CELEBio

D4.4 National Bioeconomy dossier: Slovenia

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

CCIS - Association of Chemical Industries of Slovenia

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12/2020

Gospodarska zbornica Slovenije
Chamber of Commerce and Industry of Slovenia
Association of Chemical Industries of Slovenia

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

EXECUTIVE SUMMARY

Work package	4
Activity	A.4.2.2
Task	n/a
Deliverable No	D.4.4
Deliverable Title	National Bioeconomy Dossier: Slovenia
Responsible partner	• Association of Chemical Industries of Slovenia at the Chamber of Commerce and Industry of Slovenia (CCIS-ACIS), • Central European Initiative – Executive Secretariat (CEI-ES)
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Due date of deliverable	M18
Actual submission date	M18
Level of dissemination	PU
Publishable executive summary in English	Technical reports produced in WP2 and WP3 have been edited to be used as dissemination materials to the benefit of Bioeconomy stakeholders and potential investors, highlighting the strengths of the Target Countries. Six specific dossiers have been prepared for each Target Country, each of them including: **(Part A)** an updated assessment of sustainable biomass potentials, including techno-economic information regarding infrastructures logistics and relevant costs, as well as an overview of the legislative provisions; **(Part B)** an exhaustive map (listing of relevant stakeholders; **(Part C)** presentation of a set of value chains and time-based guidelines for the development of a national Action Plan proposing concrete measures to foster investments in the Bioeconomy basing on different development scenarios.
Publishable executive summary in national language	Tehnični poročili o delovnih področjih 2 in 3 (WP2 in WP3) osvetljujeta potenciale v vsaki sodelujoči državi in sta bili predelani tako, da sta uporabni tudi kot diseminacijski material za deležnike na področju bio-gospodarstva in potencialne investitorje. Za vsako sodelujočo državo je bilo pripravljenih šest specifičnih dosjejev, od katerih vsak vsebuje: **(Razdelek A)** ažurirano oceno trajnosntih potencialov biomase, vključno s tehnično-ekonomskimi informacijami o infrastrukturi in logistiki ter relevantnimi stroški, kot tudi pregled zakonodajnih določb; **(Razdelek B)** izčrpen pregled (seznam) relevatnih deležnikov; **(Razdelek C)** predstavitev nabora vrednostnih verig in usmeritve glede časovnice za razvoj nacionalnega Akcijskega načrta s predlogom konkretnih ukrepov za spodbujanje investicij v bio-gospodarstvo, sloneče na različnih razvojnih scenarijih.

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Summary

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 six 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).

Technical reports produced in WP2 and WP3 have been edited to be used as dissemination materials to the benefit of Bioeconomy stakeholders and potential investors, highlighting the strengths of the Target Countries.

Six specific dossiers have been prepared for each Target Country, each of them including: **(Part A)** an updated assessment of sustainable biomass potentials, including techno-economic information regarding infrastructures logistics and relevant costs, as well as an overview of the legislative provisions; **(Part B)** an exhaustive map listing of relevant stakeholders; **(Part C)** presentation of a set of value chains and time-based guidelines for the development of a national Action Plan proposing concrete measures to foster investments in the Bioeconomy basing on different development scenarios.

Part A of this comprehensive report aims to provide the necessary background information needed to evaluate the possibilities for setting up bio-based production chains in three different sectors: agriculture, forestry, and waste management in Slovenia. [1]

Slovenia is a small country in the EU according to land surface with 2 million inhabitants, with approximately 44 % living in the rural areas, and around 45 % living in urban areas. However, there is a threat of the outflow of skilled labour, which in turn has a negative impact on economic performance and the economic situation in general.

Slovenia is the third country in the European Union when it comes to relative forest coverage, right after Finland and Sweden. Around 58 % of Slovenia's surface is covered by forests; they are mainly beech, fir-beech and beech-oak forests, all of which have a relatively high production capacity. However, one of the major hampering factors are

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

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strong export lines of raw wood to the neighbouring countries, predominantly to Austria and to Italy. Besides raw wood, another accessible and abundant source of biomass is waste.

Slovenia is one of the countries with the highest percentage of separately collected waste and management of recycling. The latter is attainable thanks to the RCERO, which in ranked among the most modern plants in Europe for the treatment of biological waste. The facilities can process 150,000 tonnes of mixed waste and over 20,000 tonnes of biological waste per year.

Another factor supporting bioeconomy in Slovenia is the strong R&I activity in the field of bio-based products. The most relevant research infrastructure equipment, related to bio-based industrial development may be found at the Pulp and Paper Institute, the National Institute of Chemistry and the Faculty of Chemistry and Chemical technology (University of Maribor). Research is oriented towards the development of new technologies and products, which will help to ensure the long-term development of Slovenia, and are at the same time internationally relevant.

With respect to existing industries, domestic chemical sector is particularly inclined towards the transition to bio-based solutions. The spectrum of bio-based product is quite broad, covering polymers for textile industry, various coatings, resins, wood-derived chemicals, plant extracts, biological drugs etc. One of the most vital challenges to further expand bio-based industry is the implementation of bio-refining, which is presently lacking. There is a strong industrial pull for various chemical/material intermediates, but no biomass bio-refineries are in operation. Establishing a local bio-refining capacity would drastically promote the advancement of emerging bio-based initiatives/commercialization.

Considering the current policy framework - bioeconomy is not the central topic of any specific Slovenian strategy. There are, however, several national and EU frameworks that touch on the topic of bioeconomy. As mentioned before, Slovenia has a great potential for fostering bioeconomy, but the realization of this potential ultimately depends on the financing. In order to encourage the development of the economy (which is indirectly also related to bioeconomy), the Slovenian government has started offering special investment incentives: cost-sharing schemes designed to attract serious investors, as well as promoting well-developed infrastructure and supporting industries, and clusters of specialized suppliers. Ministry funding is provided from policies and strategies (especially the S4 strategy), whereas EU funding provides resources for research and innovation. Pro-business climate in Slovenia manifests as a growing recognition of the importance of FDI (Foreign direct investment in Slovenia) as a source of fixed capital formation to economic growth and performance.

Although current bio-based industry is relatively small and there is no Bioeconomy strategy, Slovenia has a great potential to foster bioeconomy development. With a strong foothold in wood processing and food and beverage industry, there is room for significant innovation activities and new business models. This is fostered by a large number of stakeholders, that have the potential to implement bioeconomy principles in Slovenia. These stakeholders are mentioned in **Part B**, which includes an overview of all actors and actor groups that need to be involved when setting up biomass delivery chains. The actors presented can be specific persons, companies, and other type of organisations (e.g. farmers organisations), for which the following information was obtained: Company/person name; location; type of activity/function; specific number of employees; existing involvement in bio-based activities.

In order to utilize the opportunities and potentials available in the country a specific document was developed, that considers steps and activities that need to be taken, in order to realise the potentials of Slovenian bioeconomy. **Part C** tackles these issues and focuses on the existing problems and bottlenecks present in the current bioeconomy implementation process – e.g. a lack of communication between important stakeholders and leaders of the bioeconomy sector; establishment of organizations/agencies that are oriented solely on bioeconomy; connecting all

stakeholders; introducing financing for environmentally friendly practices; etc. Implementation of these measures and steps could contribute to quality implementation of vast resources and potentials that Slovenia contains, and could deliver the following results (presented in the following table):

Potential environmental impacts of the Slovenian Bioeconomy Action Plan

Reduce emissions in food industry by 25%
Reduce emissions in agriculture by 30%

Contribute to the sustainable management of natural resources and foster efficient water use.
Support a circular and sustainable bioeconomy in Europe.

Biodiversity

Local resources for products, energy and fuels

Potential socio-economic impacts of the Slovenian Bioeconomy Action Plan

Create 1,000 new jobs in agriculture, forestry and food processing industry

Leverage 50 million € private investments within ten years

Cluster creation. At least ten new collaborations between raw material providers and industrial actors

Eight new biobased value chains embedded in agriculture, food, and forest industries. Produce ten new patents and IP rights, Support the creation of ten spin-offs and start-ups.

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PART A

SUSTAINABLE BIOMASS AVAILABILITY AND SUPPLY IN SLOVENIA

D.4.4 SI-10

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1. Sustainable Biomass Availability in Slovenia

1.1. Short characteristics of country

Slovenia's land area is 20,273 km^2, making it one of the smaller EU countries. With 2 million inhabitants its corresponding population density is near the EU average (See table 1.). The average income level is below the European mean and lower than the average of other Central European countries, but higher compared to Eastern European countries.

Table 1. Main population, land surface, GDP and trade characteristics of Slovenia compared to EU average

Category	Slovenia	EU	Unit
Population	2.1	512.4	million (2018)
Area (total)	2	447	million ha (2018)
% population in urban areas	0.0%	44.9%	% of total population (2018)
% territory predominantly rural	72.8%	43.8%	% of total territory (2018)
% territory predominantly urban	0.0%	10.7%	% of total territory (2018)
Agricultural Area	0.5	173.3	million ha (2016)
Forest area	1.3	164.8	million ha (2016)
Population density	102	115	n°/km² (2018)
Agricultural Area per capita	0.24	0.34	ha/capita(2016)
Forest area per capita	0.61	0.32	ha/capita(2016)
GDP (€)/capita	22 184	30 956	at current prices in 2018
	26 595	30 956	GDP at purchasing power in 2018
GVA by Agriculture, forestry and fishing	2.2%	1.6%	% of total GVA (2018)

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

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

More than half (58 %) of Slovenia's surface is represented by forests, and about a quarter of the total area is considered as agricultural area (of which more than half is covered by grass). The main land cover distribution is presented on figure 1. There are consequently very little urban areas, with most of the population spread out in rural areas. The population density however is pretty similar to the European average. The GDP and purchasing power in Slovenia are slightly below the European average, yet quite high compared to Eastern European countries.

