3 Biomass potentials from residues and unused lands

In terms of residual biomass production, Czech Republic scores quite well as compared to most EU countries as Figure 11 shows. Per year, 12.1 Mton of residues are produced of which the main sources are cereals and oil crops. Only 2.8 Mton are known to be harvested at this moment. How much of this residual resource can be mobilised, taking into account sustainability considerations, particularly conservation of organic carbon in the soil, will be discussed in greater detail in Section 2.3.1.

[21] See http://www.fao.org/fishery/facp/CZE/en

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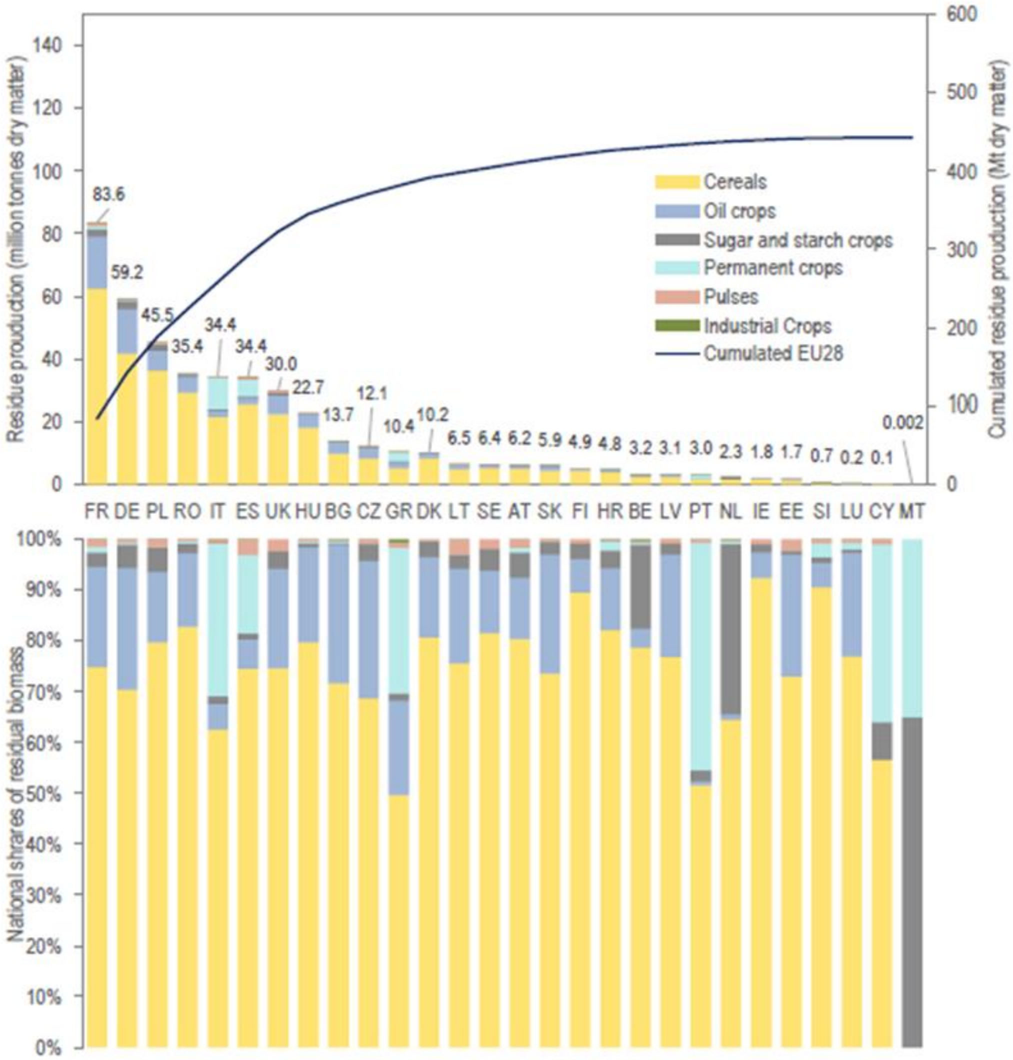


Figure 11 Residue production (top panel) from the main crop groups per member state, expressed in Mton of dry matter per year; and the shares at national level (bottom panel).
Average values over the reference period 2006-2015[22].

Primary residues are the most abundant residual source of biomass in the Czech agriculture sector. Cereals and oilseeds straw are contributing the most to the overall residual production which is approximately 11 Mton of dry matter per year (MtDM/year). Wheat straw is the most common type of primary residues with an estimated annual production of 4.84 MtDM. Total Residue yield of cereals is 7.3 MtDM/year, forming the majority of the primary residues. Rapeseed has one of the highest residues yields per ha of crop produced (8.6 t/ha) and rapeseed straw is the second most abundant source of primary residues (3.5 MtDM/year). With approximately 0.41 MtDM/year, sugar crops are less

[22] Extracted from Camia A., Robert N., Jonsson R., Pilli R., García-Condado S., López-Lozano R., van der Velde M., Ronzon T., Gurría P., M'Barek R., Tamosiunas S., Fiore G., Araujo R., Hoepffner N., Marelli L., Giuntoli, J., Biomass production, supply, uses and flows in the European Union. First results from an integrated assessment, EUR 28993 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-77237-5, doi:10.2760/539520, JRC109869.

relevant in terms of their post-harvest residues production. Crops other than cereals and rapeseed are generally less relevant in their primary residue production.

In terms of the secondary residues, cereal, oil and sugar processing industries are the most relevant sectors. The public data on secondary residues are limited and their reporting is fairly unreliable as large part of them is directly used as an animal feed and thus unreported. The European Agrimax project[23] gives estimates on the secondary residues for cereals (20-25%) and potatoes (15-25%) (Montanati, Cigognini, & Cifarelli, 2016)[24]. Based on Montanati et al., (2016), we thus estimate the production of secondary residues from cereal processing on 0.6 – 0.7 Mton. These are mainly in the form of wheat bran and husk. This data is consistent with S2BIOM statistics. The Agrimax project also provides possible utilization pathways and markets for these by-products. Given that majority of potatoes is directly consumed, the processing residues are rather limited in the Czech Republic. Montanati et al., (2016) estimates around 20% of processing residues are from potatoes manufacturing (diverse food products or starch). We estimate around 0.1 Mton of production from potatoes residues (mainly peel).

Based on the oil to seed ratio (approx. 40% (Gunstone, 2004)[25], an estimate on rapeseed secondary residues has been made of approximately 0.6-0.7 Mton. Sugar processing residues are commonly reported as a quarter of the input feedstock (Wrigley, Corke, & Walker, 2004), which mainly include pulp, molasses and other side products. The estimated processing residues are around 0.5 – 0.6 Mton for sugar beets. The overall secondary residue production thus constitutes around 2 Mton per year for cereal, rapeseed, and sugar beets, collectively. It should be noted that majority of these secondary residues are used as animal feed and their mobilization will thus compete with existing uses. This would also explain the limited reporting of agricultural processing residues by the CSO26 at only 0.113 Mton. It could also be that the estimates herein made are overly positive. More insight and data would enable a more accurate account of the secondary residues production and mobilization potential of these resources.

### 2.3.1 LIGNOCELLULOSIC RESIDUAL BIOMASS FROM CROPS

Czech Republic has a large cropping sector and therefore the residual biomass potential from arable crops is certainly of interest. However, how much crop residue (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 by mineral fertilizer application practices. The input of soil organic matter is often only dependent 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

[23] See http://www.agrimax-project.eu/
[24] See http://agrimax-project.eu/files/2017/11/AGRIMAX-D.1.2_Mapping-of-AFPW-and-their-characteristics.pdf
[25] Rapeseed and canola oil production, processing, properties and uses. Ed. F. D. Gunstone. Blackwell Publishing Ltd. 2004.
[26] See https://www.czso.cz/documents/10180/61546956/2800201802.pdf/29f9970c-b357-40e9-8800-9d68573deffe?version=1.1

sustainable removed, we use data generated in the S2BIOM project[27]. In S2BIOM a 'base potential' was assessed for residual biomass. It identified the part of the residues that can be removed from the field without adversely affecting the soil organic carbon (SOC) content in the soil. The SOC 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[28]) to provide the input data and the "RothC-26.3" model (Coleman & Jenkinson, 1999[29]) to calculate the soil carbon dynamics. Further details on the whole assessment of biomass potentials in S2BOM are presented in Annex 2 of this report. In Table 6, Figure 12, and the following text, the S2BIOM biomass potentials are presented for Czech Republic.

[27] https://www.s2biom.eu/en/publications-reports/s2biom.html
[28] Differentiation of nitrous oxide emission factors for agricultural soils
Author links open overlay panel. Jan Peter, Lesschen Gerard, L.Velthof, Wim de Vries, Johannes Kros. Environmental Pollution. 2011. 159: 11, 3215-3222.
[29] https://www.rothamsted.ac.uk/sites/default/files/RothC_guide_WIN.pdf

Table 6 Residual biomass potentials* from arable crops 2020 in ton d.m. (=S2BIOM base potential) (see for assessment approach Annex 2)

| Region | Cereals straw | Oil seed rape straw | Maize stover | Sugarbeet leaves | Sunflower straw | Total |
|---|---|---|---|---|---|---|
| Prague city | 24,433 | 4,034 | 2,330 | 1,083 | 365 | 32,244 |
| Central Bohemian region | 1,095,513 | 207,907 | 119,328 | 69,295 | 23,580 | 1,515,623 |
| South Bohemian region | 474,693 | 94,025 | 42,983 | 34 | 1,636 | 613,371 |
| Pilsen region | 357,272 | 70,774 | 32,306 | 26 | 1,226 | 461,604 |
| Karlovy Vary region | 179,651 | 23,147 | 16,513 | 1,946 | 4,200 | 225,458 |
| Usti region | 290,225 | 37,404 | 26,692 | 3,166 | 6,788 | 364,273 |
| Liberec region | 191,191 | 44,762 | 42,045 | 17,362 | 2,315 | 297,675 |
| Hradec Kralove region | 287,556 | 67,351 | 63,286 | 26,131 | 3,478 | 447,803 |
| Pardubice region | 273,253 | 63,959 | 60,159 | 24,816 | 3,313 | 425,499 |
| Vysočina region | 596,425 | 71,619 | 175,327 | 16,390 | 26,102 | 885,862 |
| South Moravian region | 630,300 | 75,638 | 185,361 | 17,335 | 27,592 | 936,226 |
| Olomouc region | 361,386 | 43,475 | 80,859 | 34,662 | 4,010 | 524,393 |
| Zlin region | 277,749 | 33,326 | 62,121 | 26,597 | 3,088 | 402,881 |
| Moravian-Silesian Region | 48,018 | 9,643 | 12,092 | 6,989 | 169 | 76,912 |
| **Total** | **5,087,664** | **847,065** | **921,402** | **245,832** | **107,861** | **7,209,824** |

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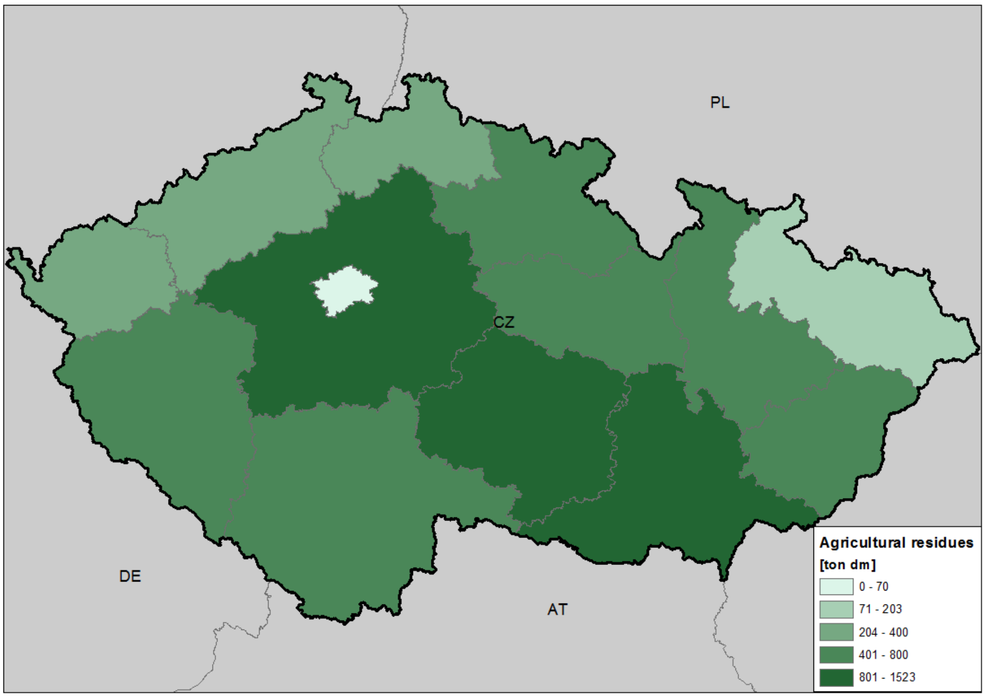


Figure 12 Total primary residual biomass potential from agriculture (S2BIOM Base potential 2020)

While the S2BIOM data are insightful into the potential of lignocellulosic biomass, we predict lower potential taking the Czech context into account. Firstly, it should be noted that the S2BIOM data, are not considering the variables introduced by the Czech droughts in 2017 and 2018. From diverse discussions with farmers or operators of incineration plants mainly in the Bohemia region, the supply of biomass has become riskier and more expensive in the recent few years, making straw more valuable. An operator of an incineration plant built around 2008, reported double the prices per ton during the driest months in the years of 2017 and 2018 than at the start of the operation and the need to import from far larger distances (Poland or South Moravia). The bark beetle and thus the oversupply of wood (see Chapter 3) also creates a pressure on the straw pellet mills.

Moreover, according to the questionnaires done by the Institute of Circular Economy (Prague, INCIEN), the farmers are rather unwilling to provide wheat straw for alternative uses, than the conventional animal bedding. The questionnaire received more than 350 responses mainly from the Association of Private Farming of the Czech Republic. The size of the respondents' farm is shown in Figure 13. It should be noted that this specific association might be more risk averse and less willing than for example the Agrarian Council which affiliates with bigger farms.

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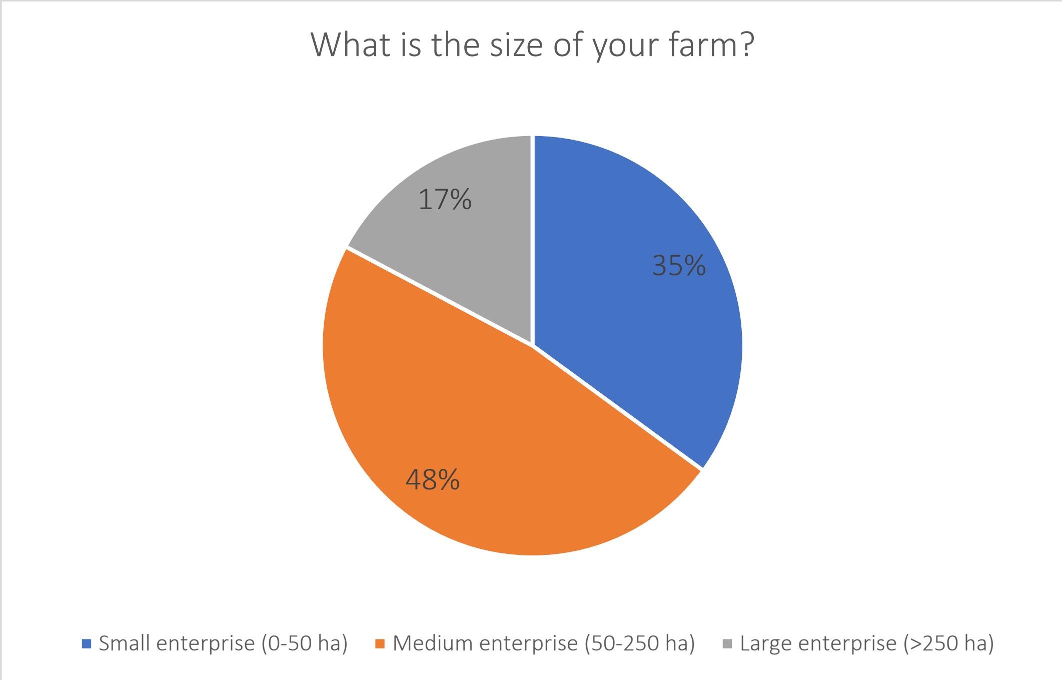


Figure 13 Size of the respondents' farms (350 responses)

Close to 90% of the farmers responded that wheat straw is a very important commodity for them. More importantly, around 85% of the respondents mentioned that they use wheat straw solely for their own purposes, either as animal bedding or as fertilizer (ploughing back to field). Only 15% of the respondent reported that they sell the straw to a second party, although this has not be verifiable. Most strikingly, there is a great confusion about the right amount of straw that should be left on the field or ploughed into the soiled (see Figure 14). However, 50% of respondents think that more than 75% or all of the straw should be left on the field. This perceived practice may present as a barrier towards the mobilisation of this biomass, as the reluctance to offer the straw is reflected in the reduced soil quality and the respective SOC levels.

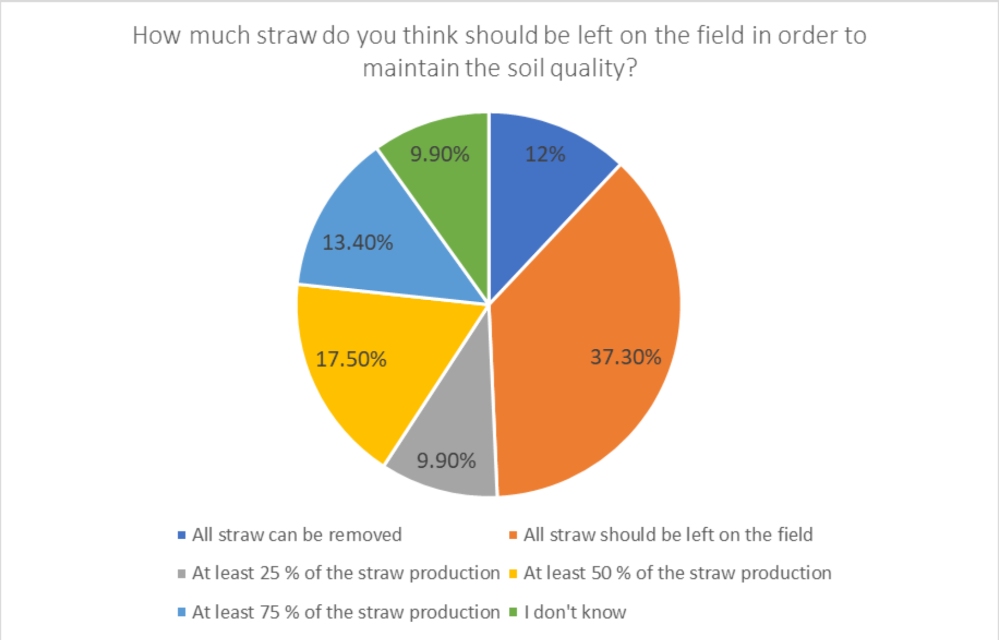


Figure 14 Perception of farmers on the correct straw removal (292 response)

The farmers were also concerned with the subsequent use of the straw (Figure 15). Around 21% reported that they are more concerned about the subsequent use of the feedstock rather than price of sale. More than 34% were mainly motivated by price, but partially also use of the straw. Only 11% were oriented solely based on price. This has been also reflected in some of our discussions with the farmers in Central Bohemia. For example, the large demand of biomass for incineration around the city of Kutná Hora has been fiercely criticized in the agriculture community. The reason is that lower yields in 2017 and 2018, due to drought, resulted in higher prices and lower perceived soil quality. While the year 2019 has been more promising, similar extreme climatic conditions may be anticipated in the upcoming years.

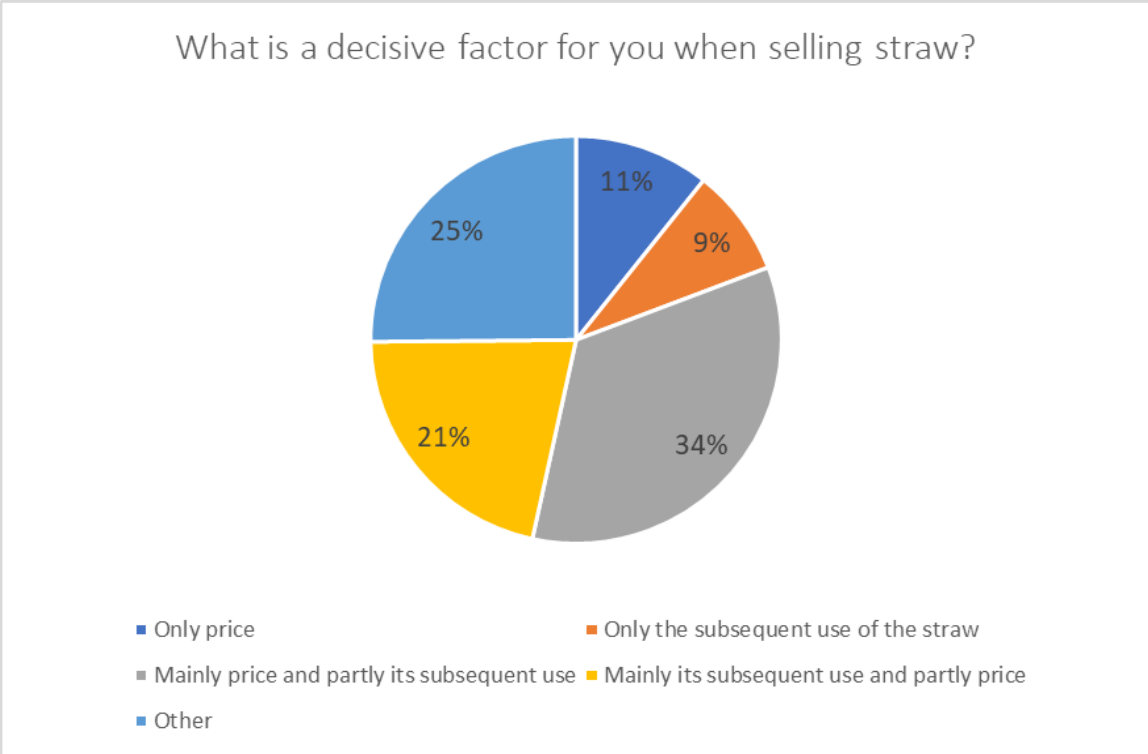


Figure 15 The main factors by which farmers sell straw (47 response[30]).

By determining the maintenance of SOC based on straw re-incorporation into soil (calculations in S2BIOM; comparing the base potential and carbon maintenance in soil, against the technical potential), on average 96% of the cereal straw could be sustainably removed. And for oil crop straw, 92% could be sustainably removed to maintain SOC. These data sharply contrast to the different viewpoints of farmers interviewed in the survey presented here.