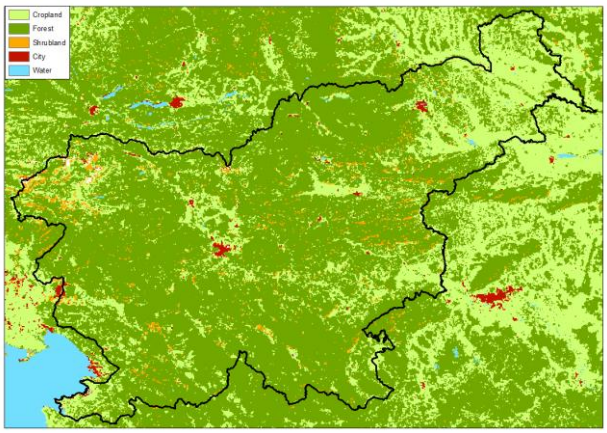

Figure 1. Main land cover distribution over Slovenia

Slovenia shares its western border and a small coastal strip on the Adriatic Sea with Italy. On the south and east it borders with Croatia, while it shares the border on north-east with Hungary. On the north Slovenia borders with Austria. Slovenian border and its neighbouring countries are shown on figure 2.

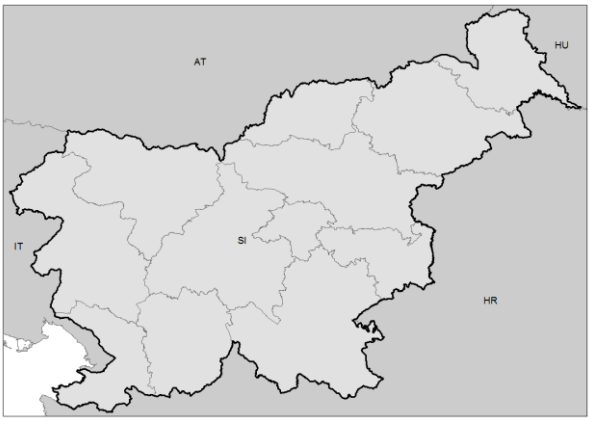

Figure 2 Slovenia and its bordering countries

In the case of traffic, Slovenia is a transit-heavy country. It is crossed by two priority railway freight corridors, namely the Baltic-Adriatic Corridor (RFC 5) and the Mediterranean Corridor (RFC 6). Also, two important road corridor cross Slovenia's territory, namely the 5th Pan-European transport Corridor (which links Lisbon via Barcelona and Ljubljana to Kiev) and the 10th Pan-European transport Corridor (links Munich via Jesenice and Ljubljana to Belgrade and Istanbul). Figure 3 shows the position of Slovenia in the Trans-Europe Transportation network.

Figure 3 Position of Slovenia in the Trans-European Transportation Network[1]

Figure 4 gives an insight into biomass flows in Slovenia (top) in comparison to average biomass flows of EU-28.

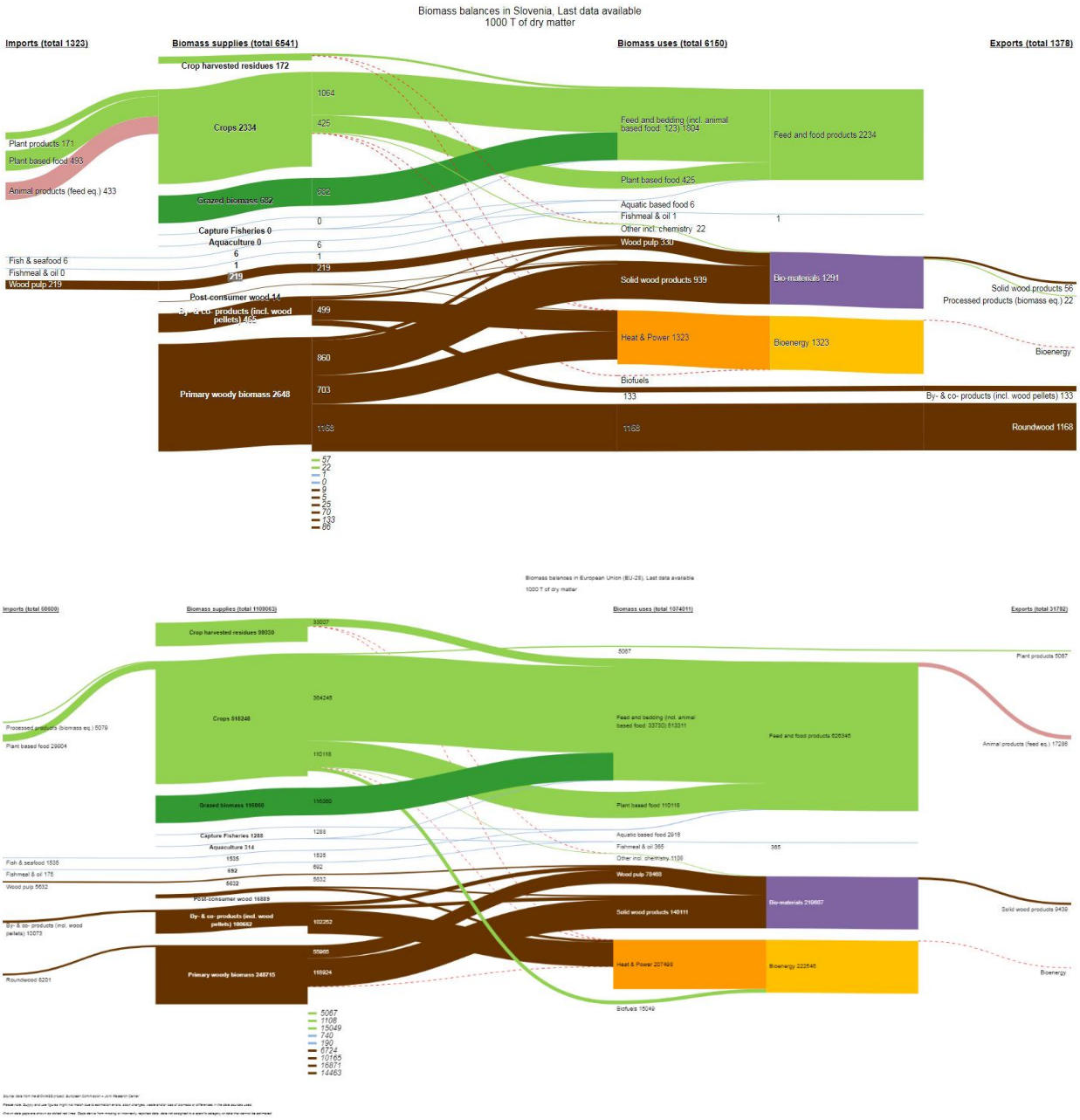

Figure 4. Biomass flows in Slovenia (top) and EU-28 (bottom)

Explanation of Sankey diagram (Figure 4):
The Sankey biomass diagram is split into biomass supply (shown on the left of the diagram) and biomass uses (right portion of the diagram). Each of these areas show different categories: agriculture, forestry and fishery (supply), as well as feed and food, biomaterials, bioenergy, and direct exports for each sector (uses). All supply and uses of biomass have been converted to kilotons of dry mass before integrating in the diagram. It is important to know that some of the components of the diagram will be missing for a certain country and/or year if the corresponding data has been reported as zero. This implies that the flow data should be interpreted with care as not all diagrams cover all biomass supply and/or use categories present.
Further information on the method and source data in: https://publications.europa.eu/en/publication-detail/-/publication/a19750d4-5498-11e7-a5ca-01aa75ed71a1/language-en

From the above Sankey diagram for Slovenia (Figure 4) one can conclude that the main biomass supply (quantities below are all expressed in million tons of dry matter) is primary wood biomass (2.65), crops (2.33) and grazed biomass (0.682). Almost half of the wood produced is exported as roundwood (1.17) and the other half is converted to heat and power bioenergy (1.32), solid wood products (0.939) and wood pulp (0.33). Unlike many of the other CELEBIO countries, no plant products are exported. Imports consist mostly of plant products, plant-based food and animal products.

Another difference that can be observed while compering the Slovenian and the general EU Sankey diagram (Figure 4) is that the supply of primary wood biomass is proportionally more sizeable than the crop biomass supply.

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

An analysis focused on utilization of Slovenian wood and wood biomass in the period from 2000 to 2017, showed that forestry, wood processing and furniture industry, as well as the pulp and paper industry, together on average created EUR 739.5 million in annual gross value added[2] (figure 5).

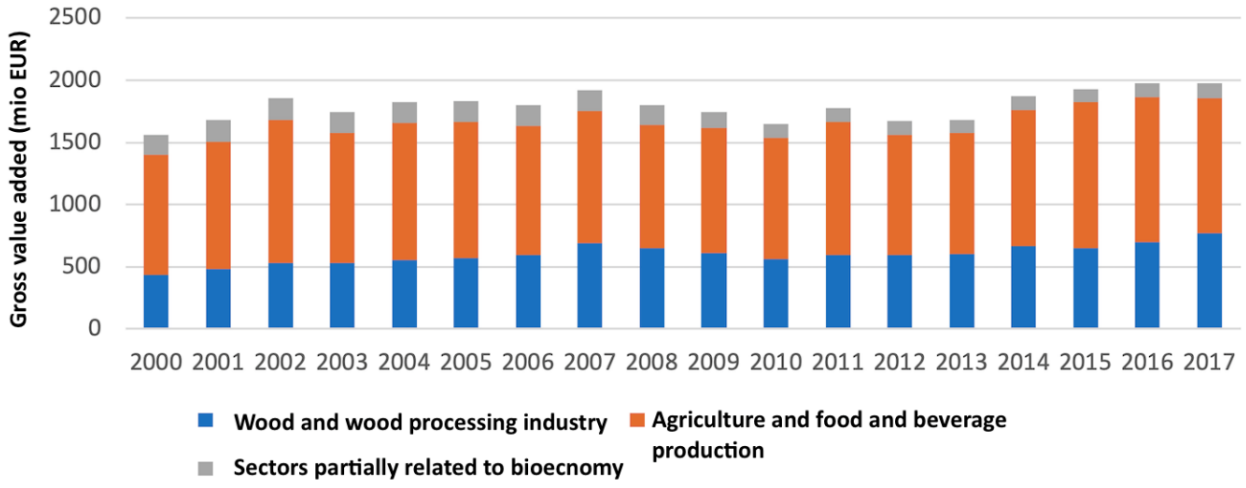

Figure 5. The gross value added represented by the two main sectors in the Slovenian bioeconomy, namely "Wood and Wood Processing Industry" and "Agriculture and Food and Beverage Production" and sectors partly related to the bioeconomy2

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

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

2. Biomass supply: agriculture

2.1. Introduction

In this chapter, the agricultural biomass production and main uses are described. A distinction is made between the main economic products produced and their main process chains and residual biomass potentials from primary production. Another topic that will be touched upon is the availability of by-products in the food processing industry. The residual biomass sources, certainly the ones from primary sources are largely not used as already became clear from Section 1.3. The attention will also be paid to the importance and the structure of the agricultural sector and to the main environmental challenges associated with agriculture in Slovenia.

2.2. Characterisation of current agriculture sector

The agriculture sector covers about 1.4 % of Slovenia's GDP, which is about 642 million Euros, and it employs around 78,000 persons. Factor income per employee in agriculture is 7,634 Euros and gross fixed capital formation in agriculture are 305.3 million Euros. [3]

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

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

For a country with more than half of the surface covered by forest, it compares very well to the average in Europe in terms of % in agricultural employment and income, and % of total crop and livestock output. There are also relatively more low input farms (50%) compared to Europe (39%). The nutrient balance for nitrogen is similar (slightly higher) than the European average and the phosphorous is 3 kg of nutrient per ha (compared to 1 in Europe). This relatively high

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surplus per hectare is likely to be related with the still relatively low yields per hectare. The soil erosion is more than twice that of Europe, and as mentioned the farm holdings are very small (7 ha UAA, compared to 16.9 ha). [4]

In 2017 the value of agricultural production and services (output) was EUR 1,161 million. It was the lowest after 2013, mostly as a result of the drop-in crop output value as a result of bad weather conditions. On the other hand, agricultural production costs (input) – purchase of seeds and seedlings, energy, fodder, fertilisers, plant protection products, maintenance of machinery – amounted to EUR 722 million, i.e. 62% of the output. [6] The key characteristics of the Slovenian agricultural sector is shown in table 2.

Table 2. Key characteristics for the agricultural sector in Slovenia [4,7,8]

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

HNV= High Nature Value

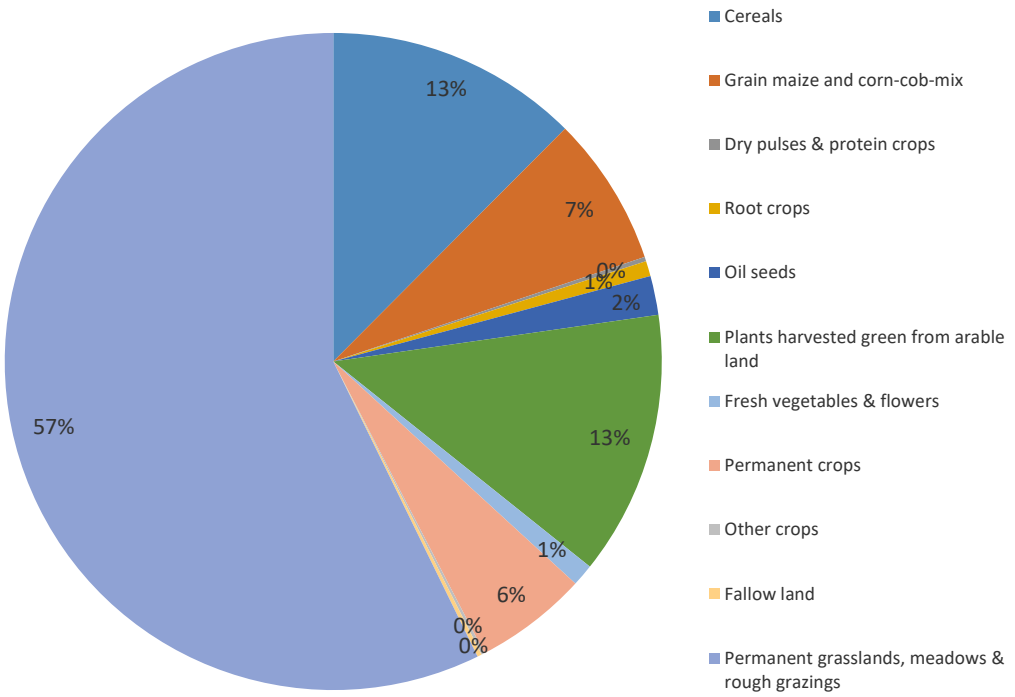

Figure 6 . Main crops and land uses in Slovenia [8]

2.3. Crop production

When looking at the production of crops for existing food and feed uses, the Slovenian production is in the average position at EU level with 8.2 million-ton of dry matter (d.m.) production (see Figure 6). The most important crops in Slovenia are cereals, plants harvested green from the arable land and maize/cob-corn. The area utilized for growing cereals is about 13 % of the total used arable land. This includes wheat, spelt, barley and other cereals. Green-harvested plants are grown on 13 % of the area, while corn fields for maize and cob-corn take up about 8 %.

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

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

The EU28 and the EU average values for economic production from the main crop, expressed in Mt of dry matter per year, are shown in Figure 7.

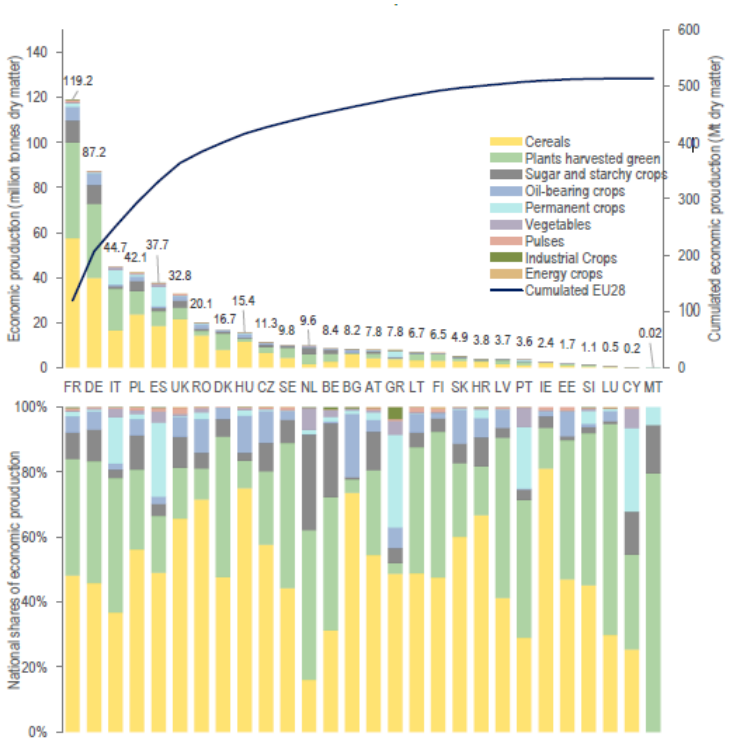

Figure 7. Economic production (top pane) from the main crop groups per member state, expressed in Mt of dry matter per year; and the shares at national level (bottom pane). Average values over the reference period 2006-2015 [73].

2.3.1. Cereals

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

Wheat. In the year 2018, the area on which wheat was cultivated in Slovenia amounted to 27,294 ha. Altogether, the amount of wheat produced on this area was 120,732 tonnes, making the wheat yield for that year 4.4 tonnes per ha. In the period 2008-2018, the wheat yield has not had a trend of increase or decrease, but it has had some fluctuation. The yield however remained between 4.0 and 5.5 tonnes per ha, unlike maize which in the same period moved between 5.4 and 9.5 tonnes per ha.

The impact of weather conditions on wheat yield is lesser compared to maize because it is a winter crop that is not so exposed to the effects of deficiency of precipitations and high temperatures. [3]

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

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

2.3.2. Oil Crops

The main oil crops in Slovenia are sunflower, rape and turnip rape seeds.