Residues from permanent crops, such as fruit trees have been further assessed according to the S2BIOM methodology. Table 7 displays, according to regions in Czech Republic, the amount of biomass potential totalling 32.4 Kton d.m.

[30] The low response rate is due to the fact that limited number of the farmers actually sell their straw (approximately than 15%).

Table 7 Residual biomass potentials* from permanent crops 2020 in ton d.m. (=S2BIOM base potential) (see for approach Annex 2)

| Region | Residues from fruit tree plantations in ton d.m. (apples, pears and soft fruit) |
|---|---|
| Prague city | 307 |
| Central Bohemian region | 7,655 |
| South Bohemian region | 1,689 |
| Pilsen region | 1,272 |
| Karlovy Vary region | 1,760 |
| Usti region | 2,843 |
| Liberec region | 1,700 |
| Hradec Kralove region | 2,558 |
| Pardubice region | 2,429 |
| Vysočina region | 4,160 |
| South Moravian region | 4,396 |
| Olomouc region | 919 |
| Zlin region | 707 |
| Moravian-Silesian region | 23 |
| **Total** | **32,418** |

## 2.3.2 Dedicated crop potentials from unused lands

Additional areas of unused or under-used lands present as a further potential for the mobilization of biomass. Additional sources of biomass include fast-growing tree species cultivated on the agriculture land. Such plantations are nowadays registered on 2687 ha of agriculture land (LPIS, 2019). With an average yield of 5-7 ton d.m./ha/year, there is a potential of woody biomass ranging between 13 435 and 18 890 ton d.m./year.

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Table 8 Biomass potentials* from unused lands 2020 in ton d.m. (=S2BIOM base potential) (see for assessment approach Annex 2)

| Region | Unused land potential |
|---|---|
| Prague city | **7,193** |
| Central Bohemian region | **424,123** |
| South Bohemian region | **151,665** |
| Pilsen region | **126,468** |
| Karlovy Vary region | **31,884** |
| Usti region | **82,535** |
| Liberec region | **44,328** |
| Hradec Kralove region | **87,950** |
| Pardubice region | **97,404** |
| Vysočina region | **174,030** |
| South Moravian region | **187,406** |
| Olomouc region | **80,960** |
| Zlin region | **63,309** |
| Moravian-Silesian region | **73,822** |
| **Total** | **1,633,076** |

### 2.3.3 Residual biomass potentials from livestock

There are approximately 1,4 million cows, 1,6 million pigs and 23,6 million poultry in the Czech Republic producing 24,5 Mton of manure/yr (Table 5).

Since 2000, an upward trend has been noticeable in consumption of industrial fertilizers with fluctuations in the individual years. While in the years 2011–2014 their development stagnated, in 2015 there was again a significant increase in consumption, mainly due to prolonged drought and lack of nutrients in the soil. When comparing the years 2016 and 2017, there was a slight decline by 2.1% to 138.2 kg.ha-1 of pure nutrients. A decline was recorded, in comparison with 2016, in the consumption of nitrogen fertilizers (by 3.3%), and in the consumption of potash fertilizers by 11.1%. Although the consumption of nitrogen fertilizers decreased, regarding the composition of the mineral fertilisers used, nitrogen fertilisers still clearly dominate and represent 81.7% of total consumption. The consumption of livestock manure saw a long-term decline between 2005–2013. In 2014, manure consumption increased slightly and then subsequently stagnated. The total input of pure nutrients from manure and organic fertilisers was 70.0 kg ha-1.

At standard humidity, the CSO study (see Section 2.2.3) estimated around 25 Mton of manure production annually. The CSO reports 13 Mton as an application onto the field. We assume the rest being directed towards the large biogas plants network where silage maize and manure are the most common feedstocks.

## 2.4 Agriculture processing industries

### 2.4.1 Main agrifood processing industries

The production of food and beverages are taken as key branches within the processing industry in the Czech Republic. Their importance is based on the fact that they provide nutrition to the population. The basic resources of the food-processing industry are domestic agricultural products, forest and water management products, as well as imported raw materials. The share of the food and beverage industry in the Czech is 2.7% of the GDP. The food-processing industry is concentrated mainly in fertile lowland areas, in particular in the regions of Polabí, South Moravia and Haná, and also in large cities such as Prague, Brno, Plzeň, Ostrava, České Budějovice and Opava. As for the portfolio, the foodstuff production comprises many specific branches.

Areas such as grasslands constitute those lands thus far untouched by chemical additives, such that organics are being grown in these sites. Currently, the bio-organic crop market is at 0.9% of all food found within the commercial stores. There have been incentives through subsidies to produce organic crops, including bio milk. Nevertheless, a lack of harvesting and processing equipment of organic products reveals a gap in this market for Czech consumers.

The key pillars of the food processing industry consist of foodstuff and beverage products.

**Foodstuff production**

The main branches are:

***Processing meat and meat products***

This branch deals with the processing of meat from both big and small farm animals and manufacture of meat products. It belongs to key branches within the food-processing industry in the Czech Republic. Leading meat producers are: AGROFERT HOLDING, a. s., SCHNEIDER – MASOKOMBINÁT PLZEŇ, s. r. o., STEINHAUSER, s. r. o., KRAHULÍK – MASOZÁVOD KRAHULČÍ, a. s., PROCHÁZKA, spol. s r. o., MASOKOMBINÁT JIČÍN, s. r. o., MASNA PŘÍBRAM, s. r. o., VÁHALA a spol., s. r. o.

### *Processing fruit and vegetables*

The branch includes the processing of potato, production of fruit and vegetable juice and other production, and processing fruits and vegetables. Leading fruit and vegetable producers are: Potato production – BESKYD FRYČOVICE, a. s., INTERSNACK, a. s., GOLDEN SNACK, s. r. o., LWM INTERNATIONAL CZ, s. r. o.
Fruit and vegetable production: HAMÉ, a. s., LITOVEL, SELIKO OPAVA, a. s., PT SERVIS konzervárna, s. r. o., ALIBONA, a. s., NOVA, a. s., KAND, s. r. o.

### *Dairy products*

The branch includes processing of milk as well as a production of dairy products, cheese and ice-cream. Leading producers of dairy products in the Czech Republic are: MADETA, a. s., PRAGOLAKTOS, a. s., OLMA, a. s., Danone, a. s., skupina LACTALIS CZ, MLÉKÁRNA HLINSKO, s. r. o., etc.

### *Production of flour and starch products*

The branch covers the production of flour, starch-based and similar products. Leading producers are: EKOPRODUKT, s. r. o., EXVER FOOD, s. r. o., MILLBA CZECH, a. s., MLÝN KOJETÍN, s. r. o., MLÝN PERNER SVIJANY, s. r. o., PENAM, a. s., PRO-BIO, s. r. o., UNIMILLS, a. s., AMYLON, a. s., AMYLEX, s. r. o., KRNOVSKÁ ŠKROBÁRNA, s. r. o., ŠKROBÁRNY PELHŘIMOV, a. s., ŠKROBÁRNY HORAŽĎOVICE, a. s.
Other important branches are the production of bread and baked goods and other flour-based products.

### Production of beverages

As regards the production of beverages in the Czech Republic, the most important production branches are:

### *Beer making*

Beer is one of the most important agricultural-related industries in beverages in the Czech Republic. The average beer consumption per capita is 160 litres/annum. The total employment generated by the beer sector in the Czech Republic provided about 76,000 jobs in 2014. In 2014, the total consumer spending on beer within the Czech Republic was 2,431 million euros (approx. 1% of the GDP). In total, in 2016, the Czech breweries produced 20.48 million hectolitres of beer. Leading beer producers are: Plzeňský prazdroj, a. s., Staropramen, a. s., Heineken ČR, Budějovický Budvar, n. p., skupina PMS (for example, Pivovar Litovel, Holba, Zubr) and smaller breweries (e.g. Černá Hora, Svijany, Eggenberg, etc).

### *Wine making*

Most vineyards in the Czech Republic are located in Southern Moravia (Valtice, Velké Pavlovice, Břeclav, Znojmo), while the main centre in Bohemia is Mělník.
The largest domestic producers of wine are: Bohemia Sekt, a. s., Moravské vinařské závody Bzenec, s. r. o., PATRIA Kobylí, a. s., Templářské sklepy Čejkovice, Vinařské družstvo VINIUM, a. s., Velké Pavlovice, VINSELEKT Michlovský, a. s., ZNOVÍN ZNOJMO, a. s., Vinné sklepy Valtice, a. s., České vinařské závody, a. s., and many others.

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### *Liquor making*

Liquor making is a traditional branch in the Czech Republic. Liquor producers are usually focused on their own production but distribute foreign products as well. Recently, there is a distinctive trend in the growing demand for beverages with a lower content of alcohol (to a 20% volume of ethanol). At present, the most significant positions in the branch of liquor and spirit production belong to: STOCK Plzeň-Božkov, s. r. o., DRINKS UNION, a. s., Rudolf Jelínek, a. s., Vizovice, Jan Becher – Karlovarská Becherovka, a. s. (owned by Pernod Ricard), etc.

### *Production of mineral water and soft beverages*

In terms of the production of mineral water, the biggest shares on the market are kept by: Karlovarské minerální vody, a. s., Poděbradka, a. s., and Hanácká kyselka, s.r.o. Leading producers of soft beverages are: Coca-Cola HBC ČR, s. r. o., Kofola, a. s., Krnov, Pepsi Co/GENERAL BOTTLERS ČR, s. r. o. Kofola, a. s. is currently the best-known Czech producer of soft drinks.[31]

[31] *Sourced on 14 December 2019; http://www.czech.cz/en/Business/Czech-companies/Food-processing-Industry-in-the-Czech-Republic*

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

From the former overview it is clear that there are many food processing industries that produce a range of secondary residues. Data on the amounts of these residues are however difficult to find. In S2BIOM for only a selection of these residues some potential estimates were made (see Tale 9).

Table 9 Biomass potentials from agrofood processing industries 2020 in ton d.m. (=S2BIOM base potential) (see also Annex 2)

| Region | Pressed grapes dregs | Cereal bran | Total |
|---|---|---|---|
| Prague city | 0 | 192,935 | 192,935 |
| Central Bohemian region | 33 | 84,277 | 84,310 |
| South Bohemian region | 0 | 65,795 | 65,795 |
| Pilsen region | 0 | 49,522 | 49,522 |
| Karlovy Vary region | 11 | 19,554 | 19,565 |
| Usti region | 17 | 31,576 | 31,594 |
| Liberec region | 0 | 22,440 | 22,440 |
| Hradec Kralove region | 0 | 33,762 | 33,762 |
| Pardubice region | 0 | 32,074 | 32,074 |
| Vysočina region | 769 | 53,408 | 54,177 |
| South Moravian region | 813 | 56,433 | 57,246 |
| Olomouc region | 33 | 37,297 | 37,330 |
| Zlin region | 26 | 28,045 | 28,070 |
| Moravian-Silesian region | 0 | 38,540 | 38,540 |
| **Total** | 1,703 | 745,657 | 747,360 |

## 2.5 Cost of main biomass sources

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 refer to *Road side cost* and these cover all biomass production collection and pre-treatment cost up to the road where the biomass is located. The road side cost are a fraction of the total 'at-gate-cost' (Table 10).

Table 10 Road side cost levels (€/ton d.m.) for agricultural biomass sources based on S2BIOM cost calculations[32]

| Road side cost for agricultural biomass | Average (€/ton dm) |
|---|---|
| | (2020 cost level) |
| Cereal straw | 19 |
| Straw from oil crops (sunflower & rapeseed Oil) | 16-19 |
| Maize stover | 16 |
| Residues from fruit tree plantations (apples, pears and soft fruit) | 167 |
| SRC unused lands | 36 |
| Dedicated crops on unused lands | 36 |

## 2.6 SUMMARY AND CONCLUSIONS IN RELATION TO SWOT ELEMENTS

What can be realistically mobilised given the land managers willingness, capabilities and given options for efficient logistical handling of the biomass? Biomass production/harvesting/collection is a challenge for different reasons. One of these is that biomass is dispersed across a large area (a low density per area) and is almost by definition bulky, low in energy density and generally contains considerable amounts of water. Furthermore, the facilities to collect, transport and pre-treat are not always well-developed in the areas with highest biomass concentration. Local arrangements and regulations can also influence access and ownership rights to lands where biomass resources are available.

We can distinguish between three types of residues in the agricultural production of food and feed. Primary residues are the most abundant source of biomass with cereal and rapeseed straw as the most relevant. Secondary residues from food processing, seem to be also a promising source of biomass. Next to the estimates made by the S2BIOM, additional estimates have also been included on other food processing value chains such as sugar beet, potatoes or rapeseed. We estimate the potential of the secondary residues to be around 2 Mton per year, however, more insight has to

[32] 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.

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made regarding the exact availability, as well as the degree to which these resources can be mobilized. Food waste can be perceived as the tertiary residues from the overall food production, with more than 800 Kton of food waste generated annually.

Straw is a valuable lignocellulosic biomass source which is a by-product from the overall harvest, of which, there are considerable other competing uses. However, it is estimated that still 7,0 MtDM/year of the cereal straw that could be sustainably removed (without losing carbon from the soil) and 3,2 MtDM/year rapeseed straw could be available. However, droughts and climate conditions make the feedstock more susceptible to price volatility and security of supply. Climate change effects are considerable and have increased in Czech Republic, and this could certainly affect future availability of straw. Bioeconomy hubs located in specific regions could increase this security, however, the costs would increase. Secondly, the most effective methodologies for straw utilization remain unclear. While there are incineration plants for straw, the added value out of these facilities are relatively low and incinerating a relatively valuable and expensive feedstock might be perceived as an ineffective utilization pathway. Second generation biofuel technologies are available, however are more challenging to find and to make investments due to market challenges, where fossil fuel-based competition is large. Building new economies of scale are not easily obtained, with the additional challenges of sourcing available biomass. Value added industries such as fine chemicals could be more suitable, but this would need investment and a sustainable plan in order for it to be realized. The infrastructure in the Czech Republic is in very good condition, there is sufficient road and rail infrastructure in order to connect the Czech industry to the international markets. Rail transport from the local water harbors into a landlocked country will however increase the price of the feedstock. Similarly, creation of a hub that would increase the security of supply will increase the feedstock pricing. One of the biggest weaknesses of utilizing straw more effectively is the confusion around the sustainable straw removal from the fields while maintaining soil nutrients. However, the S2BOM assessment of sustainable removal rates of straw, while keeping soil carbon constant, show a much higher sustainable removal rate for straw then is currently practiced and what is perceived as sustainable by most farmers in Czech Republic. Regional bioeconomy strategies would be very beneficial as this could lead to narrowing the scope, thus decreasing the uncertainty of the true availability, and take into consideration the regional climatic conditions in order to ensure proper sustainability standards.

Table 11 SWOT Analysis

| STRENGTHS | WEAKNESSES |
| --- | --- |
| • Agriculture sector is highly developed<br>• Robust food and beverage value chains<br>• Modern transport infrastructure | • Reduction in livestock production<br>• Residual biomass security unclear<br>• Low development of innovative industries for use of residual biomass |
| **OPPORTUNITIES** | **THREATS** |
| • Relatively large utilizable biomass<br>• Growth opportunity in development of Czech bio-organics market<br>• Local bioeconomy hub development | • Climate change, more drought and high temperatures<br>• Agricultural practices leading to inadequate soil and water management<br>• Monopolies is some value chains leading to competitive lock-out |

# 3 BIOMASS SUPPLY: FORESTRY

## 3.1 INTRODUCTION

Forestry is an industry deeply anchored in the Czech tradition. With its area of forest cover reaching more than 2.67 mil. hectares (CZSO, 2019a)[33], that has increased by 3% over the last 50 years, it is an important landscape and ecosystem element. It accounts for about 0.5% of GDP and gives jobs to almost 13,650 people (Figure 16)[34].

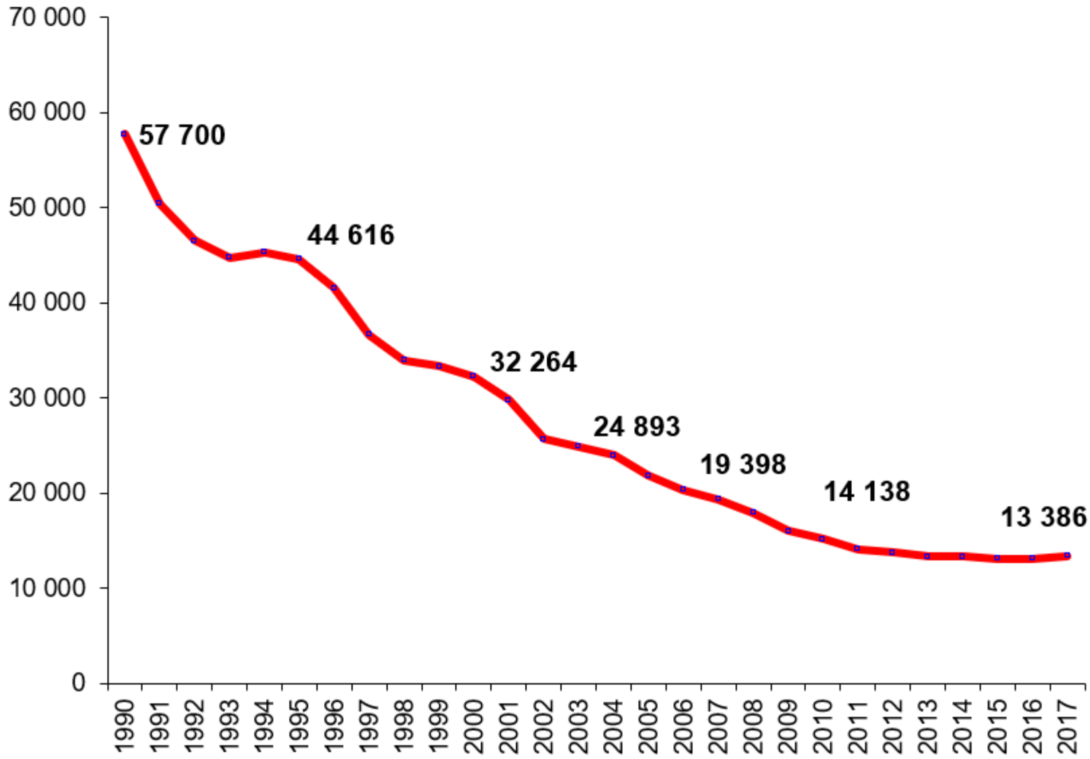


Figure 16 Number of employees in forestry sector[35]

In recent years, forestry has faced significant challenges, which include, first and foremost, the effects of climate change, as well as the effects of an unbalanced forestry cover formation in the past, manifested in particular by the bark beetle infestation. A record 25.7 mil. m$^3$ of bark-free wood was logged in the Czech forests in 2018, which is 33% more than in the previous year; salvage felling accounted for about 90% of this volume, for which predominantly bark beetle prevailed (CZSO,

[33] *CZSO (2019a): Česká republika od roku 1989 v číslech*
https://www.czso.cz/csu/czso/ceska-republika-od-roku-1989-v-cislech-2018#09
[34] *CZSO (2019b): Employees and wages in forestry*
https://www.czso.cz/documents/10180/91232997/100004191k11.pdf/faada84f-032c-4f1a-9d67-3cc8122daa59?version=1.0
[35] Jaromír Vašíček (Forestry Policies – lesson), http://www.uhul.cz/.

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2019c)[36]. The bark beetle infestation continues through 2020 with estimated 30 mil. $m^3$ of timber in 2019. The price of round timber decreases in connection with the excess supply and decreased quality of the infested timber.
The concept of sustainable forest management has become a strategy and target of forestry policy in the Czech Republic. In this spirit, Act No. 289/1995 Coll., on forests, declares in Section 1 that its "purpose is to set prerequisites for conservation, management, and regeneration of the forest as a national wealth, being an irreplaceable component of the environment so that it is able to fulfil all its functions and in order to support sustainable management therein" (Act on Forests, 289/1995 Coll.).
The basic criteria for sustainable forest management include:
1) Conservation and appropriate development of forest resources and their contribution to the global carbon cycle;
2) Preserving the health and vitality of forest ecosystems;
3) Preserving and promoting forest production functions;
4) Preserving, protecting, and appropriately enhancing the biological diversity of forest ecosystems;
5) Preserving and appropriately improving the protective functions of the forest;
6) Preserving other social and economic functions of the forest.

In 2018, the forest ownership structure was as follows: state forests 54%, forest owned by private owners 21.5%, municipal forests 15.8% and other owners 8.7% (CZSO 2019 d)[37]. State forests are mainly managed by LESY ČR, s.p., other owners are grouped in different associations such as churches, forest cooperatives, and singular companies. It has to be noted that the process of forest and land restitution after the fall of communism in 1989 has not been completed yet. In terms of tree species composition, coniferous trees represent 55% and deciduous trees 45%. The most frequently represented tree is the Norway spruce (43.7%), beech (19.8%), pine (13.5%), oak (10%), silver fir (4.4%), and acacia (2.3%)[38]. Forests are divided according to their prevailing functions into three categories: 1) protection forests make up 2%; special purpose forests (e.g. natural reserves, national parks) make up 23.7% and 3) production forests make up 74.3%.[39]

In the forest sector, stemwood, primary residues and secondary residues from forest industries are available. For bioenergy and bio-material potential assessment we particularly focus on availability of primary and secondary residues as stemwood conversion to energy is not the most resource efficient and therefore preferable use. The assessment of the stemwood and primary residue potentials is done by using the EFISCEN model and using national forestry inventory data as 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.[40]

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[36] CZSO (2019c): Roundwood removals by region.
https://www.czso.cz/documents/10180/91232997/100004191k18.pdf/87243254-ab10-4702-8a5d-923f7192fe5a?version=1.0

[37] *CZSO (2019d): Forest land by type of forest-managing enterprise*
https://www.czso.cz/documents/10180/91232997/100004192k25.pdf/6caa9890-714b-4d13-ac4c-302342c5ea25?version=1.0
[38] See http://eagri.cz/public/app/uhul/SIL/SSIL/SIL_DATA/DATA_STAT/SLHP/2018/CR/CZ.pdf
[39] See http://www.uhul.cz/images/ke_stazeni/zelenazprava/ZZ_2018.pdf
[40] See http://www.fao.org/forest-resources-assessment/current-assessment/country-reports/en/

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## 3.2 PRIMARY BIOMASS RESOURCES FROM FORESTRY

Fluctuating climatic conditions have led to increased damage, especially to spruce covers, by sub-bark insects, mainly in Moravia and Silesia, and subsequently, in the Vysočina region. The harmful effects of both biotic and abiotic agents generated high salvage felling, which accounts for 90% of the total timber logging. As a result, when it was necessary to process damaged, so-called bark beetle timber, it had an impact on the timber prices even though the Ministry of Agriculture provided allowance for bark beetle infestation mitigation. Thus, the development of average prices reflected the significant excess of supply from foresters and business owners over demand from raw timber processors on the domestic market for all coniferous timber.