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

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

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

2.2.3. Permanent crop production

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

The predominant permanent crops are fruit crops, grape for wine-making and olives. Orchards for fruit crop production take up 10,562 ha, vineyards take up 15,630 ha and olive groves 1,302 ha.

Vineyards are a prominent par of Slovenian heritage and agriculture, partly because of the effect of the Mediterranean climate in the south-west, partly because of the low hills with abundant sunshine in the east and south-east of the country. The total number of vineyards in 2015 was 49,473, covering an area of 15,688 ha. The number of vine plants according to that census is well over 57 million.

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

Table 3: Orchard fruit trees species and respective data, 2017 [10]

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

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

2.3.4. Livestock production

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

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

Number of cattle has decreased in 2018 for the second year in a row – by the end of the year there were about 477,000 cattle (1 % less than the year before), of which about 166,000 cows (in 2017, about 169,000).

Number of pigs has experienced a cyclical fluctuation, but since the year 2006 this random fluctuation has turned into a trend of decreasing of the number of pigs. This trend has slowed down after 2016 and stopped in 2017. By the end of 2018, there were around 259,000 pigs, which is just under a percent more than the year before.

The number of small ruminant animals (sheep, goats etc.) has not changed drastically from 2017 to 2018, however, previously (in the last decade) it had shown a trend of decline. Despite the number remaining on the same level, the small ruminant animal growth was 3 % bigger. By the end of 2018, there were almost 135,000 small ruminant animals. [5]

Current statistical data on livestock production show that the extent of the production in 2018 (with the exception of milk and beef production) has increased in most livestock-producing agricultural holdings.

The growth of cattle, has decrease by 2 %, but is still 2 % over the five-year average (about 78 kt). The reduction in the amount of milk produced was about 1 %, now amounting to 627 kt. This is a result of the fact that there are less milk-cows – about 103,000, which is 6 % less than the year before.

That being said, the percentage of sold milk of all milk produced has reached the highest level since 1991 – 91 %. However, dairy factories have received 571 kt of cows' milk, which is just over a percent less than 2017. The percentage of milk that was sold to foreign dairy factories (i.e. direct export of raw milk) have decreased in 2018 once again – reaching 31 %. [5]

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

Poultry production has shown growth in 2018 compared to the previous year, the growth being 1 %, which amounts to 97 kt – the highest so far.

Also, egg production in 2018 is the highest recorded – 413 million eggs. This is a 4 % increase from the year before, which is a result of a 6 % increase of the number of egg-laying hens. Of the total number of eggs laid in 2018, 82 % of them (produced by 84 % of all hens) were used for food.

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

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

2.4. Biomass potentials from residues and unused lands

When it comes to residual biomass production, Slovenia's levels are amongst the lowest in the EU – residue production of about 700 kt, as shown in Figure 8. The 0.7 million tonnes of residues are produced per year, of which the main sources are cereals.

According to the Sankey diagram (Figure 4.), Slovenia has 172,000 tonnes of crop harvested residues, which is also very low. Only this 0.2 million ton are known to be harvested at this moment. How much can be mobilised of this residual resource taking account of sustainability consideration of which the main is the conservation of organic carbon in the soil, is discussed in next Section in greater detail.

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

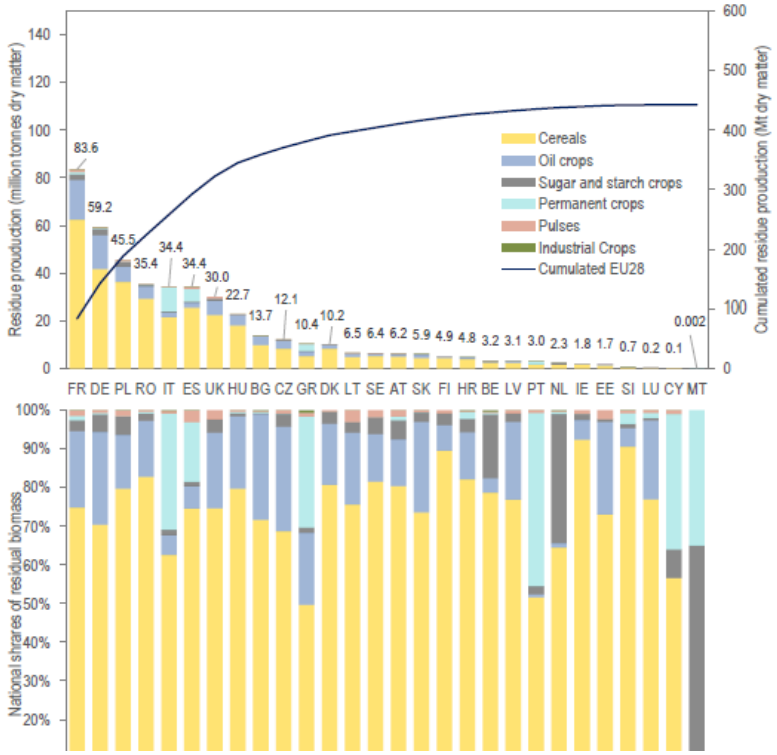

Figure 8. Residue production (top pane) from the main crop groups per member state, expressed in Mt of dry matter per year; and the shares at national level (bottom pane). Average values over the reference period 2006-2015 [73]

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2.4.1. Lignocellulosic residual biomass potential from crops

As already became clear the residual biomass potential from arable crops should be reinforced. However, how many crop residues (e.g. straw) can be removed sustainably depends on several factors. Especially the maintenance of soil organic matter is a relevant function of straw-removal. Also, the nutrient balance should be maintained, but nutrients are often replenished, mainly by manure from livestock or by mineral fertilizer application practices. The input of soil organic matter often depends only on crop residues left behind. The amount of straw to be kept in the field is complicated to estimate as it depends strongly on the soil and climate characteristics and the long-term management practices. To give a good estimate of residual biomass potentials that can be sustainable removed we use data generated in the S2BIOM project (Dees et al., 2017ab) (Table 4). In S2BIOM a 'UD1 potential' was assessed for residual biomass. How this potential was assessed is explained in Box 2.1. In the following tables and text, the S2BIOM biomass potentials are presented for Slovenia.

Table 4: Residual biomass potentials from arable crops 2020 in ton d.m. (=S2BIOM UD1 potential) (see for assessment approach Box 2.1)*[7].

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

Box 2.2: Methodology of S2BIOM to calculate the crop residues potentials in table 4. 5 and 6.

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

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

Residues from permanent (woody) crops

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

2.4.2. Dedicated crop potentials from unused/abandoned lands

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

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

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

2.4.3. Residual biomass potentials from livestock

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

According to a study by the JRC (Scarlat et al. 2018) on the development and perspective for biogas in Europe, Slovenia produces 1,242 TJ of biogas, which amounts to 35 million cubic meters. Overall natural gas use in Slovenia is

773 million cubic meters, which makes the use of biogas in particular at 4.5 % of natural gas use. Anaerobic digestion (including that of manure) is the leading way of producing biogas in Slovenia, the share of this process being about 75 %. Other processes for biogas productions are recovery of landfill gas and recovery of sewage gas. In a more general sense, the electricity production yield from electricity in Slovenia is about 132 GWh, and the heat production from biogas is 383 TJ, of which derived heat accounts for 304 TJ. [14]

2.5. Agricultural processing industries

2.5.1. Main agri-food processing industries

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

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

2.5.2. Side-products from agri-food processing

Residues from food and fruit processing represent an excellent opportunity to improve cost efficiency of agro-food processing companies. While food processing industry is generally well-adapted and able to keep up the pace with the technological development, some weak-spots are the brewing industry, dairy industry and flour-makers/bakers. Generating yield from waste streams just started to be considered as a good opportunity to improve competitiveness. It is likely that hesitation lies in the necessity to step out from the current market place and food processing as core business. However another obstacle is that, waste streams might not be abundant enough to enable achieving economies of scale in later stages of bio-refining processes.

Another aspect of this is that documents such as the 2030 Agenda dictate the reduction of food waste and food loss (it should be cut in half for each member state). The total food waste is about 68 kg per capita in Slovenia, and about 25 kg per capita of the edible portion of food waste.

Table 5, gives an overview of secondary residual biomass sources from the wine, olive oil and cereal processing industries (how these potential estimates were assessed is explained in Box 2.3).

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Table 5: Biomass potentials from agro-food processing industries 2020 in Ton d.m. (=S2BIOM base potential)[11]

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

Box 2.3: Methodology of S2BIOM to calculate the secondary residue potentials from food processing in Table 5

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

For further details on the whole assessment of biomass potentials in S2BOM consult Dees et al (2017).

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

2.6. Cost of main biomass source

Since for most agricultural residues no commodity market has developed yet, it is very difficult to provide figures on prices. Instead cost estimates can be presented building on the S2BOM methodology and assessment. The cost refers to *Roadside cost* and these cover all biomass production collection and pre-treatment cost up to the road where the biomass is located. The roadside cost are only a fraction of the total 'at-gate-cost.' The road side costs are presented in Table 6 below.

Table 6: Road side cost levels (€/ton d.m.) for agricultural biomass sources based on S2BIOM cost calculations [16]

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

2.7. Summary and conclusions in relation to SWOT elements

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

Table 7 SWOT factors regarding biomass feedstock

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

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3. Biomass supply: Forestry

3.1. Introduction

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

Table 8. summarizes the main characteristics of Slovenian forests.