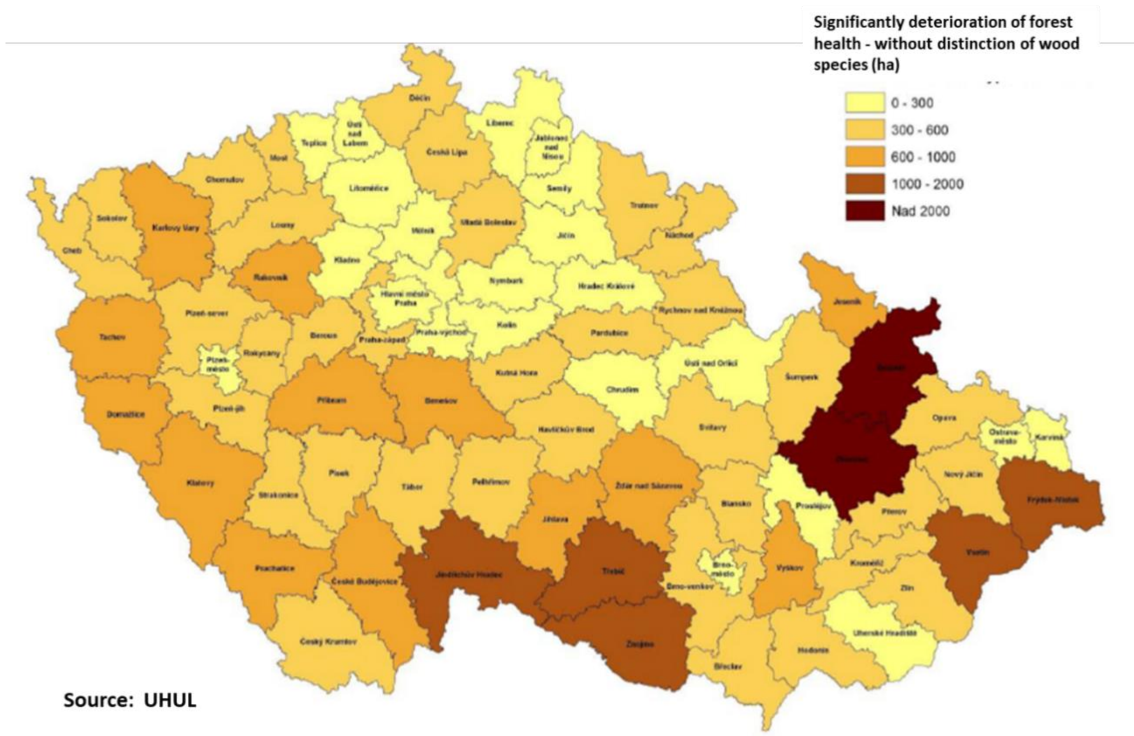


Figure 17 Considerable deterioration of forest state of health between 2016 - 2018[41]

Despite the high production of its forests, the Czech Republic belongs to countries with lower relative timber consumption, due to insufficient timber-processing capacities and low customer demand. This results in a high prevalence towards export of raw wood over import. In 2018, export of raw timber reached 11 mil. m$^{3,}$ and imports recorded 3.4 mil. m$^3$ (Ministry of Agriculture of Czech Republic, 2019)[42]. In the future, greater automation in the timber sector could address the current shortage of workers, which prevails not only within the manual labor professions, but particularly in the forestry sector (Ministry of Agriculture of Czech Republic, 2017).

[41] See http://eagri.cz/public/web/en/mze/
[42] See http://eagri.cz/public/web/en/mze/

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Timber, thanks to its physical and mechanical qualities, is used across many sectors: construction industry, furniture-making, energy sector, paper industry, chemical industry, and as an important material for sports equipment and musical instruments. Forestry and wood-processing companies are united within ASOCIACE LESNICKÝCH A DŘEVOZRAPCUJÍCÍCH PODNIKŮ (ALDP). Leading forestry companies are UNILES, a.s. (within the Agrofert Holding), followed by KLOBOUCKÁ LESNÍ, s.r.o and PETRA s.r.o.. Leading wood processors are KRONOSPAN CR s.r.o., MONDI ŠTĚSTÍ, a,s, PILA JAVOŘICE, STORA ENSO WOOD PRODUCTS ŽDÍREC, s.r.o. or LESS&TIMBER a.s., Stora Enso Wood Products Planá s.r.o, Mayr Melnhof Holz Paskov s.r.o, Pfeifer Holding Chanovice, and Lenzing Biocel Paskov a.s.

Table 12 Primary biomass potential from forests Kton d.m. (S2BIOM Base potential 2020).

| Region | Final fellings* | Thinnings | Logging residues from final fellings | Logging residues from thinnings | Total |
|---|---|---|---|---|---|
| Prague city | **27** | **17** | **9** | **4** | **57** |
| Central Bohemian region | **950** | **586** | **269** | **92** | **1,897** |
| South Bohemian region | **711** | **478** | **151** | **57** | **1,397** |
| Pilsen region | **440** | **284** | **111** | **41** | **876** |
| Karlovy Vary region | **198** | **110** | **34** | **12** | **354** |
| Usti region | **354** | **198** | **93** | **30** | **675** |
| Liberec region | **162** | **99** | **37** | **11** | **309** |
| Hradec Kralove region | **315** | **191** | **77** | **26** | **609** |
| Pardubice region | **222** | **134** | **57** | **20** | **433** |
| Vysočina regionna | **344** | **216** | **105** | **37** | **702** |
| South Moravian region | **983** | **620** | **267** | **94** | **1,964** |
| Olomouc region | **288** | **169** | **56** | **20** | **533** |
| Zlin region | **504** | **322** | **85** | **31** | **942** |
| Moravian-Silesian region | **290** | **172** | **67** | **24** | **553** |
| **Total** | **5,788** | **3,596** | **1,418** | **499** | **11,301** |

*This is stemwood harvest and is the main product for which most uses are already well developed in the market.

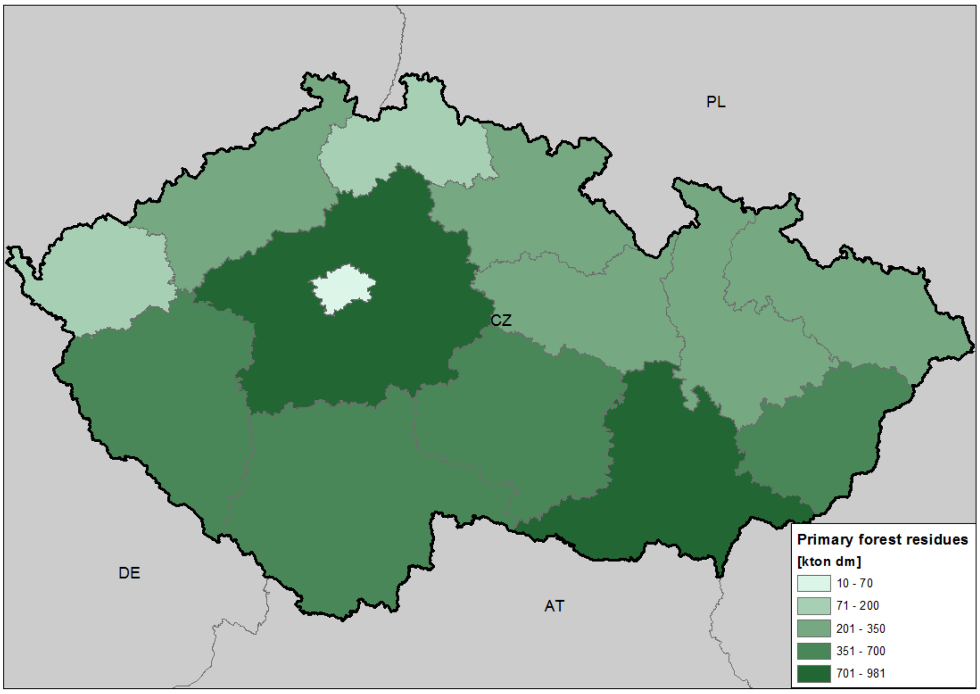


Figure 18 Distribution of primary residues potential from forests Kton d.m. (S2BIOM base potential 2020)

## 3.3 Secondary biomass resources from forestry: wood processing industries

Secondary forestry biomass includes wood processing industrial residues such as sawdust, bark and black liquor. The availability of these by-products depends completely on the development of timber and paper industries. Pellet producers are to a large proportion contained within the sawmill industry. Data on the current capacity and potential capacity of sawdust highlights which regions in the Czech Republic have the greatest potential for increase (Table 13). At the EU level, the decreasing relevance of retailers may be explained with the higher margins which can be earned with sawmill by-products. Black liquor for example is more or less fully used by the pulp industry, mainly as an internal energy source, and there are only two big producers in the Czech Republic (Štětí – Usti region, and Paskov – Moravian-Silesian region). Other industrial residues are quite often reused in the production process (chip board) or in the timber industry, owned power plants or for heat production.[43]

[43] See http://eagri.cz/public/web/file/615927/Zprava_o_stavu_lesa_2017_ENG.pdf

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Table 13 Secondary biomass reported and estimated potential from forests in the form of sawdust ($m^3$), from 2015.[44]

| Region | Sawdust, current capacity | Sawdust, potential capacity | Potential increase (%) |
|---|---|---|---|
| Central Bohemian region | **371 400** | **698 500** | **88,1** |
| South Bohemian region | **395 800** | **1 318 000** | **233,0** |
| Pilsen region | **1 187 600** | **2 416 800** | **103,5** |
| Karlovy Vary region | **77 200** | **129 900** | **68,3** |
| Usti region | **95 700** | **146 500** | **53,1** |
| Liberec region | **289 200** | **364 500** | **26,0** |
| Hradec Kralove region | **325 500** | **438 600** | **34,7** |
| Pardubice region | **99 900** | **223 700** | **123,9** |
| Vysočina region | **1 416 200** | **2 149 700** | **51,8** |
| South Moravian region | **246 000** | **393 300** | **59,9** |
| Olomouc region | **444 500** | **634 600** | **42,8** |
| Zlin region | **570 700** | **864 300** | **51,4** |
| Moravian-Silesian region | **1 480 300** | **1 820 000** | **22,9** |
| **Total** | **7 000 000** | **11 598 400** | **65,7** |

Sawdust has many qualities, making it a popular material for fibre composite manufacturing, it is absorbent, abrasive, bulky and fibrous, nonconductive, and granular. A variety of products, including bedding, abrasives, insulation, and packaging, can be produced from sawdust (Wood Energy 2019)[45].

Large-scale sawmills in the Czech Republic use bark as a main fuel for combined heat and power production, primarily in connection with pellet production. Bark is also used to produce dyes, resins, flavourings, and medicinal products, but can be difficult to use due to soil contamination during harvesting operations. However, as harvesting technologies improve, more and more chemical extracts become commercially available for use. Bark is commonly used in mulching or as a soil amendment. In addition, bark is used in building materials such as fibre and chip board as well as insulation board because it conducts heat less readily than wood. The chemical utilization of bark is still in its early stages, mainly due to the economic expense of transportation, storage, and volume of the material. Very few pure organic compounds extracted from bark have been isolated for large-

[44] National study on sawmills capacities from 2015
[45] See http://www.fao.org/forestry/energy/en/

scale production (Wood Energy 2019)[46]. Consistent bark biomass data is currently not tracked in the Czech Republic.

Production from secondary forestry biomass focuses primarily on pellets and briquettes. Wood pellets are generally made from compacted sawdust and related industrial wastes from the milling of lumber, manufacture of timber products and furniture, and construction. Pellets are space-saving, independent of fossil fuels, easy to handle and producing almost no fume. Their ash can be used as fertilizer because it might contain up to 30% of calcium, 10% of potassium, 5% of magnesium and 3% of phosphorus (Česká peleta). Briquettes, a bigger alternative to pellets, are made of sawdust, wood chips, wood shavings, barks and other vegetable waste. Pellets producers and sellers are associated within KLASTR ČESKÁ PELETA, z.s.p.o. Around 2/3 of pellets production is exported. The leading producers STORA ENSO WOOD PRODUCTS ŽDÍREC, s.r.o., BIOMAC, MAYR-MELNHOF and PFEIFER HOLZ.

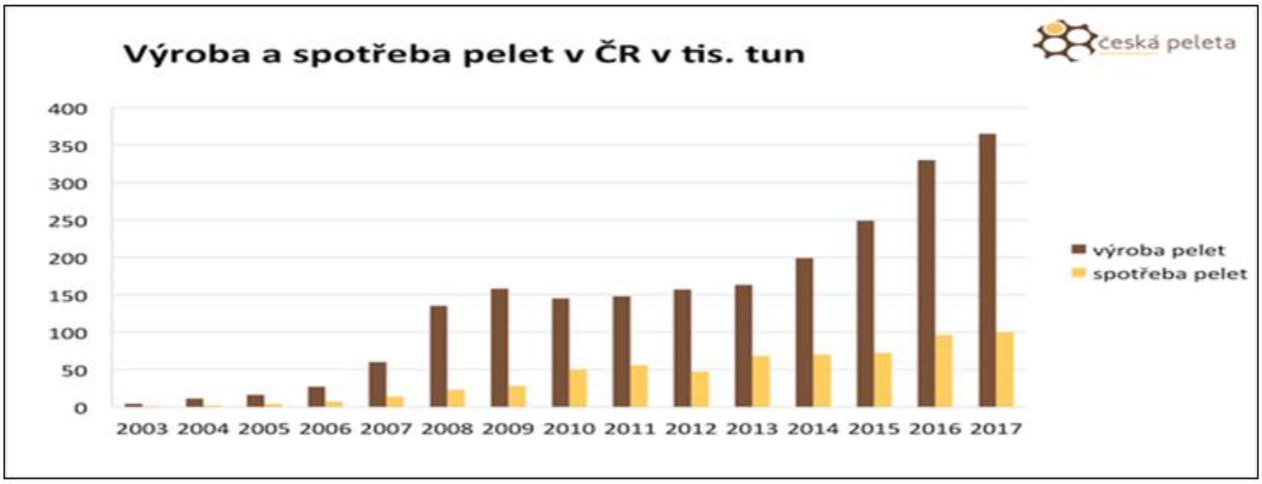


Figure 19 Production (brown) and consumption (yellow) of pellets in Czech Republic (in thousand ton)[47]

[46] See http://www.fao.org/forestry/energy/en/
[47] Source: Česká peleta

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## 3.4 Forest biomass mobilisation options

According to the numbers, there is high potential of forestry biomass mobilisation in the Czech Republic. Table 14 summarizes how the harvest levels and the total additionally harvestable stemwood and residue resource relate to the total yearly forest biomass increment. It becomes clear from this table that in almost all countries the common harvest levels are considerably below the yearly increment level, this also applies to Czech Republic, although relative harvest level is generally on the higher level in Europe comparable to that of Sweden. There is, however, still large room for increasing the removal rate taking account of the maximum additional harvestable potential (last 3 columns in Table 14). Part of the still lower current removal levels as compared to the forest increment can be explained by a skewed age structure in the forest population but may also refer to a large unused potential. Estimates using the S2BIOM methodology based on regions of the Czech Republic indicate both overall forest biomass potential and biomass potential not including roundwood (

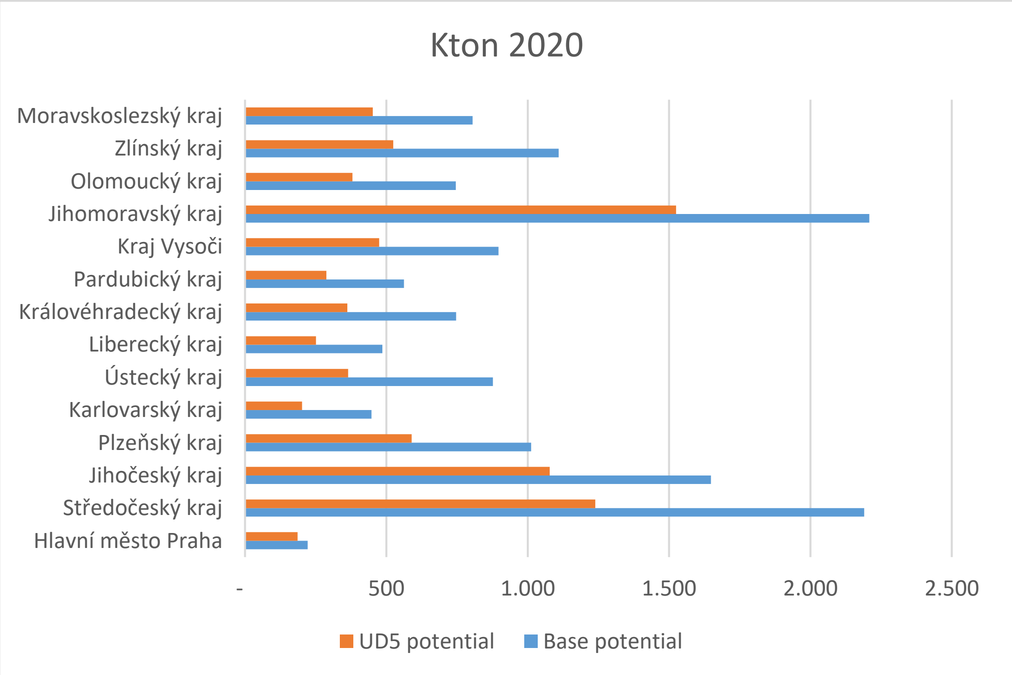


Figure 20).

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Table 14 2010, 2020 and 2030 EFI-GTM harvest levels expressed as % of yearly average biomass increment level in forests. (Source: Biomass Policies, Elbersen et al., 2016)[48]

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

[48] See https://greengain.eu/wp-content/uploads/2016/04/4_Elbersen_2016-10-21.pdf

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ES | **Spain** | **41%** | **39%** | **35%** | **73%** | **65%** | **60%** |
| SE | **Sweden** | **69%** | **62%** | **62%** | **93%** | **81%** | **77%** |
| UK | **United Kingdom** | **45%** | **47%** | **49%** | **80%** | **78%** | **84%** |


Figure 20 Forest biomass for the S2BIOM Base and UD5 (Roundwood for material use subtracted) potentials 2020

Even though forest biomass potential is high, existing barriers need to be overcome in order to mobilize it. Based on the PESTLE analysis, political, economic, social, technological, legislative, and environmental barriers were identified in the Czech forest sector.

**Summary of PESTLE barriers:**

- **Political: Department barriers**
- **Economic: Consumption habit barriers**
- **Social: Manpower shortage barriers**
- **Technological: connected with logging, transport (road load), storage, and production/recycling barriers**
- **Legislative: Absence of harmonization policy**
- **Environmental: Climatic barriers**

**Department barriers:** Nowadays, forestry, forest maintenance and all forest care up to timber logging fall under the Ministry of Agriculture; however, related activities from transport to subsequent processing of biomass are already included in the administration of the Ministry of Industry and Trade.

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Administration of employment and relations between employees and employers are under the responsibility of the Ministry of Labour and Social Affairs.

*Possibility for overcoming the barriers:*
- Active search for cooperation and synergies between the ministries concerned and collaboration on the acute issue of the bark beetle infestation. Cooperation on the preparation of the Circular Czechia 2040 strategy, which aims to identify priority areas and direction of development in the field of the circular economy (bioeconomy is understood as an integral part of circular economy). The document is being developed within the working group led by the Ministry of Environment.

- Declaring a state of emergency in connection with the negative impacts of bark beetle infestation, namely to both the production and non-production functions of the forest. An acknowledgement of the dynamics of climate change and its impact on the forest, followed by activities to anticipate risks and migration strategies are necessary.

**Consumption habit barriers:** These are often limited by the low level of knowledge of the current problems and a feeling of impossibility to influence the current situation. Customers do not recognize the benefits resulting from the demand for construction materials and products from local sources, and although the environmental awareness level has increased over the years, the adaptation to current problems, if they are not sufficiently comprehensively communicated, is slow.

*Possibility for overcoming the barriers:*
- Creation of an information campaign for the public with the support for local products purchase, and specifically bark beetle infested wood products. Appeal to support demand and processing of the Czech timber and purchase of wood products.

**Manpower shortage barriers:** The area of logging and the need for fast transport of logged biomass from the forest, is facing a lack of manpower. Given the low unemployment rate, this issue is timely, and representatives of timber companies have identified this aspect as a key to the possibility to logging. In particular, the problem is the inability to provide sufficient manpower from abroad. The whole process of work permit approval is assessed as extremely slow and inflexible. On the other hand, the bark beetle infestation is not only eminent, but also, in connection with the significant drought the Czech Republic, requires a more rapid response. The Ministry of Labour and Social Affairs (MLSA) has been relatively inefficient in communicating these issues with other ministries, currently there is no mitigation strategy, and thus it is only possible to observe a significant degree of inactivity with delayed foreign labour recruitment.

*Possibility for overcoming the barriers:*
- Quick action steps by the MLSA. Specific steps should be enacted to the acceleration of job placement with labourers from abroad.

**Technological barriers (connected with logging):** In the Czech Republic, there is a lack of technical equipment to continue logging to a sufficient extent due to over-limit amount of logged spruce timber. But, where the technical equipment is available, there is often missing qualified operators.

*Possibility for overcoming the barriers:*
- Operational loan of the equipment from abroad.
- Production of Czech made technical equipment.

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- Outsourcing of logging activities to foreign companies, without sales of the forest biomass.

**Transport barriers (road load):** Logging is followed by an extreme load on local roads from the forestry site. This situation is strongly accentuated by representatives of municipalities who are worried about damage to roads as the basic infrastructure.

*Possibility for overcoming the barriers:*
- Discussion with the Ministry of Transport and important local actors in the field of transport, and consider alternative means of transport, if possible (railway).
- Make available mobile saws and wood-processing equipment in the foresting sites to reduce excessive transport of logs and provide the post-logged remaining biomass, which is an important element for the management of forested land.

**Storage barriers:** Currently, there is an acute lack of areas for storage of debarked timber needed to dry; these are secured and paved areas or contrary, wet rooms, which are, however, more demanding and expensive to operate.

*Possibility for overcoming the barriers:*
- Cooperation with the national government and decide to set aside state property to provide these critical areas. Activation of a release of state property to address the issue.

**Production barriers:** To increase the material and economic value of the final products, several intermediate processing steps should be added. Such given steps require new, investment-related technology procedures. However, to finalize products with high-added value, it is necessary to go beyond standard practice and actively seek innovative technologies and processes that enable the Czech Republic to strengthen its position among other active European states. Support for complex bio-refineries also seems important; these can utilize biomass in a combined way, both materially (primarily) and energetically. For environmental impacts, experts assess the material utilization as more advantageous, because the fixation of $CO_2$ is not disturbed, which occurs in energy utilization. However, the latter is a suitable addition and this way of utilization can be evaluated as suitable for expansion with regard to the current rate of logging.

*Possibility for overcoming the barriers:*
- Creating a cluster/consortium/working group or other formal or informal collaborative unit, where players from each area would be represented looking for possible solutions together. Positive externalities of cooperation measurable in environmental indicators ($CO_2$ savings) and increased social responsibility can serve as motivation, as well as an economic impetus based on linked synergistic business relationships. Specifically, these are e.g. promise of demand from the private or public sectors when procuring buildings/furniture/other products made from local, bark beetle infested timber.
- Transition to circular public procurement, which, in addition to the environmental footprint aspect measurable in $CO_2$ production indicators, can take into account the timber sourced from sustainably managed forests, provision of service by the manufacturer/contractor of the construction throughout the life cycle, taking into account modularity, reparability, recyclability of the products, etc. These principles are tested abroad, and they are currently actively promoted by the Ministry of Labour and Social Affairs in the context of their responsible procurement agenda.

**Recycling Barriers:** Lack of recycling technology for bulk and wooden furniture. Most of waste of this kind is only landfilled, and a smaller part thereof is used for energy recovery. At the same time, the timber is possible to utilize as material in a form where the primary quality is not necessary.

*Possibility for overcoming the barriers:*
- Search for innovative wood-recycling technologies, cooperation between representatives of the academic sphere, sharing knowledge of circular economy even among other countries.

Only a few companies are using recycled timber in the Czech Republic. Kronospan CR (part of Kronospan company, the manufacturer of timber-based panels) produces chip boards utilizing 50% of recycled timber (imported from Germany and Austria) and plans to apply recycled timber into the oriented strand boards (OSB). Utilization of recycled wood in wood-based boards have positive impacts in terms of storage and the binding of $CO_2$. A life cycle analysis of OSB boards demonstrates that replacing 50% of natural fibre with recycled timber leads to a reduction in the loss of fossil resources, in greenhouse gas emissions, in acidification and a reduction of the overall negative impact on human health. According to Kronospan, as a result of using recycled timber in chip boards production, $CO_2$ emissions can be reduced by more than 88 000 ton/year (Gaff et al., 2018[49]). Additional companies using recycled timber - for construction flooring and roofing include Egger cz s.r.o., and customized furniture produced by www.woodcock.cz.

Figure 21 Recycled Wood Manufacture in Czech Republic

**Legislative barriers:** Missing harmonized forestry policy within the EU is seen as an obstacle to increasing sustainable recovery of forest biomass. Insufficient support for nature-friendly measures are important for adaptation to climate change. This is a weakness in the system to support separation and processing of timber waste.

*Possibility for overcoming the barriers:*
- Effective waste legislation and creation of a sophisticated separation system for used wood and timber products.
- Legislative support for material utilization of timber waste. Limiting the landfilling of timber waste significantly reduces greenhouse gas emissions in the atmosphere.

**Climatic barriers:** The extreme volume of the logged wood may lead to the creation of clearings, i.e. a space without forest cover, which becomes an important place of the so-called "thermal islands" formation, especially in the warm climatic periods. In these settings, the local water cycle is often disturbed, and young trees are exposed to extreme effects of the sun, causing them to die.

Barriers of undernourished forest land for new tree planting: Sustainable forest production requires increased return of biomass to the logging site (leaving the logging remains on site), which does not always correspond to real practices. The Czech Republic is threatened with high thermal load (thermal islands) on the clearings, i.e. places after logging trees without biomass cover. The logging remains are increasingly used for energy recovery, and there is a risk of exhaustion of ecosystem quality. Plant remains may seem meaningless if they are left in a field or soil, but they contribute

[49] Newly Developed Boards Made from Crushed Rapeseed Stalk and their Bendability Properties. Milan Gaff, Štěpán Hýsek, Adam Sikora, Marián Babiak. Bioresources. 2018. 13: 3.

significantly to the stability of the biomass production system. They protect against water and wind erosion, increase soil capacity to cumulate water, provide the soil with organic matter, and recycle nutrients.

*Possibility for overcoming the barriers:*
- Implementation of mitigation measures that have been already processed; only there is no effort for their fulfilment (e.g. quality fertilization of clearings and preparing the soil to retain enough water volume). Additionally, the selection of more drought-resistant trees/plants should be considered for re-seeding.

## 3.5 Summary and conclusions in relation to SWOT elements

Elimination of fossil resources and transition to a low carbon economy have become a global priority. The material with the highest potential to meet these goals is timber and wood-based products, and the Czech Republic has a long tradition in wood processing (Gaff et al. 2018), and it is also a big raw timber exporter. Due to the bark beetle infestation, millions of cubic meters of logged timber are available but there are not sufficient capacities to process or store them. Moreover, there are political, economic, social, technological, legislative and environmental barriers which need to be overcome in order to solve the current stalemate in the forestry sector.

Processing and production of timber products with high added economic and environmental value bring key opportunities to support the development in Czech forestry, as well as development of the timber recycling sector. An important aspect is the maximum possible reduction in transport distances and localization of timber processing within the same region. Regarding the EU's plan to move to a low-carbon economy, energy recovery is only a complementary option, since energy recovery of materials leads to $CO_2$ emissions. Specific opportunities are summarized into three key segments[50]:

***1) Application of quality wood in the construction industry.***
CLT (Cross-laminated timber) technology seems to be the most promising. This technology is widespread in many EU countries and is also behind current advanced trends of multi-story timber buildings. CLT has been considered as a standard material since 2005. Production is continuously growing, and it is becoming an important material in the construction industry as it represents an ecological and fully renewable alternative to conventional technologies (masonry, concrete) for the construction of multi-story buildings. The CLT production has already started in the Czech Republic (e.g. Agrop Nova Ptení and Stora Enso), and has initiated feasibility studies for a possible CLT unit in connection with its Ždírec sawmill.[51] In this context, it should also be noted that regarding the current state of transition to renewable resources, due to the incoming lack of building material not only at

[50] Jonáš, O. (2019): Identifikace potenciálních příležitostí v cirkulární ekonomice v lesnictví. MPO (2017): Panorama zpracovatelského průmyslu ČR 2017.

[51] See http://www.clt.info/en/news-pr/news/

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a global, but also at a European level, this material seems to be very promising for the Czech Republic as well.

***2) Furniture ecodesign – transition to renewable sources and design.***
The use of wood in the furniture industry seems quite apparent. However, it is necessary to point out that the ideas of wood usage collided with requirements of processors. The most significant companies that produce furniture and, thus, demand wood from the Czech forests apply transnational commitments to prefer wood from sources with the FSC certification. However, only about 2% of forests in the Czech Republic has the FSC certification, which is also the result of many years of struggle against this certification stemming from the past pressure of the certification bodies on the Czech producers who protested and established the PEFC certification.

The solution could be the development of innovation and cooperation between Czech forest owners, wood-processing industry and sellers. As they report, the technological advances include for example tailor-made production for a customer, who can, in addition, thanks to online programmes, adjust the colour, size or other characteristics of the products, to which the production can be tailor-made and finished in a very short time through robotization and digitization. Such an approach could be attractive to customers who could decide to use Czech wood for their ordered products.

***3) Agroforestry – Utilization of waste biomass for production of fortified fertilizers.***
In this field, the solution could be to find suitable technologies that could enrich the biomass, for example, with a digestate, to produce novel fertilizer formulations. Agriculture in the Czech Republic has been struggling for a long time with progressive soil degradation that is being caused by the lack of organic matter. Moreover, the application of barnyard manure (especially dung) and even digestate is often expensive because the digestate contains a high percentage of water and is expensive to transport, resulting in farmers choosing to use mineral fertilizers. When applying manure, specific agronomic procedures must be followed, and the field is necessary to be entered many times, which is sometimes not only economically inefficient, but also unecological as the soil is too compacted. Mixing of digestate with waste biomass and subsequent granulation could utilize both high added value material flows, and a finishing treatment could enable the application of such products with greater added value. These ideas also fit into an ever-increasing trend of agroforestry aiming, to seek synergies between these fields. In the future, this concept will be surely extended by holistically planned agriculture, silvopastoral grazing without the use of artificial fertilizers.

Finally, Czech forestry will need to adapt to the impacts of climate change currently manifesting due to deteriorating drought. This would continue to put undue stress on the current forest composition, and the possibility of deforestation may follow. Although, as highlighted in this chapter, the potential for wood biomass is not fully utilized. The current emphasis on management of the bark beetle situation seems to overshadow the overall management of forestry. Long-term planning of the forest, as well as stabilizing the wood industry value chain with the incorporation of current pest infestation, will be critical to fully utilize wood resources.

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Table 15 SWOT Analysis

| STRENGTHS | WEAKNESSES |
|---|---|
| • Strong tradition of forestry management<br>• Monitoring and surveillance of forest status | • Customer demand and appreciation for wood products is low<br>• Labor force in forestry is depleted<br>• Low level of in-country processing of wood and timber products – processing is exported |
| **OPPORTUNITIES** | **THREATS** |
| • Much under-utilized wood biomass<br>• Relatively open market for wood product development<br>• Lack of competition of novel technological solutions to the forestry-derived products and service<br>• Establish local saw mills and collective wood and timber processing centres in country | • Climate change effects lead to increasing drought and mild winters<br>• Weak containment of the bark beetle<br>• Lack of urgency in prioritizing forestry as a potential industry<br>• Decrease ground water due to current agricultural practices, leading to the forest drying |

# 4 Biomass supply: Waste

## 4.1 Introduction

Waste presents itself as a mobilizable source of biomass. From this study, data is made available for several classifications of biomass waste and its utilization. Data from paper and cardboard, animal and vegetable food waste, and finally sewage sludge are presented in this chapter. It should be noted that in general there is the assumption that the amount of waste and its use is underreported. Nevertheless, the largest potential, based on the numbers presented, could be seen in vegetable food waste. However, the landfilling, incineration, and other uses for sewage sludge are a considerable untapped resources.

Food waste is largely managed by municipalities through their waste collection systems. Although separate recycling bins are available in major cities, there is not universal separation categories for waste, and its adherence is not enforced. Much of the house-hold and restaurant waste will go in the general trash for either landfilling or incineration. Thus, the food waste is suspected to be grossly under-reported. The opportunity to harness animal and vegetable food waste would be at the municipal levels, which would include separate collection containers/facilities, combined with incentives and penalties to capture this biomass.

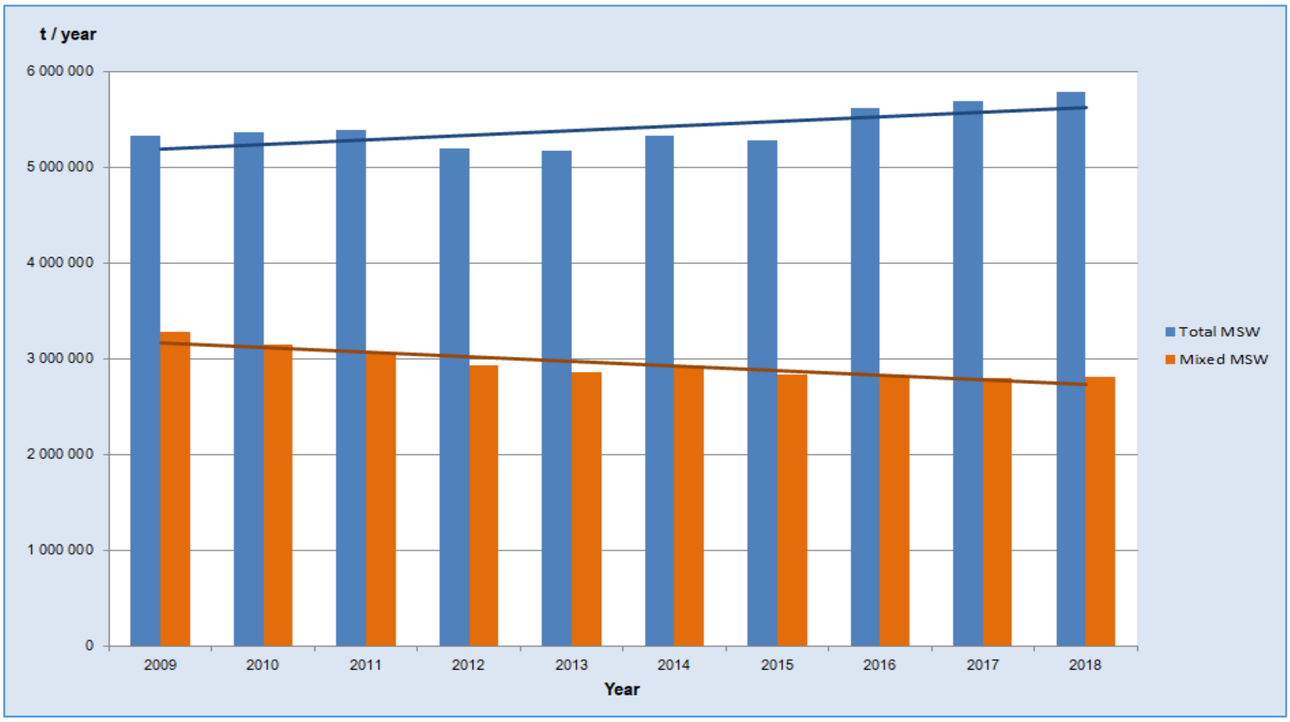

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Figure 22 shows that the dominant form of use for municipal waste continues to be through landfilling, although the material recovery rate has increase over the last decade.

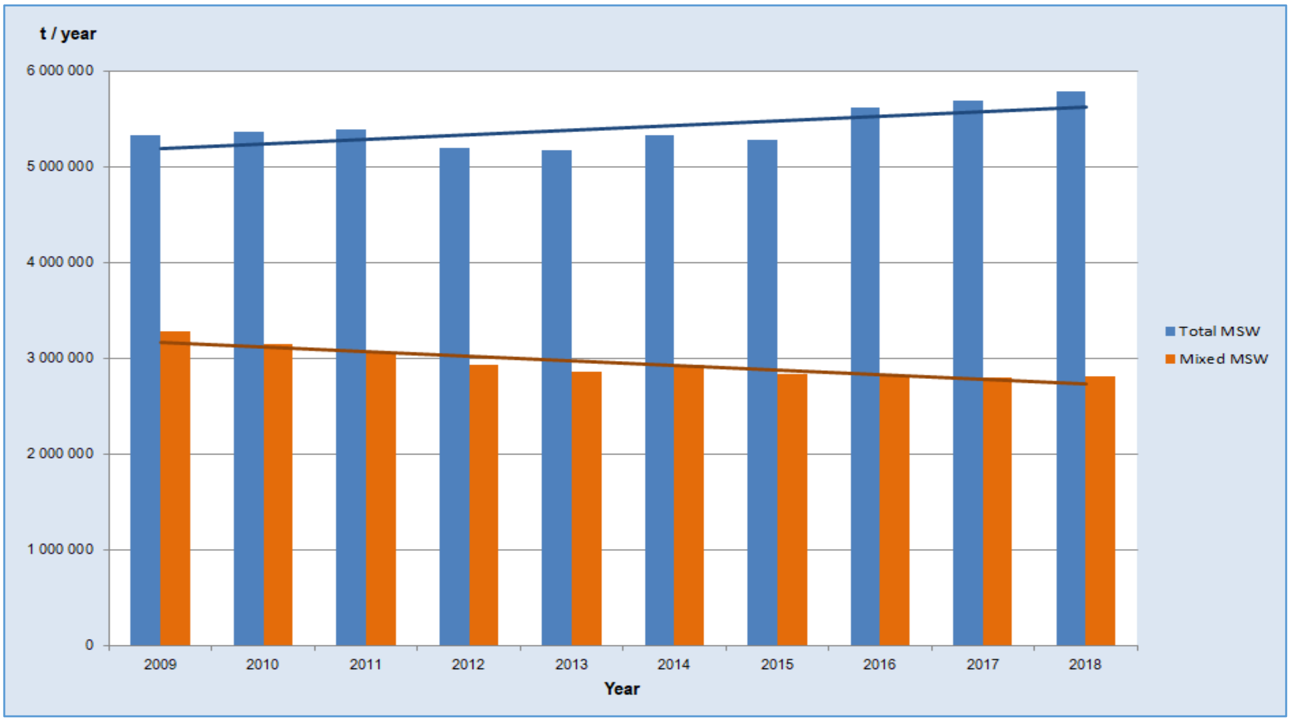
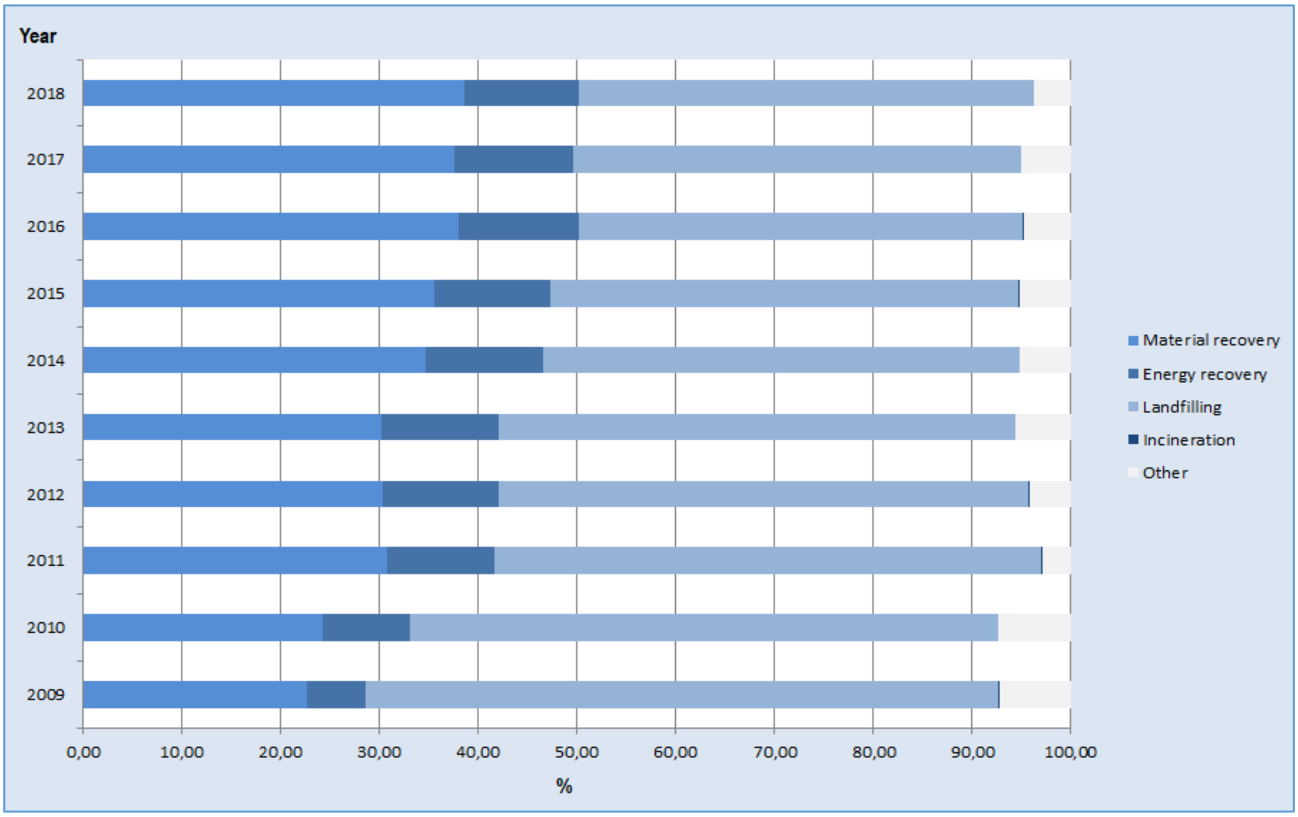



Figure 22 Municipal Waste (2009-2018); top graph shows total collected municipal waste of 5,78 Mton in 2018 (554 kg/inhab.); bottom graph shows use of municipal waste




*Source*: based on data from Environmental Statistical Yearbook 2018

## 4.2 Waste from biological resources

In order to calculate the potential waste from biological resources, the following approach was implemented:

1) First, the total waste generation per category of waste was taken.
2) Then, the waste treatment categories were identified per type of waste.
3) Waste treatment factors were applied to the total waste generated to identify which part is already going to alternative useful uses (e.g. compost, backfilling etc.) and which part of the waste is available for further conversion into energy or other future bioeconomy uses. So the part already going to energy is also perceived to be available as part of the potential.

The total waste generation reported by Eurostat in Table 16 (last column) is only the basis for assessing the biomass potential in this study. The waste assessment was done for 2010, but for several countries the waste generation data from Eurostat were fully (for all categories of waste) or partly (for some categories of waste) replaced by national figures of waste generation. A distinction is made between data used to determine the total waste generation and data to determine the current waste treatments. The latter figures determine the final potential. The geographic distribution of the bio-waste potential is displayed (Figure 23).

Table 16 Biowaste unseparately and separately collected Kton d.m. (S2BIOM Base potential 2020)

| Region | Biowaste unseparately collected | Biowaste separately collected | Total |
|---|---|---|---|
| Prague city | 65 | 35 | 101 |
| Central Bohemian region | 67 | 36 | 104 |
| South Bohemian region | 34 | 18 | 52 |
| Pilsen region | 30 | 16 | 46 |
| Karlovy Vary region | 16 | 9 | 25 |
| Usti region | 44 | 24 | 67 |
| Liberec region | 23 | 12 | 36 |
| Hradec Kralove region | 29 | 16 | 45 |
| Pardubice region | 27 | 15 | 42 |
| Vysočina region | 27 | 15 | 42 |
| South Moravian region | 62 | 33 | 95 |
| Olomouc region | 34 | 18 | 52 |
| Zlin region | 31 | 17 | 48 |
| Moravian-Silesian region | 65 | 35 | 100 |
| **Total** | 554 | 298 | 852 |

Post-consumer wood was further calculated using the S2BIOM methodology by regions of the Czech Republic (Table 17), and geographic distribution displayed (Figure 24).