Table 8: Slovenian forests in numbers, 2017[17]

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

74% of forests in Slovenia are privately owned and the remaining 26% of forests are owned by the state or by municipalities, which is presented on figure 9. Larger and unfragmented forest lands enable centralized and professional management. Private forest lands are small, with an average area of only 3 ha and even these are further fragmented into several separate plots. For the great majority of these lands, forests are not of an economic interest. Private forest property is becoming even more fragmented as the number of forest owners is increasing. According to the latest data, there are already 314,000 (with co-owners even 489,000) forest owners in Slovenia. The major fragmentation of forest property, the number of forest owners and co-owners, present a serious obstacle to an efficient and professional management in private forests which is a serious obstacle for optimizing timber production and utilization of forest potential [17].

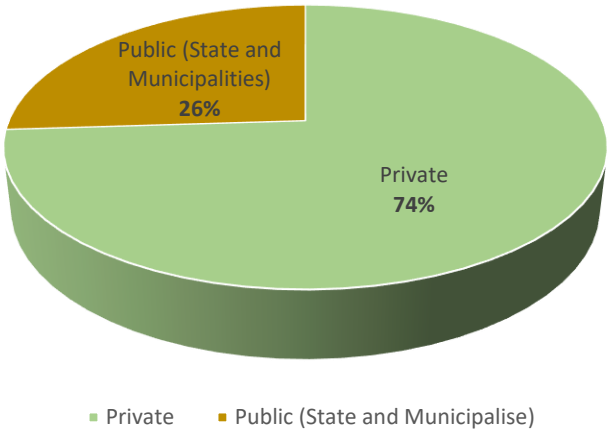

Figure 9. Ownership of Slovenian forests

WoodChainManager's web page offers an access to an interactive schematic representation of roundwood flows in Slovenia (shown on figure 10). Data, which is for the year 2014, suggests that a substantial amount of Slovenian wood is exported. Mainly it is exported as a roundwood and a firewood. Only a little fragment is exported as added-value products such as chemicals, pulpwood, fibreboard and particleboard[18].

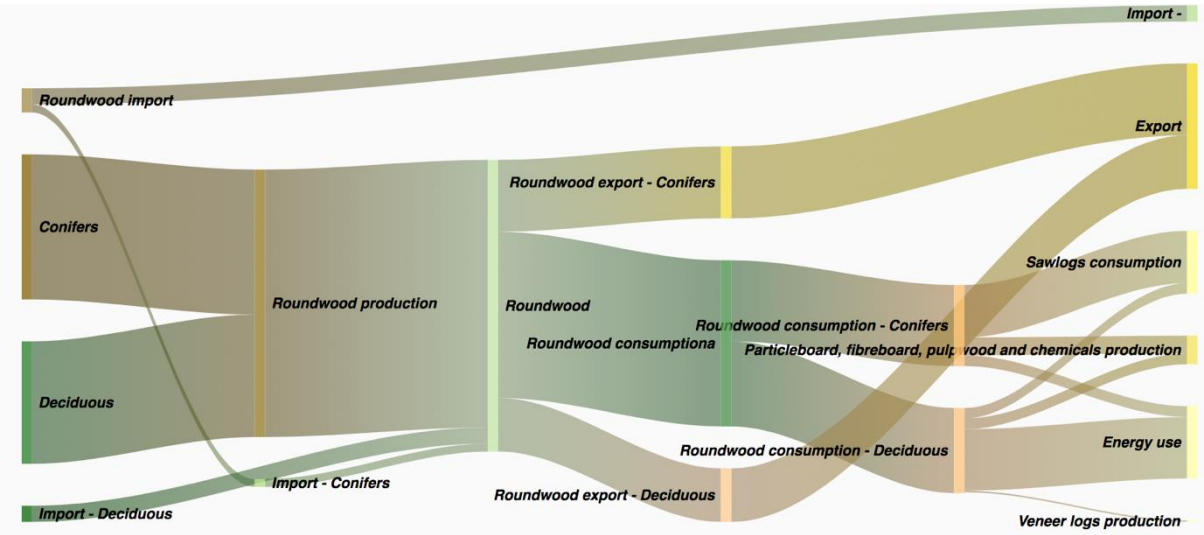

Figure 10: Sankey diagram of roundwood flows in Slovenia, 2014[18]

3.2. Primary biomass resources from forestry

The assessment of the roundwood and primary residue potentials in S2BIOM is done by using the EFISCEN model and using national forestry inventory data as an input. The secondary forestry residues from saw mills and wood processing industries build on the potentials assessed in EUWood and S2BIOM in combination with some up-dated data from national sources. In addition to this overall potential assessment, a pilot study for the Slovenian forest sector was performed by the Slovenian Forest institute as part of the S2BIOM study providing information on low quality wood potentials available in Slovenia.

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

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

Table 9. describes the primary biomass potential from Slovenian forests in 2020. Data was obtained in the scope of S2Biom project. It should be noted that biomass potential is expressed in thousands of tons (Kton) of dry matter (d.m.). Taken this into consideration, volumetric results above (expressed in m^3) coincide relatively well with estimated data for 2020 (expressed in Kton d.m.).

Table 9: Primary biomass potential from forests in Kton d.m. (S2Biom Base 2020 potential)

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

When looking at table 9 one can conclude that the current average yearly harvest in 2020 amounts to 4842 Kton d.m. Additionally the exploitation of wood biomass from Slovenia forests is relatively in line with its potentials.

Figure 11 shows the distribution of primary residues potential form forests.

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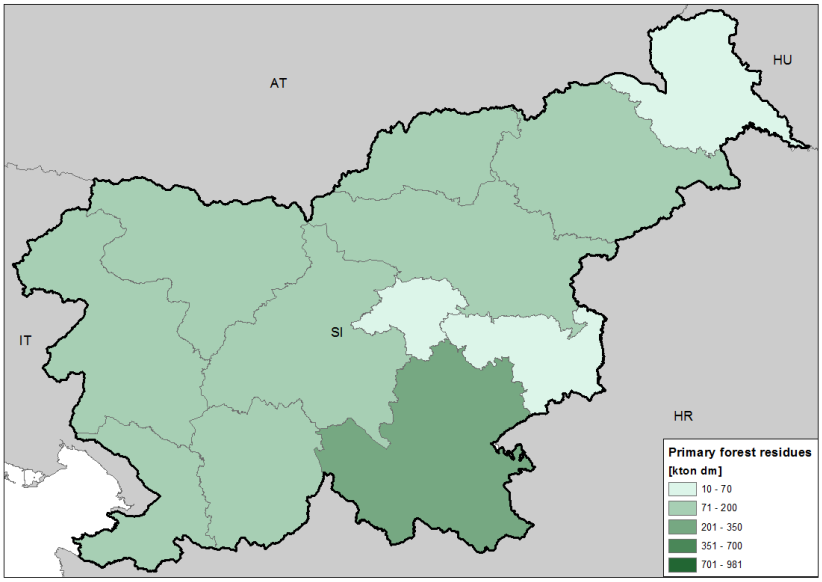

Figure 11: Distribution of primary residues potential from forests Kton d.m. (S2BIOM Base potential 2020)

The export of roundwood in 2017 was approximately 3.1 million cubic meters compared to 0.6 million cubic meters of imported roundwood[20]. The movement dynamic in external trade is an important indicator of the processing state and timber use and, consequently, capturing added value to the domestic renewable raw material. The most important exporting countries for Slovenia are Italy and Austria. Primarily low-quality roundwood and firewood is exported to Italy, while primarily coniferous roundwood is exported to Austria [18]. Export and import of roundwood in period from 2008 to 2017 is shown on figure 12. Slovenia should focus more onto producing value added products by itself, rather than just export the roundwood. It would be beneficial for Slovenian economy in first place, as well as higher amount of carbon sink would be recognized to Slovenia in accordance with LULUCF methodology.

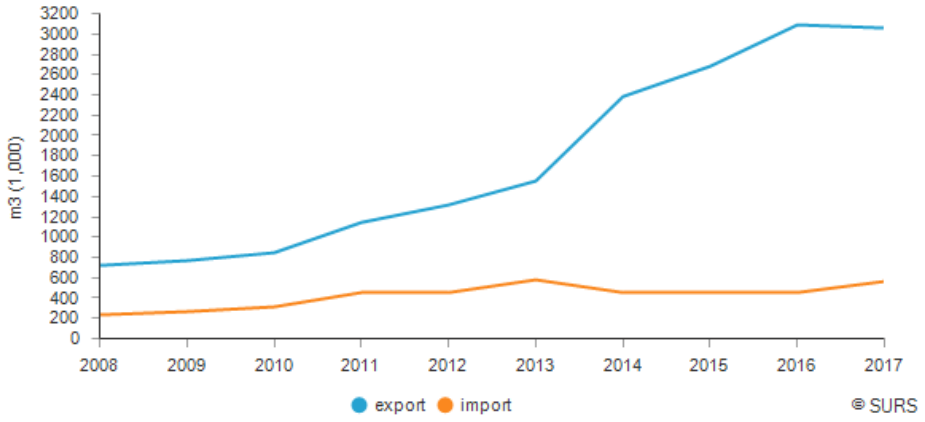

Figure 12: Export and import of roundwood, Slovenia, 2017[20]

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3.3. Secondary biomass resources from wood processing industries

Table 10 summarises wood potentials from forest industry.

Table 10: Secondary biomass potential from forests in Kton d.m. (S2BIOM Base potential 2020)

Region	Saw-dust (conifers)	Other residues (conifers)	Residues from industries producing semi-finished wood-based panels	Residues from further wood-processing	Total
Pomurska	32	29	2	5	69
Podravska	55	48	12	25	140
Koroška	37	34	12	27	111
Savinjska	67	61	20	46	193
Zasavska	13	11	3	8	35
Posavska	24	20	7	14	66
Jugovzhod Slovenija	165	70	17	37	288
Primorsko-notranjska	39	33	7	13	92
Osrednjeslovenska	61	55	11	26	154
Gorenjska	55	51	9	21	136
Goriška	59	53	8	19	139
Obalno-kraška	34	29	5	11	78
Total	**642**	**495**	**113**	**252**	**1502**

According to the data provided by WoodChainManager for the year 2018, the majority of roundwood was processed by sawmill industry (over 1 million m^3), followed by the industry of wood composites, mechanical pulp and chemical industry, all of which together processed more than half a million m^3. Among large players are also households, which annually consume over 1 million m^3 of wood, but it partially derives from non-forest resources. According to the latest research of Slovenian Forestry Institute, strengthening of wood chips industry is evident. In 2017 the aforementioned industry has a turnover of 2.2 million m^3 wood chips, which is almost 50 % more compared to 2010. Inputs are mainly residues obtained while cutting forest (36 %), low quality roundwood (32 %), sawmill residues (28 %) and other sources (4 %)[21]. Table 11 summarises forest derivatives produced in Slovenia in 2018 [21].

Table 11: Forest products in Slovenia (2018[21]).

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

Figure 13 offers an insight into a creation of gross value added in field of the woody biomass utilization during the past two decades [2].

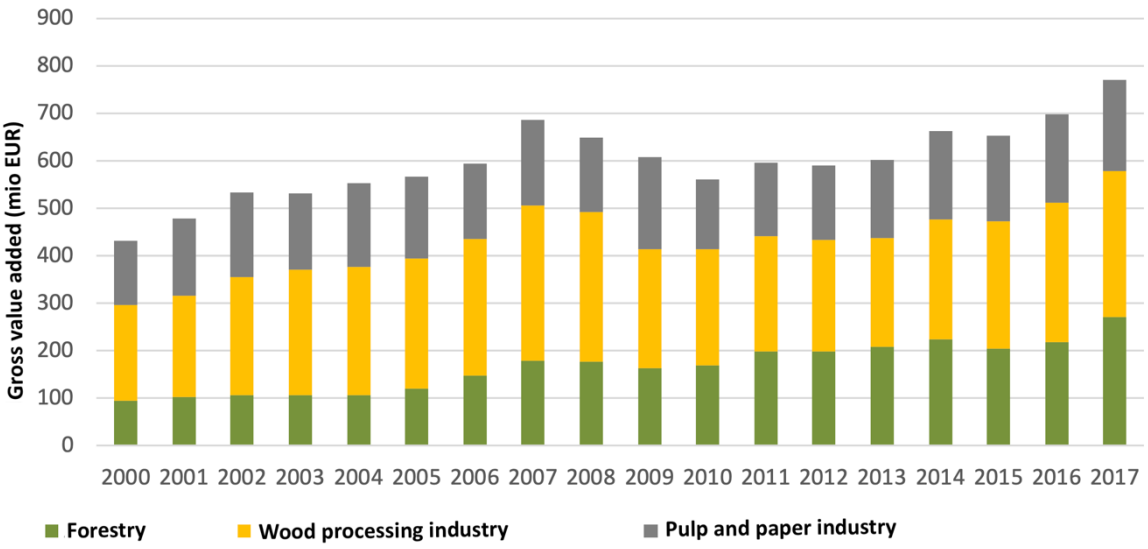

Figure 13: Contribution of forestry, wood processing and pulp and paper industry to creation of the gross value added in field of the woody biomass utilization in period from 2000 to 2017[2]

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

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

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

minimum in 2013 with only 3,900 employees, but the situation has improved by 2017 when 4,300 workers were employed[2].

3.4. Summary and conclusions in relation to SWOT elements

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

Table 12 summarises SWOT elements in relation to biomass supply from forestry.

Table 12: SWOT elements in relation to biomass supply from forestry

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

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

4. Biomass supply: Waste

4.1. Introduction

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

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

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

Table 13 summarises waste flows in 2018.

Table 13: Waste flows in Slovenia, 2018[24]

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

Figure 14. presents generated, separately collected and disposed municipal waste on landfill site in Slovenia through the period from 2011 to 2018[23].

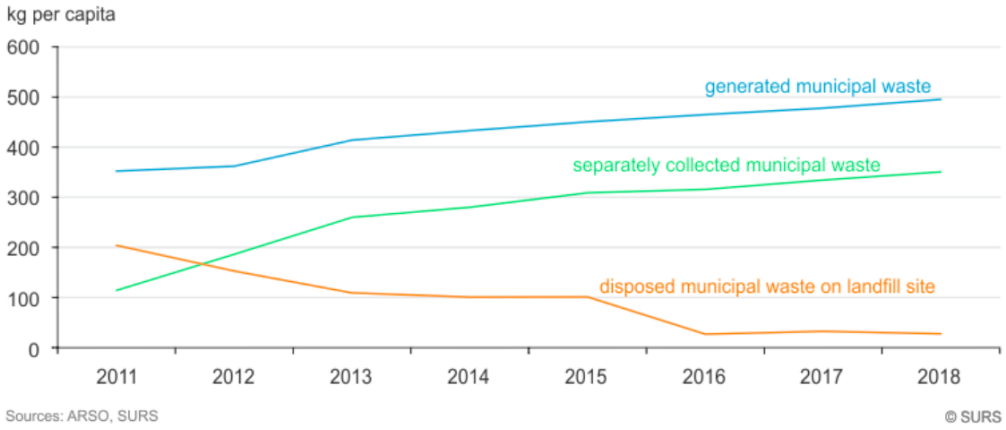

Figure 14: Generated, separately collected and disposed municipal waste on landfill site[23]

Table 14 summarises waste stream in Slovenia for the years 2017 and 2018[23].

Table 14. Waste stream in 2017 and 2018, Slovenia[23]

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

4.1.1. Example of good practice

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

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

are an emerging trend in Ljubljana, and the Voka Snaga waste department runs its own packaging-free vending machines for household basics [25].

4.2. Waste from biological resources

Table 15 presents findings of S2BIOM project about the potential of biowaste separately collected in Slovenia in 2020. All the measurements are in Kton of dry matter.

Table 15: Biowaste separately collected Kton d.m. (S2BIOM Base potential 2020)

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

The highest potential of biowaste source was assigned to Osrednjeslovenska region (see the table 15). Since Ljubljana is located in that region, the estimates seem to be logic, because of the high population density in this area a lot of waste is generated. Distribution of biowaste potential across the country is also presented on figure15.

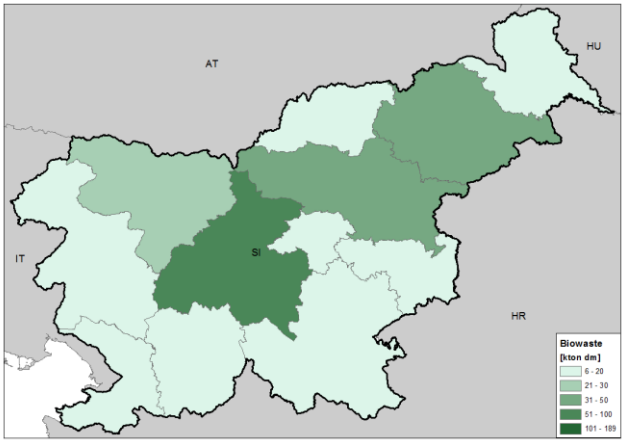

Figure 15: Distribution of total biowaste potential over country (Source: S2BIOM)

Table 16 gives an insight into generation of waste and its treatment in the sector of agriculture, horticulture, aquaculture, forestry and hunting and food preparation and processing for the years from 2016 to 2018. All measurements are in tons[24].

Table 16: Waste generated in agricultural, horticultural, forestry, hunting, fishing and food preparing and processing sector[24].

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

Based on observations from table 16, one can conclude that majority of biowaste produced in the aforementioned sectors, stays within the country.

Postconsumer wood includes all kinds of wooden material that is available at the end of its use as a wooden product, like packaging materials (e.g., pallets), demolition wood, timber from building sites, and used furniture. The quality of the postconsumer wood determines the possibilities to utilize postconsumer wood for material applications beyond combustion with energy application. Potentials of the post-consumer wood for the year 2020 were assessed in the scope of the S2BIOM project. Table 17 summarises the major findings.

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

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

Figure 16 shows the distribution of total post-consumer wood potential over the country.