Table 17 Hazardous and non-hazardous post-consumer wood Kton (S2BIOM Base potential 2020)

| Region | Hazardous post consumer wood | Non hazardous post consumer wood | Total |
|---|---|---|---|
| Prague city | 7 | 29 | 36 |
| Central Bohemia | 8 | 30 | 38 |
| South Bohemia | 4 | 15 | 19 |
| Pilzen region | 3 | 13 | 17 |
| Karlovy Vary region | 2 | 7 | 9 |
| Usti region | 5 | 19 | 24 |
| Liberec region | 3 | 10 | 13 |
| Hradec Kralov | 3 | 13 | 16 |
| Pardubice region | 3 | 12 | 15 |
| Vysočina region | 3 | 12 | 15 |
| South Moravian region | 7 | 27 | 34 |
| Olomouc region | 4 | 15 | 19 |
| Zlin region | 3 | 14 | 17 |
| Moravian-Silesian region | 7 | 29 | 36 |
| **Total** | 62 | 247 | 309 |

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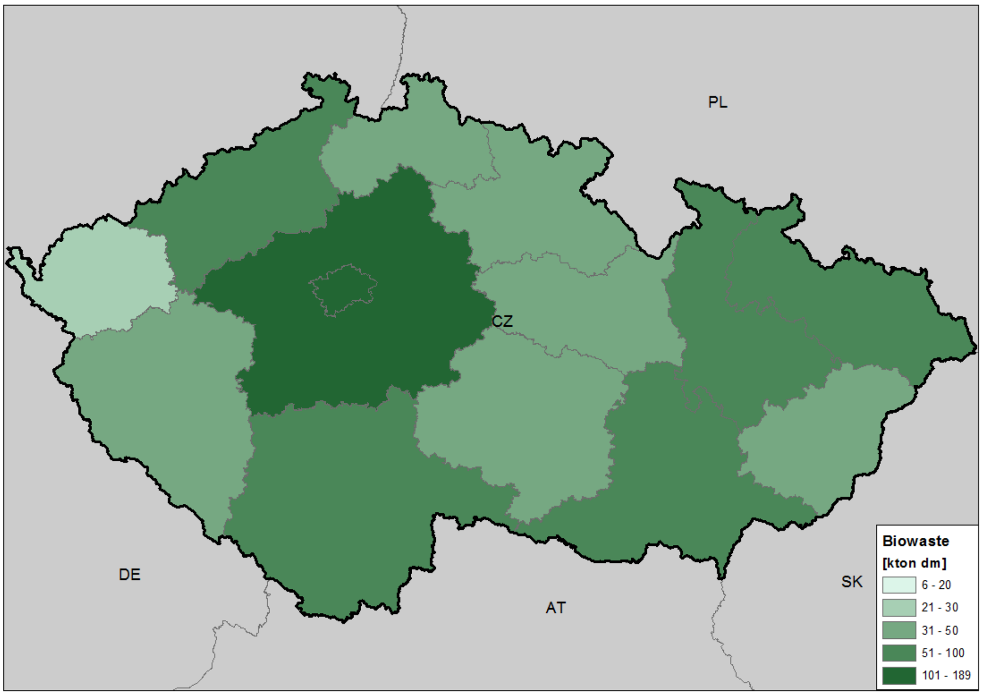


Figure 23 Distribution of total bio-waste potential over country

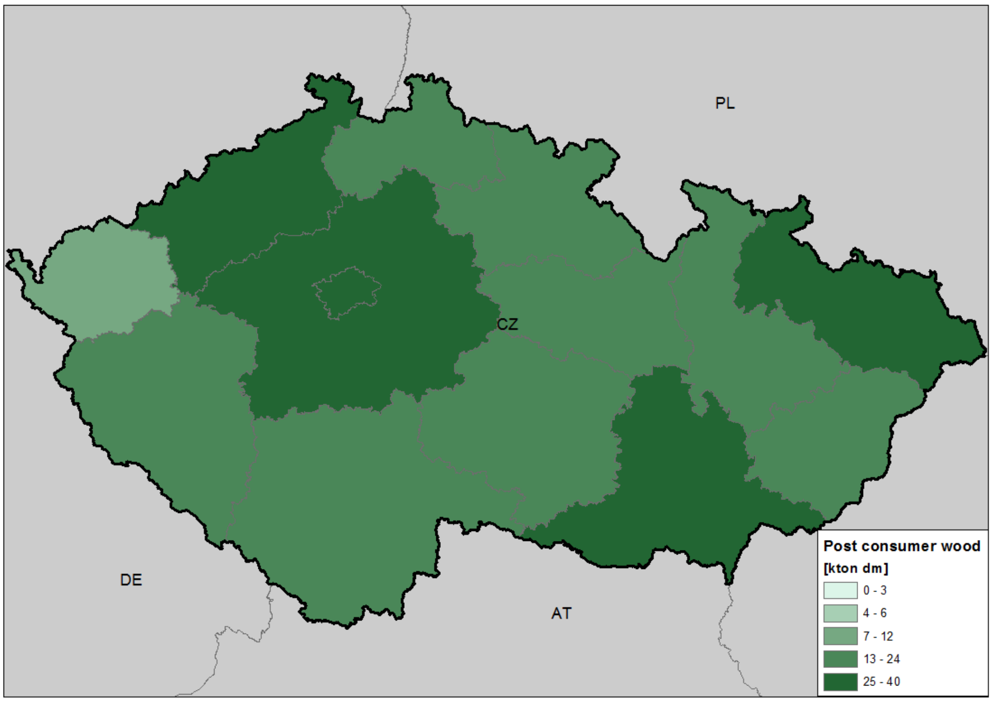


Figure 24 Distribution of total post-consumer timber potential over country

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## 4.3 Current waste treatment and unused potential estimates

Current disposal methods for sewage sludge include landfill, incineration, composting, and agricultural use.

Table 18 displays the total sewage sludge production by regions of Czech Republic and their method of utilization. The key opportunity will be with new uses of sewage waste, particularly as an energy source, such as for biogas conversion near municipalities. The inclusion of recycled food from potential municipality collections, could be further processed for biogas conversion, would create an incentive to establish means for food-waste collection which is absent in my cities across Czech Republic.

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Table 18 Sewage Sludge Production and Disposal for 2018 (tonnes d.m./year)

| SEWAGE SLUDGE | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | Tonnes of dry matter |
| | Method of sludge disposal | | | | | |
| **Region** | **Total sludge production** | **Agricultural use** | **Composting** | **Landfilling** | **Incinerating** | **Other** |
| ***Czech Republic*** | **202 358** | **88 883** | **64 515** | **17 728** | **19 440** | **11 792** |
| Prague city | **21 865** | 19 621 | 1 681 | 0 | 0 | 563 |
| Central Bohemia region | **20 681** | 5 013 | 13 159 | 2 215 | 0 | 294 |
| South Bohemia region | **12 627** | 6 737 | 5 647 | 59 | 0 | 184 |
| Pilzen region | **8 843** | 5 783 | 2 237 | 535 | 0 | 288 |
| Karlovy Vary region | **4 144** | 0 | 1 710 | 1 006 | 39 | 1 389 |
| Usti region | **35 307** | 14 743 | 216 | 4 980 | 15 255 | 113 |
| Liberec region | **4 933** | 4 589 | 0 | 269 | 1 | 74 |
| Hradec Kralove region | **9 277** | 3 696 | 4 790 | 258 | 0 | 533 |
| Pardubice region | **7 702** | 747 | 2 342 | 389 | 0 | 4 224 |
| Vysočina region | **7 155** | 3 391 | 3 236 | 99 | 0 | 429 |
| Southern Moravia region | **20 261** | 1 780 | 13 095 | 298 | 2 534 | 2 554 |
| Olomouc region | **10 175** | 6 843 | 2 312 | 507 | 0 | 513 |
| Zlin region | **14 943** | 5 238 | 1 943 | 6 005 | 1 611 | 146 |
| Moravian-Silesian region | **24 445** | 10 702 | 12 147 | 1 108 | 0 | 488 |

Source: 2018 data Czech Office of Statistics

Additionally, the used cooking oil, is currently not tracked for its end-use, although for year 2018, cooking oil waste was assessed at 3 405 tonnes (Source: CZOS). Some innovative companies in Czech Republic have developed processes to convert used cooking oil to bioplastics. More data should be collected on the end-uses of these oils. Currently, data from the few bioplastics companies within the country have been difficult to ascertain, presumably due to the early-stage development and competition within this sector.

## 4.4 Summary and conclusions in relation to SWOT elements

Table 19 SWOT Analysis

| STRENGTHS | WEAKNESSES |
|---|---|
| • Sludge is controlled by the municipalities, the accounting for its production and usage is likely to be reliable.<br>• There is a trend to decrease landfilling | • Food waste, the majority of this biomass remains unused.<br>• The recording of waste materials are extensive for Czech Republic, however these data are dependent on the reporting of the individual actors which can be variable. |
| **OPPORTUNITIES** | **THREATS** |
| • A key opportunity will be the installation of new infrastructures within and around municipalities to harness both sludge and recycled food waste.<br>• New legislation will need to put in place to recycle organic waste and use of the biomethane for public transport vehicles in cities. | • The main threat is political inaction and unwillingness to incorporate measures which may undercut existing business interests, even though the social, environment, and/or economic benefits favor a changed approach. |

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# 5 BIO-BASED PRODUCTS INDUSTRIES AND MARKETS

Conversion of biomass into secondary products which are in demand by either business or customers, are a key step in the value chain of the bioeconomy. The Czech Republic has a long-history of success during the age of industrial manufacturing. In this chapter we examine the current state of bio-based products within the country and suggest areas of opportunity, given the available primary biomass resources and the existing expertise of the population.

## 5.1 CURRENT BIO-BASED INDUSTRIES

**Textiles**

Czech Republic in the early part of the 20th Century had a robust textile industry. In 2017 Czech companies sold fibres, textiles and clothing worth 55.3 billion CzK, according to a survey carried out by the Czech Association of Textile, Clothing and Leather Industries (ATOK).

The results were fuelled mainly by the fast growing economy and by the focus on technical textiles, which are used in the automobile industry, agriculture, health-care and aviation, which could present as an opportunity of the bio-based textiles.

Several companies operate from the Czech Republic utilizing biomaterial as a source for textile development. Some of these companies are using biological textile waste as a source for material to be re-used in construction or insulation, included in the value chain is sourcing, waste process, and finishing the materials. The source of the materials could be from wool, hemp fiber, flax fiber, cellulose, and used rugs or other textiles. The company Lenzing Biocel Paskov a.s. from the Lenzing group is the fourth biggest producer of dissolving pulp from wood in Europe. The whole production is exported nowadays. There is an opportunity to process dissolving pulp into textile fibers in the Czech Republic.

Hemp is currently cultivated on approx. 500 hectares, however the demand for hemp related products exceeds the current levels of production. The majority of the hemp products, including seeds, oil, CBD, as well as fibers are imported from either Canada, China or Lithuania. The example from Lithuania claims that 1 hectare of grains generates 300 euros of profit, while the same amount of land planted with hemp would generate around 1500 euros of profit. With the increased use of hemp in interiors of the automobile manufacturing industry would, additionally lend itself to increase the output of hemp in Czech Republic. A Hemp Cluster is currently present which include businesses which incorporate hemp in several consumer products such as cosmetics, food additives, insulation materials. The barriers of legislative guidance on THC-levels would need to be standardized to support this market. Also, an investment in machinery to farm and process hemp in regional hubs would support this effort. Currently, experimental remediation using hemp for soil restoration is being tested in abandoned coal mines.

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### Biotechnology

Recently, a few good examples of biotechnology-related achievements oriented towards three areas: nanotechnology, pure biotechnology and human health care, for which the global market is the primary target.

Nanotechnology is a promising Czech inventory sector, recently expanding from the traditional chemical structures to biological materials (hyaluronic acid) with Contipro launch of a patented multi-nozzle system. Contipro is one of the world's leading manufacturers of hyaluronic acid and derived applications. Elmarco's Nanospider technology, a process for producing a range of organic and inorganic nanofibers, has scaled up from the laboratory to industrial production. These inventions brought already more than 50 patents and Czech nanotech companies are the world leaders today.

Elmarco Nanospider Technology was managed by the Nafigate Corp. This company is involved in another promising biotechnological project - original microbial biotechnology for conversion of waste frying oils into bacterial bioplastics called polyhydroxyalkanoates (PHA).

There are a number of medical biotechnology companies in Czech Republic, the most successful focus on immune-cell therapies for treatment of cancers. There are a number of companies producing veterinary products, as well as some molecular biology reagent manufactures (Table 20).

Table 20 Featuring biotechnology companies in Czech Republic[1].

| | Company | Specialization |
|---|---|---|
| Czech Republic | Sotio<br>www.sotio.com | Advanced cell immunotherapy R&D using activated dendritic cells; Phase 3 trials for prostate cancer |
| | AB Check<br>http://abcheck.eu | Human antibody technologies; Phase 2 trials for lymphomas, owned by Affimed |
| | Contipro<br>www.contipro.com | Sales and formulation of Hyaluronic Acid for use in wound-healing, cosmetics, and veterinary products |
| | Bioveta<br>www.bioveta.eu/en | Sales of a wide range of animal products, and some bacterial lysates for humans |
| | Dyntec<br>www.dyntec.cz | Vaccine R&D, and sales of bacterial and viral lysates |
| | Biopharm<br>www.bri.cz/en | Distribution of veterinary products and vaccine R&D |
| | Erban Lachema<br>www.erbalachema.com | Analysis of urine, blood chemistry, microbiology, immunology, etc. |
| | Generi Biotech<br>http://www.generi-biotech.com/generi-biotech-en/ | Services for genetic, oncology, and microbiologic diseases |
| | BioVendor<br>www.biovendor.com | Developing and manufacturing *in vitro* diagnostic and for-research-use immunoassays, antibodies, and recombinant proteins |
| | Protean<br>www.protean.bio/en | Antibody, enzymes, transcription factor, custom protein production; services for diagnosis in stomatology and tick-borne diseases |
| | GenTrend<br>www.gentrend.cz/en | Services for diagnosis in stomatology and tick-bome diseases |
| | Exbio<br>www.exbio.cz/ | Antibody sales for laboratory use and diagnostics development |
| | Bio Agens Research and Development – BARD<br>www.pythium.eu/ | Over the counter fomulations of the microorganism Pythium oligandrum used to treat pathogenic surface fungi |
| | Nafigate Corporation<br>www.nafigate.com/en/ | Hydal biotechnology – biodegradable polymer derived from cooking oil waste, for use in applications such as food packaging |
| | LentiKat's Biotechnologies<br>www.lentikats.eu/en/ | Applications in wastewater treatment, distilleries, and chemicals for food and pharmaceutical supplements |
| | Enantis<br>www.enantis.com | Modification of protein properties, such as thermal stability, protease or solvent resistance, for use in environmental and medical functions |
| | Bor Biotechnology<br>www.borbiotechnology.cz/en/ | Build and operate eco-facilities for generation of electricity and heat from wood chips |
| | i2L Research<br>www.i2lresearch.com/ | Facilities and service provider in plant chemical testing, and insect sales |

### Bioplastics

Although there are a number of plastics producers in the Czech Republic, there is a growing trend of bioplastics manufactures additionally present. New entrants to this market will see an increase in output and eventual competition for this sector. It should be noted that no all "bioplastics" are similarly biodegradable, and the details of the chemistry used in creating such polymers are an important environmental factor to take into consideration. Currently, there are no incentives to recycle these materials, nor is there currently enough customer demand to mandate supermarkets use of "bioplastics". However, a proposal by the Ministry of Environment has been presented, which would ban the use of single-use plastics.

### Furniture and Construction

The utilization of wood in Czech Republic primarily goes toward the furniture making industry and lumber for construction. This is a fairly traditional sector, with a minor segment used to produce pellets for heating. Further restrictions should be applied to the burning of stemwood for heating, as benzo(a)pyrene levels are above acceptable limits for the majority of the population in Czech Republic, where emissions come primarily from household heating (98.4% in 2016).

There is certainly room for new entrants with creative uses for wood, especially in the areas of novel packaging of consumer goods.

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

### Novel Engineering

A significant opportunity for Czech Republic remains the world-class position of the country's engineers. Not much has been dedicated to the machines and devices needed to operate an efficient bioeconomy, as focus has been on the biomass, which may be due to the early stage of some these enterprises. A platform for addressing upcoming problems and barriers to the automation of bioeconomic value chains would lend itself to the challenges of finding engineering solutions. Such a platform would not only serve the Czech Republic's labour market, but also the sales of such devices and machines would spur the bioeconomies of other countries. For example, the design of machines to help sort waste, or to improve the harvest of non-conventional agricultural crops. Finding solutions to improve the bioeconomy value chains and accessibility would further overcome the inherent economic barriers to foster the transition toward bio-based materials.

## 5.3 Future biomass valorization options

Biomass valorization has numerous opportunities in the Czech Republic including, solid biomass combustion with wood waste, pyrolysis to convert biomass into syngas and biochar, or hydrolysis to sugars. Many of these processes would need investment into infrastructure. As for the sugar industry, it used to be very developed, although it is an example of foreign companies having consolidated the sector, with sugar hydrolysis taking place primarily in foreign countries.

**Wood pyrolysis**

The level of forested areas in Czech Republic with wood marked by bark beetle infestations would be a clear source of biomass for biochar. The current state of soil quality in the country may benefit from biochar to help in water retention and increase the nutrient content in agricultural lands. Pilot projects should be initiated for creative, environmentally sound concepts to restore soil and water on agricultural lands, although barriers to entry include the economic price point for biochar.

**Manure**

Currently the management of cow and pig manure is being handled at the farm site. It is assumed that some of the manure is reincorporated into the fields, however the data are incomplete. The introduction of anaerobic "closed-loop" digesters would allow for a utilization of manure as an additional source biogas.

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## 5.4 Summary and Conclusions in Relation to SWOT Elements

Table 21 SWOT Analysis

| | |
|---|---|
| **STRENGTHS**<br>• Czech Republic has a large number of biogas facilities.<br>• Strong tradition and skill set in textiles and engineering | **WEAKNESSES**<br>• Underdevelopment of innovative solutions and willingness to try new concepts. |
| **OPPORTUNITIES**<br>• Engineering new tools and machines for the automation of processes of bioeconomic sectors.<br>• The Czech organic food market is still underdeveloped, the share of organic food in the total consumption of food and beverages was only 0.9%.<br>• The "bioplastics"/alternative packaging market can be further developed.<br>• The availability of used cooking oil may be a good source of unused biomass.<br>• The use of residual wood can be used for any novel business ideas, as this resource seems under-utilized.<br>• The Czech Republic is the leading producer of poppy seeds, with 31% of global poppy seeds production. The poppy seed crop grown in the Czech Republic is mainly produced for export.<br>• Abandoned mining lands offer the opportunity to reclaim such lands through remediation crops, such as hemp or Calotropis gigantean.<br>• Hemp molded interiors for vehicle assembly,as the demand for industrial textiles is increasing due to the car industry. | **THREATS**<br>• Soil erosion and contamination of soil through increased chemical fertilizers and pesticide use.<br>• Overall land contamination, without remediation will reduce the overall output of biomass in agricultural lands.<br>• The water stress and lack of adequate management of the bark beetle, will significantly reduce forestry stocks. |

# 6 INFRASTRUCTURE, LOGISTICS AND ENERGY SECTOR

In this chapter, we introduce the infrastructure, transport networks and bio-based energy sector. The Czech Republic is very developed in infrastructure, with an extensive network of train and roads which are in very good condition. The use of biomass for energy is not uncommon for the country, however there are a few dominant players which act throughout the value chain. One note, is that the biogas sector is in a very developed state in the country, with widespread penetration within the market.

## 6.1 EXISTING INDUSTRIAL HUBS AND HARBOURS

A main fuel hub in the Czech Republic is in the northern part of the country around the city of Usti nad Labem (Figure 25). Here you will find several companies dedicated to fuel refining, as well as utilization of biomass as a feedstock. The primary feedstock for biofuels in the Czech Republic is rapeseed, of which 1.2 Mton is harvested annually, with an additional 40 th. ton of sunflower seed, and 15 th. ton of soy. Waterways are not significant transport avenue for primary feedstock, but rather the good network of roads and rail.

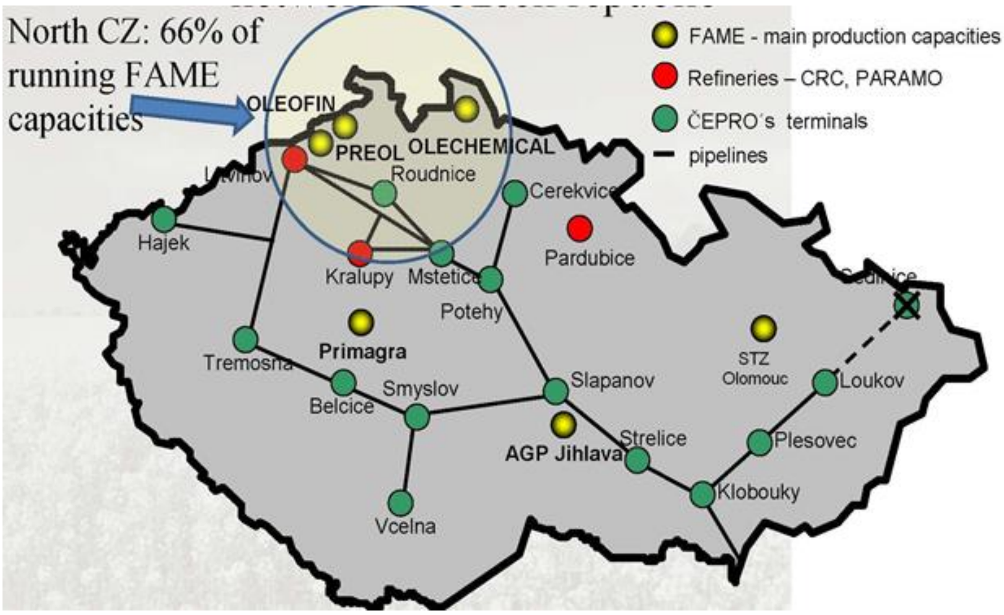


Figure 25 Fuels and biofuels – storage and distribution networks in Czech Republic.

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Czech Republic has 574 biogas plants, distributed all over the country. The primary source materials are from agricultural biomass residues, but also for municipal and industrial waste, waste water, and landfill (Figure 26).