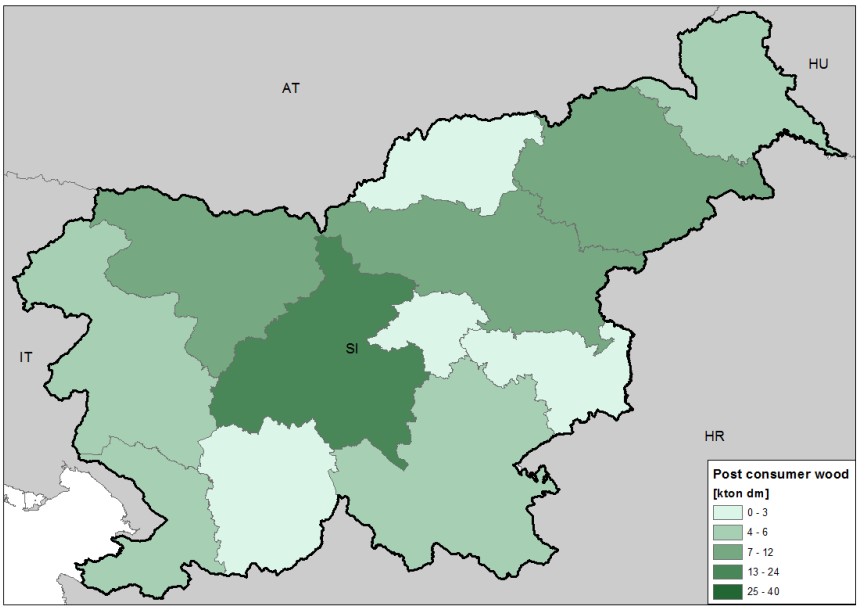

Figure 16: Distribution of total post-consumer wood potential over the country

Another important source of biowaste in Slovenia is food preparation and processing sector. Sources that generated food waste in 2018 are described in table 18. Additionally, the table gives an insight into treatment of that waste. Based on data obtained, it can be concluded that most of the food waste is recovered in biogas plants.

Table 18: Food waste generation by source and treatment, Slovenia, 2018[24]

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

Table 19 summarises amounts of certain groups of municipal waste (with the focus on biological waste) generated in Slovenia in 2018[24].

Table 19: Amounts of municipal waste in relation to its biologic origin, Slovenia, 2018[24]

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

Based on observations from table 19, one can conclude that separately collected biowaste sources ("paper and cardboard", "biodegradable kitchen, canteen waste" and "wood as a waste") for the year 2018, if summed together, amounted to 209,811 tons. The results coincide relatively well with S2BIOM's estimated potential of separately collected biowaste in 2020 which is 246,000 tons.

4.3. Current waste treatment and unused potentials estimates

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

386 facilities for waste recycling, where almost 2.9 million tons of waste was recycled (52.3% of all waste generated this year in Slovenia)

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

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

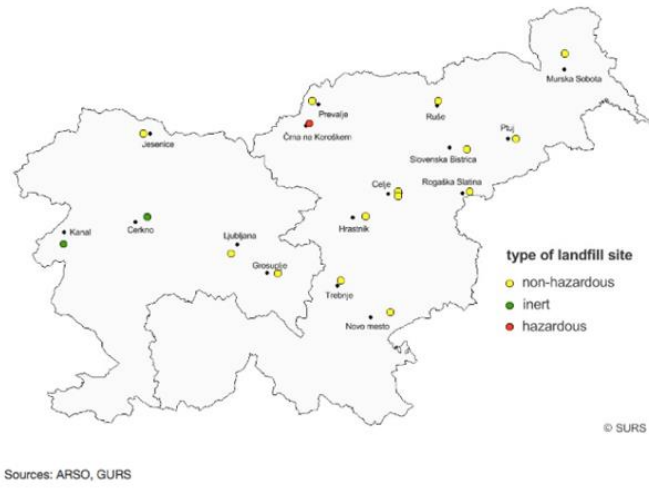

Figure 17: Operating landfill sites, Slovenia, 2016[22]

Table 20 compares data on waste treatment facilities and amount of waste treated in years 2014 and 2016[22].

Table 20: Waste treatment facilities and amount of waste treated, Slovenia, 2014 and 2016[22]

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

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

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

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

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

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

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

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

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

4.4. Summary and conclusions in relation to SWOT elements

Slovenia is among the countries with the highest number of separately collected waste and management of recycling. It separately collected almost 71 % of all municipal waste and manage to recycle more than 42 % of all waste generated in 2018. In 2016, 386 facilities for waste recycling, 180 facilities for backfilling and 10 facilities for waste energy recovery operated in Slovenia. Waste was incinerated in three incineration plants and landfilled at 17 (legal) landfill sites [22]. During the past 10 year, Slovenia has managed to constantly decrease disposed waste on landfill site. Ljubljana is also the first European capital to commit to going zero-waste. The development of the most modern plant in Europe for treating biological waste (RCERO) has been a major step towards meeting the city's commitment to a minimum 75% recycling rate by 2025. RCERO Ljubljana performs mechanical biological treatment of two types of waste:

biological waste collected separately, and mixed municipal waste. It can process over 20 000 tonnes of biological waste per year[26]. The aim of the treatment is to reduce the quantity of waste going into landfill, to separate waste which can be recycled or thermally treated in incineration plants, such as metal and glass, and to produce compost from biological waste for use in gardening and landfill maintenance. It involves mechanical separation of mixed municipal waste followed by preparation of solid fuel, and breaking down of biodegradable municipal waste and fermentation of separately collected biological waste to produce biogas[26]. Each year, the facilities produce 60,000 tons of solid fuel, 35,000 tons of digestate (material remaining following the breakdown of mixed municipal waste), 6 000 tonnes of wood, 7,000 tons of compost and 25,000 tons of waste that can be recycled to generate raw materials. The facility also generates 17,000 MWh of renewable electrical energy and 36,000 MWh of heat energy from biogas[26].

Table 21: SWOT analysis in relation to waste sector in Slovenia

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

5. Bio-based industries, products and markets

5.1. Current bio-based industries

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

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

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

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

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

5.1.1. Food and feed ingredients industries

SRIP HRANA[33] is a long-term Strategic Research and Innovation partnership for Sustainable Food Production. It has developed into a dynamic community of agriculture holdings, companies, cooperatives, research institutions, investors and other interested parties, whose main interests are focused on improvement of research and development activities in the companies for the purpose of agri-food sector development. As it is coordinated by the Chamber of Commerce and Industry of Slovenia, it includes all leading stakeholders.

5.1.2. Commercial biorefineries

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

5.1.3. Regional bio-based initiatives

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

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

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

EFFECTIVE[28] is the only demonstrational project, which is coordinated by a Slovenian partner, specifically, Aquafil. Polyamides (Nylon) and polyesters are two of the most widespread families of polymers, with applications spanning from garments, carpets and sportswear to automotive parts, packaging materials, fishing products, electric and

electronic components. In recent years, the developers of such large-volume products have started to increase their interest in the production of green products at affordable prices, which implies not only the use of bio-based materials but also the application of strategies that ensure a sustainable end-of-life of the products. In this view, the EFFECTIVE project aims to demonstrate first of its kind and economically viable routes for the production of bio-based polyamides and polyesters from sustainable renewable feedstock towards the obtaining of fibres and films with enhanced properties, market competitiveness and increased sustainability.

AGRIMAX[38] is having Gospodarsko Interesno Združenje Grozd Plasttehnika as a partner, as well as one of its demo sites/locations in Slovenia. Around a third of all food produced globally is wasted each year. This waste occurs throughout the whole value chain, from farmers to consumers. However, there are significant amounts of valuable compounds contained in the wasted food that could and should be recovered.

The AGRIMAX project is designed to establish the technical and economic viability using bio-refining process on waste from crops and food processing to deliver new bio-compounds for the chemical, bio-plastic, food, fertilisers, packaging and agriculture sectors.

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

Last but not least, the aforementioned CEL.CYCLE[37] is the largest research, development and innovation project, which includes Slovenian partners exclusively. Partners in this programme aim to discover full potential of integrated and cascade use of biomass through comprehensive research and by systematically collecting and recording findings. The project intends to develop and optimise new, sustainable technologies and procedures to lead us to useful biomass components, which can be later used as environmentally acceptable and renewable materials and products. Whatever biomass residue should remain at the end of it all, we will convert it into energy. Various research-production circles interconnect within this programme. They create new value chains with a common goal – optimal material utilisation of biomass throughout the circuit. Mastery knowledge base of research institutions intertwines with production/manufacturing competences of industry through entire process, from developing fundamental knowledge to industrial application. Partners from industry actively participate as early as initial phase of basic research by supplying relevant information about what results they expect and what is essential for the knowledge to be applicable in the industry. By doing so we can ensure that the search for new findings is focused on needs and demands, clearly stated by the industry as end user, thus allowing for successful market uptake and following principles of closed materials loops. All mentioned above demands a tight partner cooperation, high level of trust and creativity as well as open communication at all stages of process and between all value chains. CEL.CYCLE is developing the cascade use of biomass, industrial symbiosis, and circular economy.

5.3. Future Biomass valorisation options

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

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

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

Consequently, **a local** (hence smaller) **bio-refinery concept** may be **more appropriate for Slovenia** (shown on figure 18).

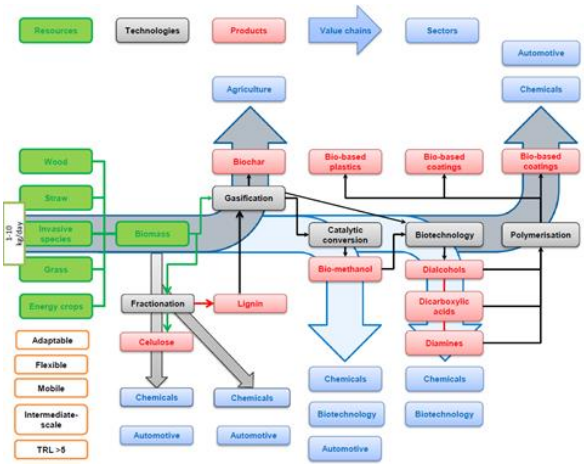

Figure 18. Bio-refinery concept suitable for Slovenia. Source: National Institute of Chemistry[41]

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

5.4. Summary and conclusions in relation to SWOT elements

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

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

The main SWOT analysis findings considering the bio-based industries, products and markets are summarised in table 22.