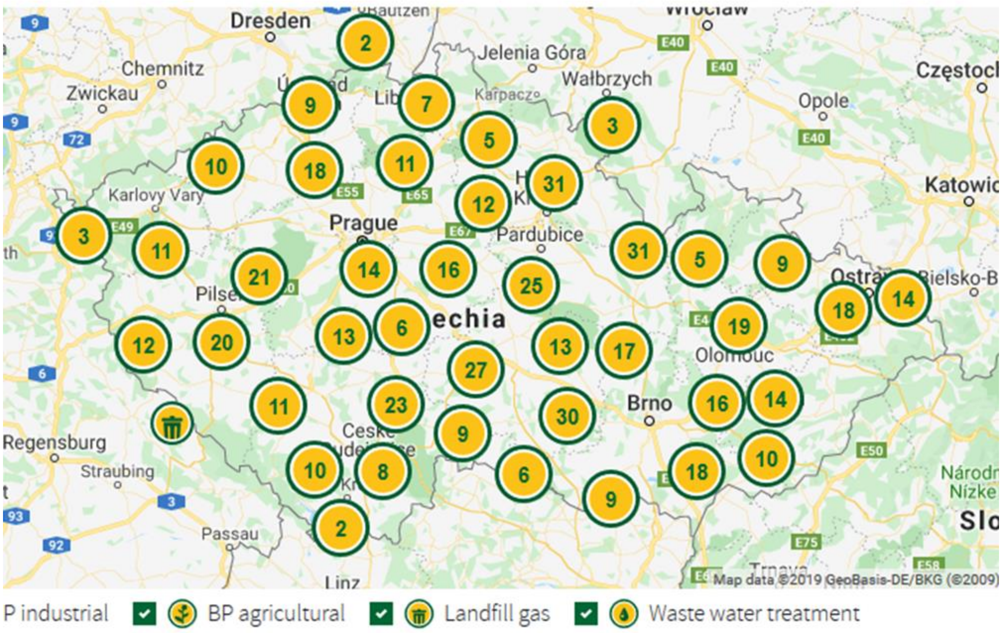


Figure 26 Map of biogas plants in the Czech Republic

## 6.2 Existing railway

Rail transport in the Czech Republic carried 162.906 million passengers and 68,37 Mton of cargo in the year 2009.[52] The majority of passenger services run nowadays are operated by the state company České dráhy (Czech Railways), which until 2007 also managed cargo services now run by ČD Cargo. In 2009 the country had 9.420 km of standard gauge track, 3.153 km of which is electrified (Figure 27). There are two main electrification systems in the Czech Republic, 3 kV DC in the northern part, and 25 kV 50 Hz AC in the south (in addition, one historical 24 km long line uses 1,5 kV DC; and since 2009 one short local line to Austria uses 15 kV 16,7 Hz AC).

[52] České dráhy Group, Statistical Yearbook 2009, available online on http://www.cd.cz

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Figure 27 Network of Railways in Czech Republic

## 6.3 EXISTING ROAD AND INFRASTRUCTURE

Highways in the Czech Republic are managed by the state-owned Road and Motorway Directorate of the Czech Republic – ŘSD ČR, established in 1997. The ŘSD currently (2018) manages and maintains 1 250 km of motorways (dálnice), whose speed limit is of 130 km/h or 80 mph (or 80 km/h or 50 mph within a town).[53] The present-day national motorway network is due to be of about 2 000 km before 2030. Although highway connection exist on routes to Nurnberg, Dresden, Bratislava, and Katowice, the highway connect to Vienna and Linz remain to be built (Figure 28).

[53] *České dálnice. Available online at: http://www.ceskedalnice.cz*

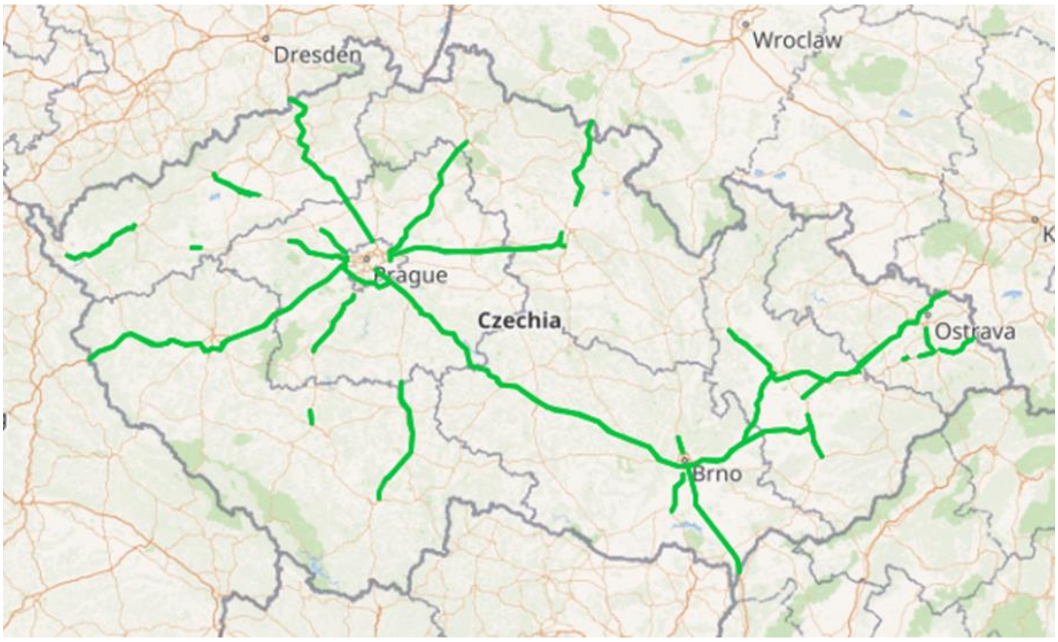


Figure 28 Network of Highways in Czech Republic

## 6.4 ENERGY SECTOR

In 2017, Czech gross electricity production reached 87 TWh (terawatt-hours), while domestic consumption was around 74 TWh. The Czech energy mix was made up of 57,4% fossil fuels (44% lignite, 5.5% natural gas, 5,4% bituminous coal, etc.), 35% nuclear power, and 7,6% renewable energies (3.6% biomass, 2,1% solar, 1,4% hydro, 0,45% wind energy, etc.). The country's 13 TWh surplus was exported to neighboring countries. As such, the Czech Republic is the ninth largest electricity exporter in the world and the third-largest in the EU.54

Heat in the Czech Republic is produced mainly by the combustion of brown coal (43.3%) or natural gas (30.1%), which is the predominant fuel for domestic boilers and small heat generation systems. The conversion to more renewable sources of energy, and the reduction of the dependence on coal, would suggest an increased demand in biomass as a source for heating.

**Leading Sub-Sector**

Coal still provides the majority of fuel used in Czech power generation. While Czech coal production has declined from 13 Mton in 2007 to 8 Mton in 2017, coal imports are increasing, especially from Poland and Germany. Some coal imports are sourced from the United States. The Czech Republic has no significant production of natural gas or oil and is fully dependent on gas and oil imports. The country is integrated into regional transmission systems and can purchase oil and gas from different countries based upon on market prices in Rotterdam or elsewhere. The majority of oil and gas is

[54] Czech Republic – Energy, Primacy Shield Framework, Available online at: https://www.privacyshield.gov/article?id=Czech-Republic-Energy

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imported via Germany and Russia. The Czech Republic has two nuclear power plants at Dukovany and Temelin, which delivered over 28 TWh of electricity in 2017. Both plants were designed and built and designed in the 1980s and rely on Soviet-era technology. Russia provides fuel for both plants. The reactors at Dukovany are expected to remain in operation until 2035, and Temelin's reactors until the 2040s, but all will ultimately need to be replaced.

The Czech government has placed a priority on nuclear power. The country's June 2015 Czech National Action Plan for Nuclear Energy states that nuclear energy should constitute about 50 percent of the Czech energy mix by 2040. CEZ, the state-controlled operator of the current reactors, launched a tender for new reactors.

Despite strong and long-standing government and public support for nuclear power, the strategy of building a new unit at the Dukovany Nuclear Power Plant has not yet translated into an offer of state financial support for the project. The Czech Republic sees the expansion of nuclear power production as an energy security imperative to maintain its position as an electricity exporter, while phasing out old coal-fired power plants. The government is wary of promoting gas power plants as this could increase Czech dependency on Russian gas. The European Union and the Czech Government support conservation efforts and increasing the use of renewable energy sources. To meet EU and Czech targets, the country will likely need to invest $3 billion annually through 2030. Such funding should provide opportunities for innovative technologies and smart solutions.

An overview of the energy profiles of Czech Republic, as compared to the EU is presented in Table 22.

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Table 22 Czech Republic and EU Energy Profile

| Category | Czech Republic | EU average | Unit | Assessment | Similar countries |
|---|---|---|---|---|---|
| **3. Energy** | | | | | |
| Primary energy consumption | 3.86 (2015) | 3.22 | toe/capita (2012) | Medium | ES, FR, PL, SI, SK, ME |
| Energy dependence | 35% (2016) | 55.4 | % | Medium | |
| Renewable energy share | 14.9% (2016) | 17.9 | % | Medium | |
| GHG emissions | 12.2 (2017) | 9.47 | ton $CO_2$-eq/capita | Medium | |
| **8. Renewable energy (RE)** | | | | | |
| Bioenergy in RE | 88% | 69% | % | Medium | FR, SI |
| Bioenergy in total energy | 7.9% | 10.6% | % | Medium | |
| **9. Energy infrastructure** | | | | | |
| Biofuels prod. Capacity | 0.057 | 0.051 | ton/capita | Low | |
| CHP | 13.7% | 17.3% | % gross electricity generation | Low | |
| District heating | 7,738 | 7,404 | km | | |
| | 0,7 | 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

### Ethanol

In 2015, the Czech Republic produced 104,715 Mton of bioethanol (Table 23). The main feedstock used in its production was sugar beet (55%), corn (45%). Production capacities involve 4 ethanol plants that could together produce nearly 300,000 MT of bioethanol annually. In 2015, as well as in 2014, only 2 of them were operating.

E85 consumption in 2014 totaled 23,288 MT. In 2015 it dropped to 12,329 MT. Recent increase in biofuel excise taxes increased price of E85 resulting in a significant drop in demand. Many distributors drastically reduced their E85 stocks and stopped offering this high-percentage biofuel. A map of gas stations, where the E85 is available can be found at http://www.bioethanole85.cz/cerpaci-stanice-e85.

Table 23 Production and consumption of bioethanol in the Czech Republic (2011-2015)

| Year | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|
| Production (MT) | 54,412 | 102,195 | 104,488 | 104,112 | 104,715 |
| Consumption (MT) | 78,961 | 89,592 | 86,432 | 119,042 | 119,548 |

*Source: Ministry of Industry and Trade, www.mpo.cz*

### Biodiesel

Production capacities for biodiesel consist of 5 major plants and a few small scale ones, totaling at slightly over 400,000 Mton potential per year. In 2015 only 3 of them produced biodiesel. Czech biodiesel production in 2015 reached 167,646 Mton, with rapeseed the main feedstock (Table 24). The biofuel industry supports 8 000 jobs with an annual turn-over of 420 M €.

Table 24 Production and consumption of biodiesel in the Czech Republic (2011-2015)

| Year | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|
| Production (MT) | 210,092 | 172,729 | 181,694 | 219,316 | 167,646 |
| Consumption (MT) | 245,216 | 242,267 | 228,084 | 300,413 | 277,268 |

*Source: Ministry of Industry and Trade, www.mpo.cz*

### Advanced Biofuels

There is one plant (Oleo Chemical) producing biodiesel from animal fat from a rendering plant in the Czech Republic. Its capacity is reported in the media at 62,000 Mton per year. The production is estimated to be lower than what the full capacity would allow. It has been used for export to other European member states so far.

### Biomass for Heat and Power

Use of biomass for renewable electricity and heat production has been increasing, with corn silage and agricultural waste the main feedstock. According to data published by the Czech Ministry and Trade, deliveries of electric energy produced from biomass to the grid reached 1,120,003.4 MWh in 2014. Heat production from biomass amounted to 20,368,960.5 GJ in 2014.

## Biogas

Biogas has good potential in the Czech Republic and the production and number of biogas stations keep rising. Agricultural biogas stations produce approximately 88 percent of biogas in the Czech Republic. The primary feed stock is corn silage, with some use of hay and straw, industrial and municipal waste. Electricity produced from biogas in the Czech Republic reached 2 637 GWH, and the amount of installed power is 366 MW for 2017 (Figure 29). The biogas industry supports 4 300 jobs with an annual turn-over of 240 M €.[55]

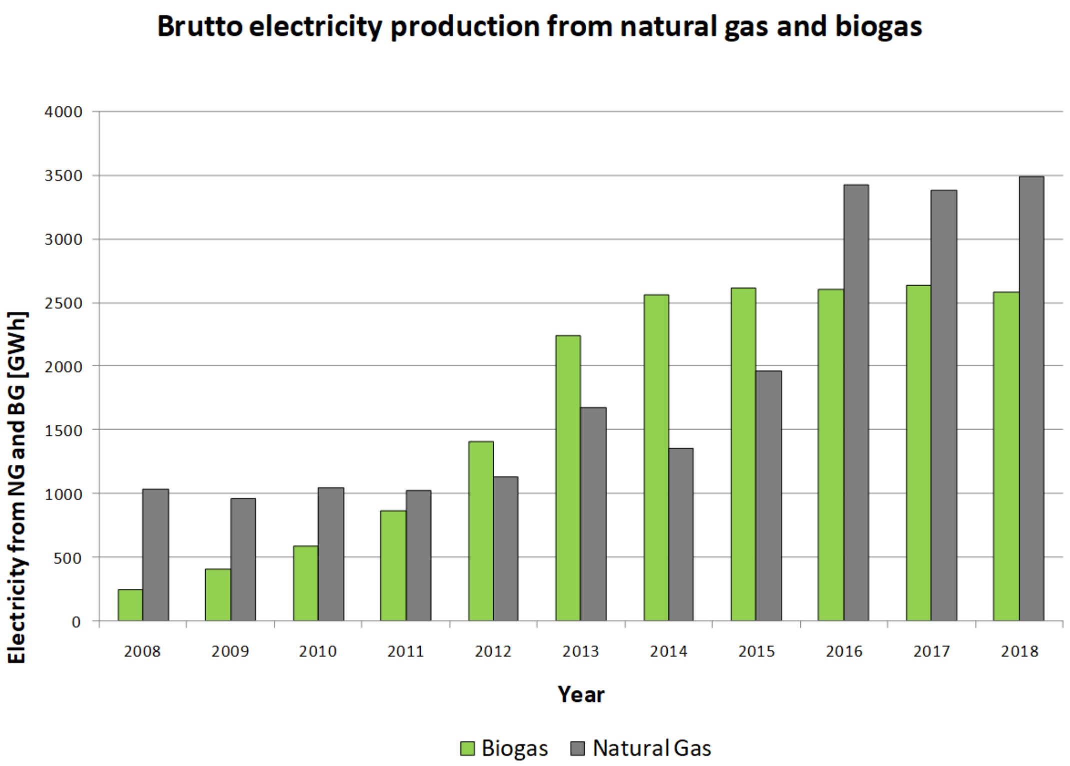


Figure 29 Electricity Production from Gas (biogas and natural gas)

The Czech Republic's National Energy and Climate Plan has been prepared on demand of Regulation 2018/1999 of the European Parliament and of the Council on the Governance of the Energy Union with measures in the field of climate change and contains objectives and policies in all five dimensions of the Energy Union for the period 2021-2030.[56] The key part of the National Plan consists of setting the Czech Republic's contribution to the so-called Europe's climate and energy targets for reducing emissions, increasing share renewable energy sources and increasing energy efficiency. Estimated trajectories for the demand for bioenergy, for use as heat, electricity and transport, have been estimated. In the case of forest biomass, an assessment of its source and impact for the demand for bioenergy, broken down by sectors of heat, electricity production and transport. Czech Republic does not expect significant imports of solid biomass, and consumption by 2030 will

[55] See https://www.czba.cz/en.html Czech Biogas Association Website
[56] See https://ec.europa.eu/energy/sites/ener/files/documents/cs_final_necp_main_cs.pdf

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be covered mainly by domestic sources. The Czech Republic is to date, a net exporter of solid biomass, the assumption has been made that there will be a partial decline in exports, however, whether this happens depends on several issues, including mainly market factors. Some exception to these assumptions include consumption demands for liquid biofuels, especially biodiesel, when the consumption will be associated with higher imports from abroad.

Today's acreage of agricultural land, which is steadily used for the production of raw materials in the energy sector, it is around 350 - 400 thousand. ha. Within forestry, is annually 2 million $m^3$ of wood chips produced, 1.5 Mton of cellulose extracts and less than 5 Mton firewood further used for energy purposes. In this regard, agricultural and forestry management significantly contributes to the production of biomass further used as a renewable energy source, and thus it significantly contributes to increasing energy self-sufficiency and meeting national climate commitments.

## 6.5 Summary and conclusions in relation to SWOT elements

The strategy of the Ministry of Agriculture of the Czech Republic with an outlook to 2030 allows for an increase in energy use of agricultural biomass, up to 20% by 2030, but only under conditions in which agricultural production levels for food is not threatened (as referenced in, Czech Republic's National Energy and Climate Plan)[57]. The strategy thus confirms that the main use of agricultural land is to ensure food production for human nutrition and feed for farm animals. This basic function can be influenced by a number of negative factors such as agricultural soil decline, limits for erosion-hazardous crops (e.g. corn, potatoes, beet, soy, sunflower and sorghum), or an overall increase in the instability of agricultural production caused by climate change (e.g. long-term drought, new pests, increased freezing of winter and spring, damage caused heavy rain, hail, etc.).

Thus, the additional land available to increase energy biomass production can in fact be very limited. By 2030, both the acreage of agricultural land and, in particular the arable production, which means that the area of land usable for energy biomass production is predicted to stagnate or grow only slightly. Further uncertainty arising from yield fluctuations is the development of prices not only of purposefully grown biomass, but also of harvest residues (especially, cereal straw). Increased demand for feed can cause a rise in prices, which will also affect those interested in its energy use. In general, therefore, in the period from 2020 to 2030, an increase in energy biomass prices would be anticipated, relative to the levels of inflation.

In view of the above, it would not be responsible to continue intensive development the use of agricultural land for energy purposes and needs to focus on more efficient use in terms of the unit amount of energy from renewable energy sources. To do this, development of biomethane production or partial replacement of targeted biomass could contribute in biogas plants using biological waste and municipal sludge rather than agricultural crops and wood biomass. This could free up a certain area of the agricultural land for more efficient ways of energy generation.

57 *Vnitrostátní plán České republiky v oblasti energetiky a klimatu* (2019). Available at: https://www.mpo.cz/en/energy/strategic-and-conceptual-documents/the-national-energy-and-climate-plan-of-the-czech-republic--252018/

Regarding forest land and timber biomass production, in the period under review as of 2030, it is expected that the year-on-year volatility of its availability for energy and technical use will depend on the development of pest spread (e.g. Bark Beatle), processing capacities, increased incidental logging and timber processing capacities in the sawmills, and the paper and pulp industry. In areas of high intensity of incidental mining, in the coming years, it can be expected, a lack of timber biomass for energy use and rising prices for bioenergy. The Czech Republic's adaptation strategy and the National Action Plan for Adaptation to Climate Change also addresses the possible conflicts and synergies of biomass production and its energy use in terms of biodiversity and ecosystem services.

Table 25 SWOT Analysis

| STRENGTHS | WEAKNESSES |
| --- | --- |
| • The vast de-centralized bio-energy plants located directly on farm-lands, minimizing the need for transport of biomass, and secondary residues can be incorporated into crop lands. | • Biodiesel production is impacted by rapeseed crop yield, which respond to increased chemical fertilizer and pesticide use.<br>• Subsidies as incentives sustain conversion of rapeseed to biodiesel. |
| **OPPORTUNITIES** | **THREATS** |
| • The opportunity presented by the EU Green Deal, may be the only factor that could unlock this sector.<br>• If the financial incentives and regulations are changed in the country, new forms of energy may take root, particularly more decentralization and renewables. | • The energy sector is difficult to penetrate from outside.<br>• Existing infrastructure of natural gas, and the dominant position of nuclear power does not allow for new entrant viability.<br>• The biodiesel sector is dominated by a few players with a competitive advantage.<br>• Taken together, the flexibility in the energy sector of Czech Republic has been limiting. |

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# 7 SKILLS, EDUCATION, RESEARCH AND INNOVATION POTENTIAL

One of the strengths of the Czech Republic is its vast number and variety of education and research opportunities pertaining to the bioeconomy. Although, there is as of yet, not a specific programme of study entitled "bioeconomy", but rather many of the elements of study and research in this topic are already in place. The missing link is the translation of all of this research and knowledge to application through innovative design. Here, as in most other scientific topics, the research and education sector of Czech Republic is in the early stages of developing a mind-set for solving problems through innovation. It will require a significant step of connecting customer demand for innovative solutions to start to steer education and training in this orientation.

## 7.1 AVAILABILITY OF SKILLED OPERATORS AND SERVICE PROVIDER

One significant cluster where both businesses and research activities are conducted are in the northern city of Liberec. There focus has been in the areas of nanotechnology and have pioneered nano-weaving, and generating any number of materials for textiles, "bioplastics", and surgical application, using bio-based primary sources.

## 7.2 RESEARCH INFRASTRUCTURE

A number of institutions which are engaged with different aspects of the bioeconomy are listed (Table 26). Most provide either training, awareness or research in areas as diverse as climate change (eg. CzechGlobe), biotechnology (eg. Contipro), circular economy (eg. Institute of Circular Economy), biofuel research (eg. UniCre), or organic foods.

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Table 26 Research Institutes related to Bioeconomy

| Name | Description of activities | Subject | Education | Web |
|---|---|---|---|---|
| **CzechGlobe** | Climate analysis and modeling, Ecosystem Analysis, Environmental Effects on Terrestrial Ecosystem | Environmental Sciences | MS/PhD | http://www.czechglobe.cz/cs/ |
| **Contipro** | Product Incubator, Technology Transfer in Medical Research, Contipro Institut for Uni students, | Pharmacy, cosmetics (BIO, CH, F) | Training | https://www.contipro.com/ |
| **Institute of Circular Economy** | Advocacy and implementation of circular economy | Circular economy | Seminars | https://incien.org/ |
| **UniCre** | efficient and environmentally friendly production of fuels, preparation of feedstocks for the production of polymers, sustainable use of renewable raw materials, reduction of harmful emissions, | Fuels | Training | http://www.unicre.cz |
| **Institute of Environmental Technology** | energy recovery of waste, cleaning of flue gases and waste gases | Environmental Sciences | PhD | https://iet.vsb.cz/cs/o-nas/ |
| **České ekologické manažerské centrum, z.s.** | Industrial and municipal ecology, environmental consulting, education and publishing of ecological titles | Ecology | Seminars | https://www.cemc.cz |
| **EPS Biotechnology** | Service in the field of environmental biotechnology, environmental protection, R&D, waste management and renewable energies. | Environmental Biology | R&D, Seminars, Training, Conferences | https://epsbiotechnology.cz/ |
| **National Cluster Association** | Coordinate sustainable development of cluster initiatives + develop cluster policy | Clusters and Competitivenes | Seminar, Edu activities | http://nca.cz/ |
| **Czech Academy of Agriculture Sciences** | Advisory body of the Ministry of Agriculture of the Czech Republic, internationalization, science communication | Agriculture Research | - | https://www.cazv.cz/ |
| **Bioinstitut** | Training and seminars for the agricultural community. | Agriculture Research | Seminars, | http://bioinstitut.cz/cz3/nase-prace/vzdelavani |
| **Potravinárska komora ČR** | Czech food | Food | Seminars, public awareness | http://www.foodnet.cz/ |
| **PRO-BIO – Svaz ekologických** | To protect the environment, nature and its resources by sustainable organic farming, to produce quality organic food | Food | Seminars, Conferences, Excursions, | https://pro-bio.cz |

| | | | | |
|---|---|---|---|---|
| **zemědělců, z.s.** | | | Exchanges on Bio-Farms | |
| **Nadace na ochranu zvířat** | Animal protection | Animals | Awareness | http://www.ochranazvirat.cz |
| **Hnutí duha** | Nature protection | Nature | Awareness | http://www.hnutiduha.cz |
| **Pro Bio Liga** | Development of organic farming in the Czech Republic | Agriculture | Popularization, awareness | https://www.lovime.bio |
| **ENVIC** | Environmental Information Center | Enviro | Popularization, awareness | http://www.envic.cz/o-siti-envic/ |
| **AREA Viva** | support of sustainable forms of agriculture, rural development and promotion of organic farming in the Czech Republic | Agriculture | Popularization, awareness | http://www.areaviva.cz/ |
| **BIO-info.cz** | Build long-term relationships | Organic | Popularization, awareness | http://www.bio-info.cz/o-nas |
| **Veterinary Research Institute** | Delivering high quality research to both the academic community and practical users in the agricultural and food industry. | Farm animal health<br>Food and feed safety | PhD training | https://www.vri.cz |
| **Institute of Animal Science** | Basic and applied research focusing on innovation and the practical use of knowledge in animal science. | Farm animal nutrition and breeding | R&D, Seminar, Training | https://vuzv.cz |
| **Crop Research Institute** | Development of scientific knowledge in the fields of integrated crop production and production of hygienically-safe foodstuffs. | Crop health, management, genetics and breeding | R&D, Seminar, Conferences, Excursions | https://www.vurv.cz |
| **Forestry and Game Management Research Institute** | Characterization, monitoring, and development of tools for forest sustainability. | Forestry and game management | Research projects, monitoring and published reports | https://www.vulhm.cz/ |
| **Research Institute of Agricultural Engineering** | Technological systems for productive agriculture; energy and logistics of biomass utilization for non-food purposes | Agriculture and energy | Research, consultancy and training | http://www.vuzt.cz/ |
| **Food Research Institute Prague** | Securing of healthy and safe nutrition, through research projects concerning chemical technology, food engineering and nutrition. | Food technology | R&D, seminar, training | https://www.vupp.cz/ |
| **Research Institute for Soil and Water Conservation** | Soil surveying, mapping, monitoring and evaluation of land use and conservation; integrated water resources management and conservation | Soil and Water | Research and education | https://www.vumop.cz/ |

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## 7.3 Educational infrastructure

Czech Republic has a great number of universities addressing topics at the higher education and research levels pertaining to the bioeconomy (universities and faculties are listed; Table 27). The most involved universities in these topics remain the Czech University of Life Sciences in Prague and the University of South Bohemia in Ceske Budejovice. Both have offered international summer schools on the topic of bioeconomy. Currently, it is proposed to develop a regular curriculum on the subject of bioeconomy, coordinated within the Czech Republic. Additionally, the Czech University of Life Sciences in Prague is the host institution for the information portal, Bioeconomy Platform of the Czech Republic, https://bioeconomy.czu.cz/en/.

Table 27 Universities engaged in bioeconomy-related subjects

| PUBLIC UNIVERSITIES - CZECH REPUBLIC | |
|---|---|
| Czech University of Life Sciences Prague | Faculty of Agrobiology, Food and Natural Resources |
| | Faculty of Forestry and Wood Sciences |
| | Faculty of Environmental Science |
| | Faculty of Economics and Management |
| Czech Technical University in Prague | Faculty of Biomedical Engineering |
| | University Centre for Energy Efficient Buildings |
| University of South Bohemia in České Budějovice | Faculty of Agriculture |
| | Faculty of Fisheries and Protection of Waters |
| | Faculty of Science |
| | Faculty of Economics |
| Masaryk University in Brno | Faculty of Informatics |
| | Faculty of Social Studies |
| | Faculty of Education |
| | Faculty of Economics and Administration |
| | Faculty of Science |
| | Faculty of Medicine |
| Mendel University in Brno | Faculty of AgriSciences |
| | Faculty of Forestry and Wood Technology |
| | Faculty of Horticulture |
| | Faculty of Regional Development and International Studies |
| University of Ostrava | Faculty of Medicine |
| | Faculty of Science |
| Technical University of Liberec | Faculty of Textile Engineering |
| | Institute for Nanomaterials, Advance Technologies and Innovation |
| University of Hradec Králové | Faculty of Science |

| | |
|---|---|
| **Jan Evangelista Purkyně University** | Faculty of Social and Economic Studies |
| | Faculty of the Environment |
| | Faculty of Science |
| **Charles University in Prague** | Faculty of Science |
| | Faculty of Arts |
| **Palacký University Olomouc** | Faculty of Science |
| **University of Pardubice** | Faculty of Chemical Technology |
| **Tomas Bata University in Zlin** | Faculty of Technology |
| | Faculty of Logistics and Crisis Management |
| **University of Veterinary and Pharmaceutical Sciences in Brno** | Faculty of Veterinary Medicine |
| | Faculty of Veterinary Hygiene and Ecology |
| **VSB Technical University of Ostrava** | Faculty of Mining and Geology |
| | Faculty of Materials, Science and Technology |
| **University of Chemistry and Technology in Prague** | Faculty of Environmental Technology |
| | Faculty of Food and Biochemical Technology |
| **Brno University of Technology** | Faculty of Chemistry |
| **University of West Bohemia** | Faculty of Applied Sciences |
| | Faculty of Economics |

## 7.4 Environment for start-ups

An appetite for start-ups has been quite active lately, particularly in the ICT sector, and dominantly in the city of Prague, and secondarily in Brno. However, the number of start-ups in sectors outside of the ICT sector are relatively few. There has been an interest in recent years in the medical biotechnology sector, but with the general reluctant for long-term risk, these are rare in the Czech Republic. In general, the academic and educational training institutes do not systematically enable start-ups.

However, it is interesting to underscore the existence of dedicated institutions supporting and encouraging the creation of start-ups, as well the enhancement of entrepreneurship amongst scientists and innovators (e.g. CzechInvest, CzechTrade, TAČR), while many ministries have dedicated departments aiming to support initiatives of this kind (e.g. Ministries of Education, Industry and Trade, Environment, Agriculture, etc.)

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## 7.5 PUBLIC-PRIVATE PARTNERSHIP

The Czech Republic has no formal framework for public-private partnerships (PPP). There are the rare PPP, through research cooperative agreements between research organisations and private sector companies, which could define a co-development path, however none of those existing agreements are within the bioeconomy sector. Research cooperation through fee-for-service arrangements are relatively common, and function to a moderate extent. The primary barriers to these arrangements consist of the lack of knowledge and experience of the public sector entities to formalize agreements with attainable deliverables. There is one example which seems to stand-out, Nafigate Corp presented an original microbial biotechnology for conversion of waste frying oils into bacterial bioplastics called polyhydroxyalkanoates (PHA), which was the result of a research cooperative agreement with the Faculty of Chemistry at Brno University of Technology.

The key issue is that in the investments related to R&D, Czech universities rather do not consider the expenditure of private financing, and mainly focus on financing from public sources, which influences its behaviour. It's a fundamental difference, because expenses from business sources in the EU are relatively important share of GDP, while in the Czech Republic has a relatively low proportion of private money dedicated to R&D (Figure 30, Figure 31, Figure 32). Total expenditure on R & D = public expenditure from national sources + public expenditure from EU (and other external) sources + expenses from business sources. Depending on the sources of money received, the funding organisation dictates the expectations of deliverables as an outcome of the R&D. With a relatively weak reliance on private R&D financing, the Czech Republic's public institutions do not cooperate with industries as much as might be possible.

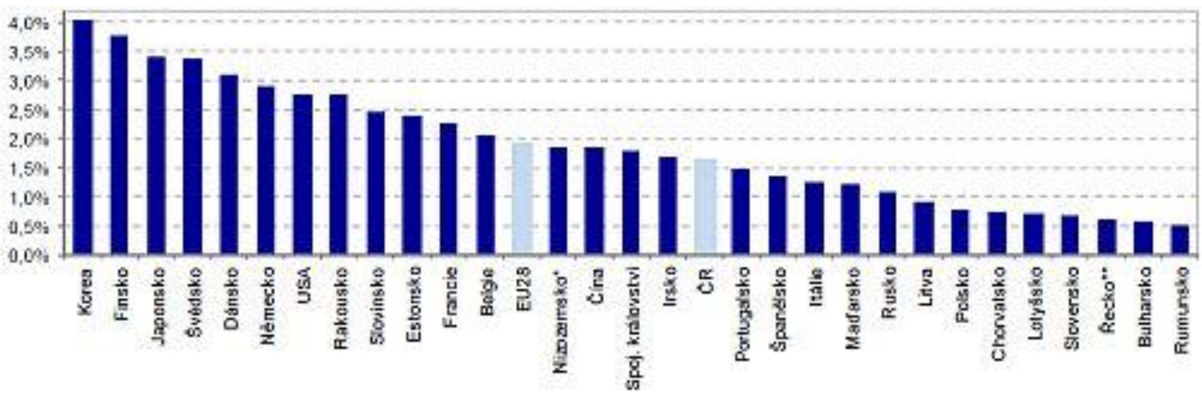


Figure 30 Total Expenditure on R&D as % of GDP (2017)

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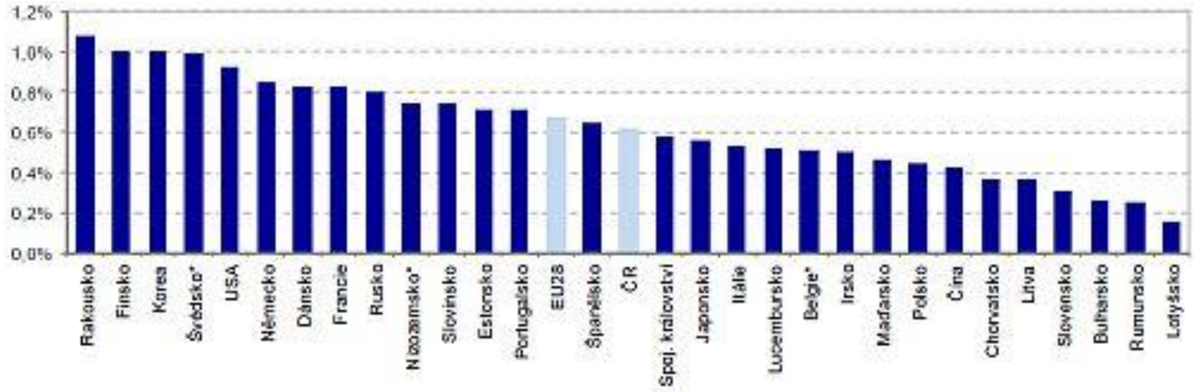


Figure 31 Expenditure on R&D financed from domestic public funds as a share of GDP, 2017 (%).Source: OECD MSTI 2018-1, Eurostat

The Czech Republic's Europe 2020 target for R&D expenditure from public funds was set at 1% of the GDP. This figure includes both expenditures of the state budget (26.1 billion in 2016) and grants from the EU, which in 2015-2016 amounted to 17 billion crowns. EU money goes mainly to investments in large modern scientific infrastructure (BIOCEV, ELI, CEITEC, etc.). Over the course of the recent years, the financial objectives have been achievable due to huge support from EU funds, the volume in the coming years is likely to decline.

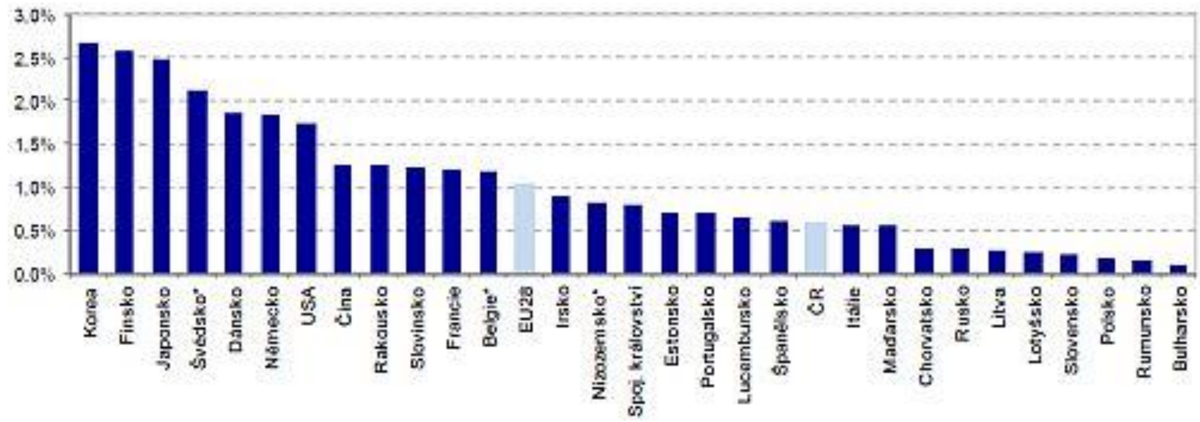


Figure 32 Expenditure on R&D financed from private funds as a share of GDP, 2017 (%)

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## 7.6 Summary and Conclusions in Relation to SWOT Elements

Table 28 SWOT Analysis

| STRENGTHS | WEAKNESSES |
|---|---|
| • Abundant research infrastructure<br>• Czech Republic has been the recipient of extensive EU structure funds for regional development, therefore the Higher Education Institutions has very well-equipped laboratories with state-of-the-art instrumentation.<br>• This should be considered a key asset for research in any area of discipline. | • Bioeconomy has not been explicitly addressed in university curricula and is not generally considered within the public institutions or society.<br>• There are however a whole range of agriculture, forestry, and engineering programmes, which tangentially are relevant to bioeconomy. |
| **OPPORTUNITIES** | **THREATS** |
| • An initiative to develop a bioeconomy curriculum is taking shape in the Czech Republic as the coordinator, for a multi-country stakeholder programme across the EU.<br>• The emergence of environmentally focused NGOs has increased in the last few years as a response to the absence of business and government activities in areas related to plastic use and waste recycling, for example. | • The lack of acceptance of new activities and change of mind-set is the biggest barrier to activities such as mobilization towards a bioeconomy. |

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# 8 POLICY FRAMEWORK: REGULATIONS, LEGISLATION, RULE OF LAW & TAXES AND TARIFFS

## 8.1 INTRODUCTION

In this chapter, policies are catalogued which have relevance for the bioeconomy in Czech Republic. At present, a concept report for the bioeconomy has been drafted, as well as a report which related the Czech Republic's position on the sustainable development goals. These documents are declarative in nature, although without target goals, and coupled with legislation on agriculture, forestry, energy, and waste management contain the policy frameworks related to the bioeconomy.

## 8.2 EXISTING LEGISLATION AND REGULATIONS ON BIOECONOMY AND BIO-BASED ECONOMIES IN CZECH REPUBLIC

### 8.2.1 OVERVIEW – MAPPING

There is not as yet a specific regulatory frame in Czech Republic exclusively dealing with bioeconomy and bio-based economies. So far, any related regulation has been implemented according to the EC directives and it is accommodated to the existing legislations issued by the Ministry of Agriculture, Ministry of Trade and Industry, and the CTIA (Czech Trade Inspection Authority).

### 8.2.2 ENVIRONMENTAL PROTECTION

The State Environmental Policy of the Czech Republic (SEP) defines a plan for implementing effective environmental protection in the Czech Republic up to 2020. The main objective is to ensure a healthy and good environment for citizens living in the Czech Republic, to significantly contribute to the efficient use of all resources and to minimise the negative effects of human activities on the environment, including transboundary impacts, and thus contribute to improving the quality of life in Europe and worldwide. The SEP is focused on the following thematic areas:

- **Conservation and sustainable use of natural resources**, protection of water and the improvement of its status, waste prevention, ensuring maximum recovery of waste and limiting its negative impact on the environment, protection and sustainable use of the soil and geological environment.

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- **Climate protection and air quality improvements** with the aim of reducing greenhouse gas emissions, reducing the levels of air pollution, promoting efficient and environmentally friendly use of renewable energy sources and improving energy efficiency.
- **Nature and landscape protection,** consisting mainly in protecting and enhancing the ecological functions of the landscape, preserving the natural and landscape values, and improving the quality of the urban environment.
- **Safe environment** involving the prevention and reduction of the effects of natural hazards (floods, long-term drought, extreme weather phenomena, slope instability, erosion, etc.), reduction of the negative impacts of climate change on the territory of the Czech Republic and prevention of hazards of anthropogenic origin.

As a member of the European Union (EU), the Czech Republic will, in the field of the environment, put emphasis on the implementation of commitments arising from the approved environmental legislation of the EU and will continue to be an active and trusted partner in discussing new legislative, non-legislative and strategic EU documents at all levels of consultation in the EU structures.

The Czech Republic will actively develop both bilateral and multilateral environmental cooperation, which will help not only to address national, regional and global issues, but will also contribute to employing Czech experts, experience and to promoting the export of Czech technologies related to environmental protection.

Whereas it is necessary to reckon with limited financial resources from the State budget, it is foreseen that the implementation of the proposed measures will make use, mainly, of the EU funds resources. The allocation of funds from the State budget will be specified based on the approved budget for the year concerning and according to the mid-term budgetary framework.

**The basic principles of the environmental policy**

In the State Environmental Policy of the Czech Republic, the following principles are mainly applied:

- **The principle of integration of policies.** The environmental policy is cross-cutting, having the same application as the other sectoral policies. These policies must be coordinated and interlinked. That requires cooperation at all levels of the public administration, where a number of strategic and conceptual documents are prepared with a central, sectoral and even regional scope. All relevant strategic documents should be based on a common analysis of external influences (the same socio-economic starting points), principles and possible development scenarios.
- **The principle of prevention.** Prevention, is the most important principle in environmental protection, because the most effective environmental policy is based on preventing damage to the environment. Timely introduction of preventative measures is more efficient and economically more effective than remedying damage in case of irreversibly polluted environmental compartments, exhausted resources, disturbed ecosystems and damaged health. Application of the prevention principle is also of great importance in cases of natural disasters, which mostly take the form of floods in the Czech Republic. An example of the preventive approach is the eco-design of products.
- **The precautionary principle.** The principle of preventive action stems from the fact that it is necessary to act even in cases where there is no certainty in how quickly the undesirable phenomena will occur, or if they will occur at all, taking into account all of the related costs. If there is a risk of irreversible damage to health or the environment, and the phenomenon

has not been sufficiently explored yet, preventive measures are taken to avoid economic losses.

- **The "polluter pays" principle.** The "polluter pays" principle is based on the assumption that everyone should take responsibility for their actions. In the context of environmental protection, this means that "anyone who causes damage to the environment, should bear the costs associated with it". One of the goals of applying that principle is to include negative externalities in the polluters' costs. The inclusion of negative externalities in the costs of polluters by projecting those costs into the price of the relevant products or services corrects the incorrect price signals towards the consumer. The subsequent reduction of the demanded quantity or the motivation of the polluters to implement preventive measures and new cost-effective solutions, helps to completely eliminate or mitigate the produced pollution.
- **The principle of cost effectiveness.** Effective allocation of limited resources is an attempt to reach an economically optimal level of degradation and protection of the environment. The effectiveness itself includes two areas: efficiency, i.e., to what extent the desired objectives will be achieved, and economy, i.e., at what cost. The principle of effectiveness requires achieving the best relationship between resources used on the given activity and the effects achieved.
- **Increasing public awareness of environmental issues.** The prerequisite for successful implementation of the SEP is the appropriate public awareness of the environment. Raising public awareness of the importance of environmental protection and its sustainable use leads the public towards better understanding the context of the economic, environmental and social development of the society, to improving the quality of decision-making of the citizens as consumers and indirectly also to improving the quality of life.
- **The principle of international responsibility.** The principle is applied in particular through development cooperation, by respecting the adopted commitments arising from EU membership and from international agreements, conventions and membership in organisations such as the United Nations (UN) and the Organisation for Economic Cooperation and Development (OECD). In sharing the global and regional responsibility from the position of an economically developed country it is also necessary to respect the specific conditions and the specific interests of the Czech Republic and the EU.

### 8.2.3 Industrial Regulations & Quality Standards

These regulations establish and generally define the State's supervisory jurisdiction, and delineates its authority with respect to the entities it controls. The Act also authorizes CTIA to penalize certain infringements (for example, the use of officially unverified measuring instruments or methodologies). The Acts included in this regulatory set comprise:

**Act No. 634/1992 Coll., on Consumer Protection:** This Act defines certain business practices relevant to consumer protection. Non-compliance constitutes an administrative offense punishable by sanctions. It is a fairly diverse mix of business practices that includes, for example, the fair selling of goods and/or services, a ban on unfair commercial practices, the prohibition of discrimination against consumers, various obligations for product and service information, information on how to register a consumer complaint and the official complaint process (i.e. not the appropriateness of the complaint resolution – here, in the case of a dispute, the issue is handled by a court or arbitrator).

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It also should be noted that the Consumer Protection Act is not a complete compilation of consumer rights or the responsibilities of entrepreneurs. Many other provisions for consumer protection can be found in other texts, whether in civil law (the Civil Code) or public law (legislation addressing specific businesses, such as the energy industry, electronic communications, etc.). The Consumer Protection Act also does not regulate all forms of business activities, i.e. self-employment professions (e.g. legal or tax advice).

The Czech Trade Inspection Authority is one of the authorities responsible for the implementation of this Act to the extent outlined in Section 23. Unlike other agencies, the CTIA's competencies in implementing this act are not defined in a material manner. The CTIA regulates compliance with the Act as a whole, except for cases where the exclusive responsibility is given to a specialized agency. This relates to compliance with the various regulations for agricultural, food and tobacco products; goods and services covered by the Act for the protection of public health (including products that come into contact with food, products for children under three years of age, cosmetics, food services, swimming pools, drinking water supply, etc.); veterinary care; firearms, ammunition and pyrotechnics; entities under the supervision of the Czech National Bank; the energy business sphere; pharmaceuticals; electronic communications and postal services.

***Act No. 102/2001 Coll., on General Product Safety:*** This law establishes the responsibilities and processes to ensure that products dangerous to the consumer do not appear on the market. Each product is regulated by the agency, under whose jurisdiction it falls. If the product does not fall under any specific agency, the Czech Trade Inspection Authority is the responsible entity.

***Act No. 22/1997 Coll., on Technical Parameters for Products:*** This law, by outlining government regulations, requires that certain products groups, prior to market introduction, must be evaluated so that they do not endanger the health or safety of individuals, property, the environment, and/or other aspects of interest to the public. This process, called a conformity assessment, culminates with the product being marked with the appropriate designation, typically the letters "CE". The implementation of the technical requirements for products law falls primarily to the Czech Trade Inspection Authority. However, if established by special law, the responsibility may fall to another agency: for example, the Czech Mining Authority (for explosives) or Railway Authorities (specific products for operations of railways), etc.

***Act No. 477/2001 Coll., on Packaging:*** The purpose of this Act is to protect the environment by preventing wasteful packaging. The CTIA is one of the administrative government agencies supervising the given area. As such it monitors and inspects the fulfilment of obligations pertaining to prevention, the introduction or the distribution of packaging on the market, labelling and re-use (with the exception of cosmetics packaging), packaging that may come into direct contact with food, packaging of medicinal products, and the packaging of raw materials used in the preparation of medicinal products for humans. The Agency also inspects the return acceptance of the packaging by those businesses that introduced the packaging or packaged products to the market. The Agency also controls the sale of beverages in returnable packaging by those businesses or physical persons authorized to do business and who put the packaged beverages on the market or into circulation by selling to the consumer.

***Act No. 201/2012 Coll., on Air Pollution:*** The Czech Trade Inspection Authority is one of the agencies responsible for air-pollution prevention. Specifically, its responsibilities include checking fuels on the

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domestic market, stationary combustion sources, and inspecting persons who handle selected paints, varnishes and products for repairing the paint on road vehicles.

***Act No. 311/2006 Coll., on Fuels:*** In accordance with this law, the Czech Trade Inspection Authority controls and monitors the quality of fuel intended for motor vehicles. Results are reported to the Ministry of Industry and Trade.

***Act No. 65/2017 Coll. – on health protection from the harmful effects of drugs:*** Which completely prohibits smoking in indoor restaurants, entertainment areas, etc., ban the sale of alcohol, tobacco and related products in **healthcare** facilities, schools and educational establishments.

***Act No. 353/2003 Coll., on Excise Tax:*** The CTIA controls compliance with the Act with respect to proper labelling of tobacco products, with respect to the ban on sale of spirits and tobacco products outside outlets approved for the retail sale of goods or the hospitality sector (Section 133), and also with respect to the marking and colour-coding of select mineral oils.

***Act No. 257/2016 Coll., on Consumer Credit:*** The aim of the new regulation is the strengthening of the position of the consumers and the increase of responsibilities of the creditors. Among the significant changes belongs for example the so called "reflection period". The creditor is not allowed to change or to withdraw from the proposal of the contractual terms for the mortgage loan within the period of 14 days. In case of a different contract on consumer credits than on mortgage, the consumer is allowed to withdraw from the contract within the period of 14 days after the conclusion of the contract. The creditors are newly obliged to get a license from the Czech National Bank, currently business license is sufficient.

***Act No. 189/1999 Coll., on Emergency Oil Stock:*** The CTIA is one of the agencies that would control the fulfilment of the responsibilities delineated for the event of an emergency arising from a lack of crude oil and petroleum products.

***Act No. 253/2008 Coll. – Some Measures against Money Laundering and the Financing of Terrorism:*** As part of the process of executing this Act, the CTIA inspects individuals authorized to trade in used goods, to broker such transactions, to pawn goods, and to trade in cultural monuments and objects of cultural value or to broker such transactions. According to this Act, the CTIA has authority to control informational responsibilities which pertain to fuel consumption and carbon dioxide emissions for newly manufactured personal automobiles.

***Act No. 56/2001 Coll., on Operation of Vehicles on Roads:*** According to this Act, the CTIA has authority to control informational responsibilities which pertain to fuel consumption and carbon dioxide emissions for newly manufactured personal automobiles.

***Act No. 247/2006 Coll., on Restrictions of Night Operations of Pawnshops and other Establishments:*** The Act stipulates that, at night, between 10 pm and 6 am, it is prohibited to purchase and sell all used goods and goods without a proof of purchase, to receive such goods for pawning, to broker such purchase or pawning (in bazaars and pawnshops), as well as to purchase any secondary raw materials (waste metals for recycling) by facilities intended for the collection and purchase of secondary raw materials. The supervisory authority, in addition to appropriate local Trade Licencing Office, is also the CTIA.

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***Act No. 73/2012 Coll., on substances that deplete the ozone layer and fluorinated greenhouse gases:*** The Czech Trade Inspection Authority inspects the labelling of products and equipment containing the given substances.

***Act No. 185/2001 Coll., on waste:*** The Czech Trade Inspection Authority is one of the government bodies active in the field of waste management. Its mandate includes inspecting the compliance with obligations relating to batteries and accumulators.

***Act No. 156/2000 Coll., on the control of firearms, ammunition, and pyrotechnics, as well as on the proper ways of handling certain pyrotechnic products:*** The CTIA inspects compliance with the duties imposed by this Act on persons who handle the pyrotechnic products.

***Act No. 307/2013 Coll., on mandatory labelling of spirits:*** The CTIA is one of the government bodies that examine and deal with various offenses in the area of handling packaged alcohol products, and the government-issued control strips.

***Act No. 226/2013 Coll., on placing timber and timber products on the market:*** The CTIA, pursuant to this Act, requires traders in timber and timber products to provide information about their suppliers and customers.

### 8.2.4 Regulations Related to Sustainability

Czech Republic has not a specific set of regulations for sustainability. The most recent declarative document on sustainability is the "Strategic Framework Czech Republic 2030", created and adopted in 2017. https://www.vlada.cz/assets/ppov/udrzitelny-rozvoj/projekt-OPZ/Strategic_Framework_CZ2030.pdf

This document is rooted in addressing the long-term vision of Czech Republic from the perspective of the Sustainable Development Goals. The six pillars highlighted are cross-cutting areas which address the 17 SDGs.

**The six main components of this strategy framework are:**

**1. People and society**

Vision

The Czech Republic is a cohesive society of educated, responsible and active inhabitants. The society is cohesive thanks to functional families and participating communities, dignified labour, accessible healthcare and social care, an equal approach to culture and an effective education system that allows everyone to reach their individual maximum level of education and that supports development of transferable competences. People living in this society prefer a healthy lifestyle, to live in a healthy environment and prefer purposeful consumption. Both material and non-material needs of individuals are met while environmental impacts and social exclusion are minimised.

**2. Economic model**

Vision

The economy of the Czech Republic is purposefully reducing its material and energy intensity. Economic institutions deliver long-term growth in the economy, built on entrepreneurship, innovation, people's creativity and abilities, higher value added industries, the circular economy, low-carbon technologies, robotics and digitisation, and rely on a robust and quality infrastructure. It is based on the principles of the social-market economy, the core of which is cooperation and coordination between the public, business and non-profit sectors. Public finances ensure that the resources for the implementation of public policies are spent adequately and efficiently.

**3. Resilient ecosystems**

Vision

Agriculture, forestry and water management respect natural limits and global climate change; they improve soil quality, slow water drainage from the landscape and help maintain biodiversity. The development of settlements and technical infrastructure, especially transport infrastructure, takes place with the utmost regard to maintaining and strengthening ecosystem services provided by landscape.

**4. Municipalities and regions**

Vision

Responsible use of land creates the conditions for a balanced and harmonious development of municipalities and regions, improves spatial cohesion, directs the suburbanisation trend and limits forced mobility. Cities and towns create preconditions for maintaining and improving the quality of life of their population. Competent public administration communicates openly with citizens and integrates them systematically into decision-making and planning. Housing is adapted to climate change.

**5. Global development**

Vision

The Czech Republic, as a confident and cooperative member of the international community, contributes both through its domestic and foreign policies to the promotion of values and principles of sustainable development in the EU and the world.

**6. Good governance**

Vision

The Czech Republic has a mode of governance that is both democratic and efficient in the long-term perspective. The decision making structure is resilient, flexible and inclusive. Citizens participate in decision-making on public affairs and the state creates suitable conditions to facilitate this. Public administration enhances the quality of life of the population of the Czech Republic via public policies and achieve the goals of sustainable development in the long-term perspective.

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### 8.2.5 Financing Regulations

Czech Republic follows general Financing Regulation applicable in all domains, including the bioeconomy and bio-based economies. Those are:

- **Act No. 253/2008** on Selected Measures against Legitimisation of Proceeds of Crime and Financing of Terrorism, English version (working translation, for information only) is available on the website of the Ministry of Finance of the Czech Republic
- **Act No. 69/2006** on the Implementation of International Sanctions
- **Act No. 254/2004** on Restriction of Cash Payments
- **Regulation (EC) No 1889/2005** of the European Parliament and of the Council on controls of cash entering or leaving the Community
- **Regulation (EC) No 1781/2006** of the European Parliament and of the Council on information on the payer accompanying transfers of funds

## 8.3 Integration of Regulation

### 8.3.1 To the National Strategy Priorities

There is not a national strategy on bioeconomy, but rather Concept of Bioeconomy for the Czech Republic from 2019-2024, prepared by the Ministry of Agriculture.

The bioeconomy concept spans the whole topic of bioeconomy and presents the potential focus of future development of bioeconomy in the Czech Republic. Due to its complexity and the wide focus of bioeconomy, the potentials for development are displayed for these five topics: Field of ecosystems and ecosystem services, Rural – Social area, Economic area, Field of food industry, and, Innovation and Research. The leaflet about the bioeconomy concept is in the attachment, below.

http://eagri.cz/public/web/file/630927/Koncepce_biohospodarstvi_v_CR_z_pohledu_MZe_na_leta_2019_24.pdf

This document refers to the scope of bioeconomy within the country, which covers the different types of biomass, and their potential uses as would serve the economy. Please note that the activities listed below are based on the strategy of the Ministry of Agriculture of the Czech Republic with an outlook up to 2030 (not contained in the bioeconomy concept), and concerns the bioeconomy area in the following strategic objectives:

- Ensure food security while substantially improving the impact of agriculture on natural resources;
- Develop the use of agricultural biomass as a renewable energy source;
- Improve agricultural-rural relations;
- Increase soil protection in times of climate change with a view to sustainable management and comprehensive development and landscape creation;
- Ensure a rational level of food security in terms of sufficient processing capacity;

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- Environmentally friendly growth of efficiency and productivity of the Czech food industry;
- Increase the importance of food industry in employment and rural development;
- Sustainably manage forests while continuously improving their state;
- Bring competitiveness of the forest-based value chain;
- Maintain competitive and economically viable traditional aquaculture with positive non-productive functions;
- Strengthen technological development, innovation and knowledge transfer in the sector of aquaculture including related processing, investment in the development of modern intensive breeding technology enabling sustainable fish production with low water consumption and minimal environmental burden, and ensuring the welfare of farmed fish;
- Stabilize the number of bee colonies in the Czech Republic and promote an even distribution of bee colonies;
- Optimize the numbers of individual game species by age and sex in accordance with natural landscape conditions, which allow natural development of populations and ecosystems without damage to game;
- Mitigate of drought consequences in the context of climate change;
- Sustainably manage water resources in the Czech Republic;
- Improve the status of aquatic ecosystems by implementing measures from river basin management plans;
- And, promote cooperation between research organizations and the application sphere.

### 8.3.2 To the General Regulatory Framework

The General Regulatory Framework in Czech Republic is well organized, modern, and in some cases quite flexible. It has been unanimously agreed that it is crucial to achieve good governance practices. Good governance is the basic prerequisite for long-term development. In this area, Czech Republic 2030 identifies several critical challenges such as decreasing the extent of political participation via traditional channels (political parties and elections), weak ability of horizontal coordination of the public administration, limited ability to work when making decisions with long-term perspective, poor involvement with contemporary international debate and severely limited ability to innovate governance. It is therefore necessary to strengthen all mechanisms that provide policy coherence, develop an innovative environment in public administration, improve representation, and strengthen participative and deliberative elements of democracy, strengthen data, knowledge and skill capacity of the public administration and develop a system for sharing data and information both inside the public administration as well as with citizens. These principles should be adopted at all levels of public administration. In order to provide implementation of the strategic document Czech Republic 2030, an autonomous implementation document will be adopted that will assess fulfilment of contemporary specific objectives and identify the space for adjustment of existing policies or potential for adoption of new policies or measures. The objectives of the strategic framework Czech Republic 2030 will be fulfilled via measures on a national and regional level. This report will assess the condition and trends in quality of life and its sustainability in the Czech Republic on the basis of indicators. Representatives of other sectors will be invited to prepare and challenge it. The report will also include recommendations on a possible update of the strategic framework.

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The implementation document on Sustainable Development will include a proposal on how to analyse gaps in current policies and identify causes that prevent potential goals from being met. At the same time, it will determine the responsibility of individual ministries for achieving and fulfilling the goals. There will be concrete actions and measures (such as regulation of legislation and regulation in general, securing financing, etc.). Data collection and preparation of indicators is ensured by the relevant Committees. The Report will then be subsequently discussed in the Committees of the Government Council for Sustainable Development, approved by the Council and submitted for discussion to the government. On the basis of this, and on the basis of interim findings, the Office of the Government enters a dialogue with ministries to ensure compliance with the Czech Republic 2030. Non-profit and private sector participants not represented in the government's Sustainable Development Council will be invited to prepare a shadow report during the preparation of the Report.

### 8.3.3 In accordance with the recommendations of the EC

Both the Czech Government and the Czech private sector, need to understand that the growth and development perspectives of Europe are just a reflection of those perspectives in each EU member state. Therefore, the implementation of the European directives are mainly supporting the national growth and development. It is essential the use the national potential in this direction.

It is very positive that in the document "Czech Republic 2030", in its Strategic objectives versus the EU, there are the following statements:

- The Czech Republic co-creates an environment actively supporting sustainable development at a global and European Union level and with an emphasis on national priorities.
- The Czech Republic promotes the global implementation of international commitments in the field of sustainable development, their implementation at the European Union level and their reflection in the activities of international organisations and fulfilment of these commitments.
- The Czech Republic at both global and European Union level supports the fulfilment of the Sustainable Development Objectives and specifically Objective No. 16 Peace, Justice and Strong Institutions.
- The Czech Republic increases its value added for operations in international organisations and the European Union.

## 8.4 What is to be done – Recommendations

- Starting the procedure for the adoption of a National Strategy on Bioeconomy
    - Nomination of a committee of experts
    - Data collection – classification
    - Consideration on National and Regional levels
- Consideration of International coexistence and cooperation within networks
- Alliance with the EC priorities and directives

- Faster implementation
- Establishing and/or reinforcing of non-governmental alliances within Europe
    - Alliance with private initiatives and industrial networks
    - Alliance with non-governmental initiatives in European Scale

## 8.5 Summary & conclusions - SWOT elements

Table 29 SWOT Analysis

| STRENGTHS | WEAKNESSES |
|---|---|
| • Modern structures<br>• Well established regulatory framework<br>• Discipline at all levels<br>• Flexible regulatory mechanisms | • Slow implementation of EC directives<br>• A general anti-EU climate<br>• Lack of complementarity among authorities<br>• Gaps in communication at many levels<br>• Lack of justification and of evidence-based decision-making |
| **OPPORTUNITIES** | **THREATS** |
| • Participation of the country in international and macroregional Networks (Danube Microregion, Bio-East, V4)<br>• Good economic outlook which can be further improved<br>• A good and modern financing and banking system | • Lack of support from key stakeholders<br>• Negativity towards change within the public sector<br>• Negative lobbying tactics<br>• An unexpected economic or financial crisis |

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# 9 FINANCING

## 9.1 INTRODUCTION

The financial support for a bioeconomy-based business in Czech Republic should be considered from at least three categories: loans, investments, and grants. However, before considering these options, it should be mentioned that the overall society is risk averse. Generally, the population would tend to have regular employment over under-taking a new, un-tested venture. Moreover, the tendency to change behaviour for a new and untested endeavour faces societal scepticism and at times collective resistance. One underlying issue to this effect is the legal constraints of the bankruptcy laws, which do not support new loan applications from those who have previously defaulted on a loan. This has reinforced the societal tendency to avoid risk.

From a financial perspective, the Czech Republic has experienced unprecedented levels of prosperity in the last decade. Unemployment has been at record lows (2,6% November 2019), compared to other European countries, and the growth in GDP has ranged between 2-6% from 2014 to present. Access to financing is relatively uncomplicated. The current rates of standard lending through a Czech National Bank insured loans stands at 2% interest. Business loans assess the overall fiscal health of the business plan, with assumed earned revenues. An alternative is through the European Investment Bank, which provides financing for innovative SMEs at favourable conditions.

The mind-set of Czech local investors for innovative, risky venture is largely absent. There is a segment of 'Angel' investors, who have made their money through hard-work in traditional industries, or those who have managed to accumulate wealth by less-transparent means. In either of these cases, their knowledge of innovative sectors or new areas, such as bioeconomy, is rather embryonic. Moreover, there seems to be a lack of trust among the Angel investors, which hampers so called "club deals".

Although the public funding system is somewhat complicated due to the different segmented ministries which would oversee a bioeconomy agenda, the Ministry of Agriculture has been slated to lead the bioeconomy strategy for Czech Republic, and as such it would be incumbent on this Ministry to push this transition with specific grant initiatives. The second agency which already financing project ideas which are innovative in nature, is Technology Agency of the Czech Republic, TAČR. These grants typically target research ideas which could be beneficial for industry in a solutions-oriented manner. Some of the TAČR projects already address bioeconomy issues.

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## 9.2 Summary and conclusions in relation to SWOT elements

Table 30 SWOT Analysis

| | |
|---|---|
| **STRENGTHS**<br>• Financing is available for pragmatic solutions which would bring return on investment or earned revenue.<br>• Untapped biomass available | **WEAKNESSES**<br>• Generally, lack of motivation to start new initiatives in Czech Republic.<br>• Investors and lending agencies are not presented with sufficient ideas to make an investment.<br>• Division between the academic centres, which train the up-coming generation, and the private sector which does not connect well with those in the public sectors.<br>• Market related problems are not connected with those willing to try new initiatives.<br>• Knowledgeable local business partners are challenging to find.<br>• There are no tax subsidies specifically for bioeconomy initiatives. |
| **OPPORTUNITIES**<br>• The introduction of a new idea which has some market potential, financing can be made available.<br>• Several innovation voucher programmes for novel business solution, which are relatively uncomplicated to obtain and administer. | **THREATS**<br>• Foreign competition based on scalability, distribution channels, and quality are all threats to the Czech enterprises.<br>• Local conglomerates which tend to buy out small players through tough business practices pose a barrier for new entrants.<br>• The case for environmental or social sustainability are rarely considered in examining the business case for financing. |

# 10 CONCLUSIONS

## ▪ KEY MESSAGE

The Czech Republic, which has a well-developed infrastructure and economy, is a country which has a tremenous opportunity, as the sectors contained in the bioeconomy agenda, have thus far been under-explored. The country openly embraces innovation, and the access to technologies and an educated population can translate to new tangible solutions to align with this new economic vision.

## ▪ EXPLOITABLE RESULTS / LESSONS LEARNT

The information resulting from this report covers many sectors of the overall Czech economy, but is far from complete. Nevertheless, some lessons can be learned from this exercise. In general, the resources from the forestry sector, which covers almost one-third of the land cover, are the largest opportunity with respect to biomass. However, the authors propose innovative use of wood products which does not include combustion due to the high-levels of benzopyrene in the Czech atmosphere.

An overarching consideration takes into account the highly developed nature of Czech engineering capabilities. Skilled personnel in the field of mechanical engineering are in abundance, and should be considered in the creation and development of novel instrumentation to support the novel specializations coming out of the emerging bioeconomy. With the anticipated automation of harvesting, processing, and finishing of products, this will enable bioeconomies of scale to take root.

Currently, waste management within municipalities need advancement both in infrastructure and process. At present, the biomass found within waste is largely not collected, and can be seen as an opportunity to develop new industries and encourage a mentality for recycling.

In this report, estimations are given for the residues from agricultural crops, largely cereals and rapeseed. Through a survey of farmers, it was revealed that there is not standardization of the amount of straw residue to be re-introduced into the fields, thus leaving a large under-realized resource of lignocellulose. Of note, beets which have been traditionally grown in this region for the Czech sugar industry are now largely further processed outside of the country, which presents an industrial processing opportunity within the Czech territory.

Finally, soil and ground-water management need improvement in order for a sustained bioeconomy to be enabled. As mentioned the land plots have been traditionally over-sized with agricultural practices which have led to soil erosion and ground-water levels to shrink.

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## ▪ VALUE FOR TARGET COUNTRY/ STAKEHOLDERS

The process by which this report was compiled included stakeholder engagement to introduce the CELEBio project, but also resulted in extensive discussions of the contents of this report. As such, the awareness of the bioeconomy as a comprehensive, and systemic approach, achieved greater awareness among the stakeholders within the Czech Republic. Additionally, the assessment of available, and under-utilized biomass within the country explores the potential for new economic outlets which should increase both the social and environmental sustainability of the sectors contained within this report.

## ▪ VALUE FOR BBI JU/BIC/EU STAKEHOLDERS

Czech Republic is a very business-friendly country, with functioning institutions, access to resources (both financial and raw materials), highly developed transportation networks, and a well-developed legal structure, The overall awareness of the bioeconomy is in its beginning, coupled with the availability of under-utilized biomass, and low competition in select sectors, indicates a strong opportunity for external stakeholder involvement.

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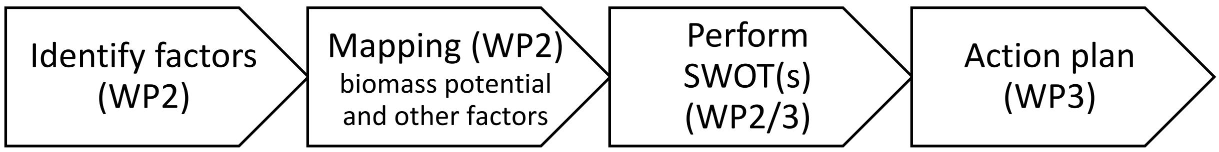
# Annex 1 Approach guiding the structure and contents of this report

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

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

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

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




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

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Highest ranked factors:

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

Medium raked factors:

- Financing: investors, subsidies, guarantees, risk minimization options
- Taxes and Tariffs
- By-product valorization: heat, CO2, fodder, lignin

Lowest ranked factors:

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

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

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

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

# Annex 2 EXPLANATION OF THE S2BIOM APPROACH TO ASSESSING LIGNOCELLULOSIC BIOMASS POTENTIALS FROM AGRICULTURE, FORESTRY AND WASTE

In S2BIOM project the core biomass cost supply data was generated in WP1 for 37 European countries at regional level. 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:

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| Potential | Biomass from agriculture | Biomass from forestry | Biomass from waste |
|---|---|---|---|
| Technical potential = TP | X | X | X |
| Base potential = BASE | X | X | X |
| User defined potential 1 = UD1 | X | X | X |
| User defined potential 2 = UD2 | | X | |
| User defined potential 3= UD3 | | X | |
| User defined potential 4 = UD4 | | X | |
| User defined potential 5= UD5 | | X | |
| User defined potential 6 = UD6 | | X | |
| User defined potential 7 = UD7 | | X | |
| User defined potential 1 = UD8 | | X | |
| HIGH potential | | X | |