Table 22: SWOT analysis of bio-based industries, products and markets in Slovenia.

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

6. Infrastructure, logistics and energy sector

6.1. Existing industrial hubs and harbours

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

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

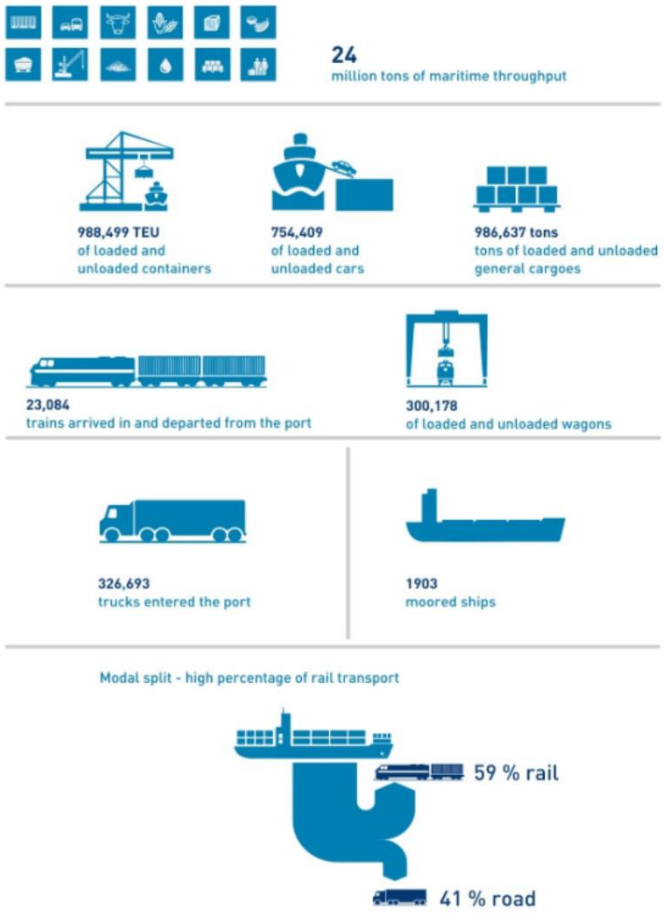

Figure 19: Highlights of Luka Koper Group's business year 2018[44]

No inland waterways exist in Slovenia[45].

Large scale bio-based production chains require transportation of large volumes of materials, i.e. the supply of biomass and the export of (intermediate) products. The only cheap options for transportation of large volumes are waterways and railways. Experts indicated that hubs are essential for establishing successful biorefineries. Using the results of the project "Methodology for defining and gathering business zones and entities of innovative environment in Slovenia"

we were able to map the current industrial hubs in Slovenia with constrains on size of industrial zones (15 ha or more) and distance to the nearest freight railway track (up to 1 km)[46].

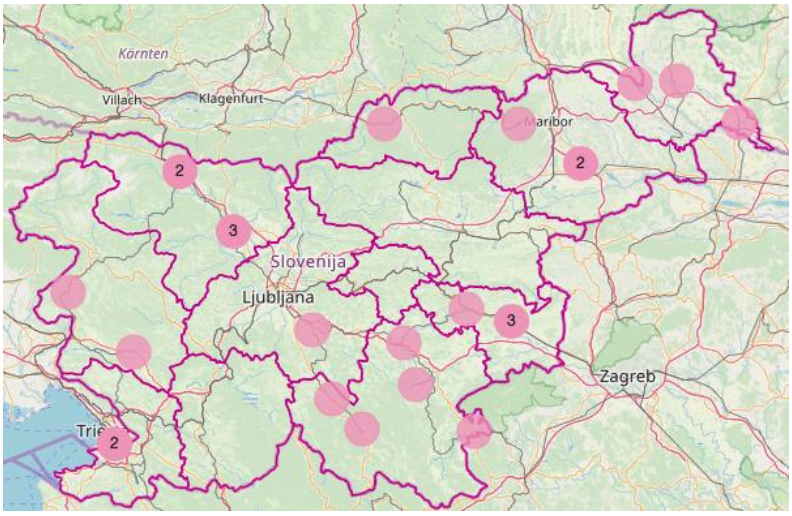

Figure 20: Current industrial zones in Slovenia that are more than 15 ha large and are less than 1 km distant from the freight railway track[46]

Industrial zones illustrated on figure 20 are also listed in table 23 with respect to corresponding municipality[46].

Table 23: Current industrial zones in Slovenia, larger than 15 ha and distant less than 1km to the nearest freight railway track[46]

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

Business zone Ruše – TDR (RU26)	Ruše
Business zone ZGO (ex iron works Ravne)	Ravne na Koroškem
Radovljica Gramoznica Graben	Radovljica
Sava Labore	Kranj
Savska cesta	Kranj
North craft-industrial zone – SOIC I., II. And III.	Murska Sobota

6.2. Existing railways

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

The railway network in Slovenia is divided into major and regional tracks in terms of traffic volume, economic importance and the interconnecting role. Railway infrastructure is further divided by the number of tracks into single-track railway where trains run on the same track in both directions and double-track railway where each track is intended for a particular direction[49]. Table 24 summarises length of railway tracks.

Table 24: Length of railway tracks[49]

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

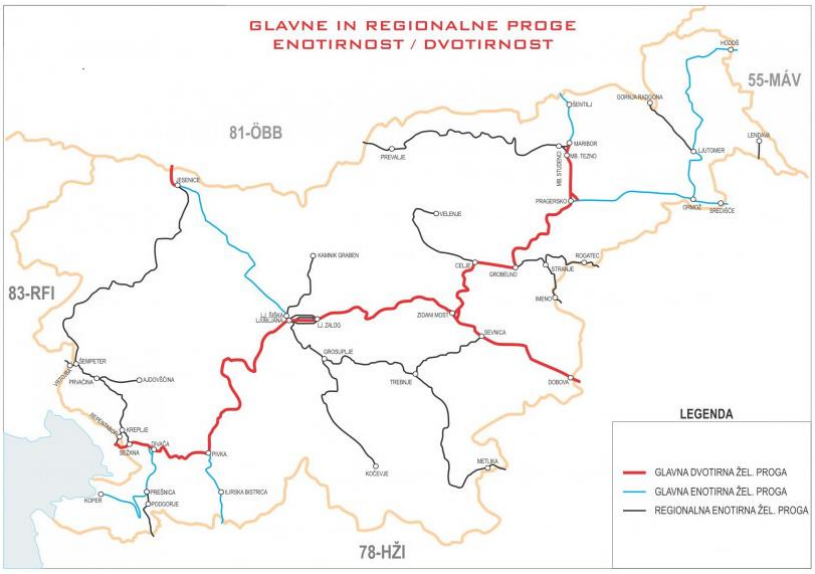

Figure 21: Map of the main and regional tracks, single / double track railways. Main double track railway is marked by red, main single track railway by blue and regional single track railway by black[49].

All the major railways, with exception of junctions with foreign railway, are electrified by a single DC system with a nominal voltage of 3 kV[49] (shown on figure 21.)

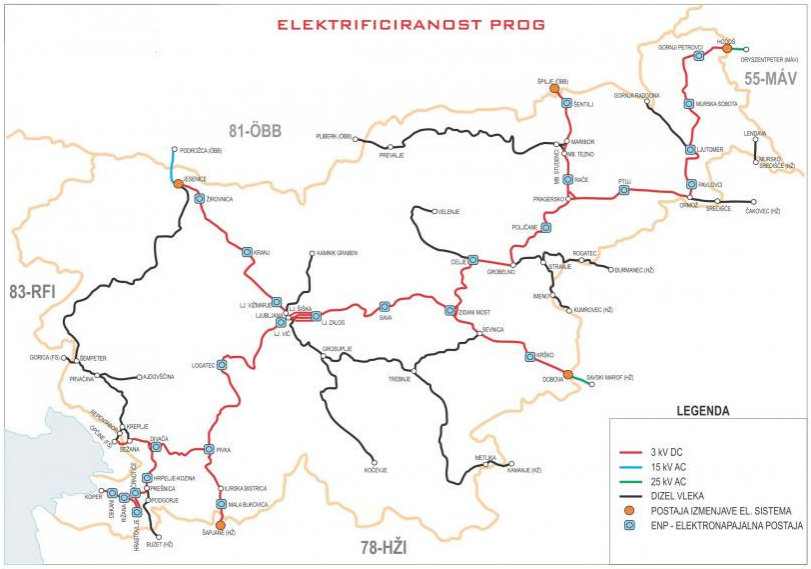

Figure 22: Map of the electrified railways. 3 kV system is marked with red. By black are marked railway tracks that are not electrified [49].

With the respect of the permissible mass load on tracks by freight wagons, the tracks are categorized according to the permissible axle and permissible length load. The permissible axel load is the maximum mass, in tonnes, that can be applied to the one axle of a railway vehicle on a given track, regardless on its total number of axles. The permissible load per running meter is the maximum mass in tonnes that be applied to one running meter of railway vehicle on a given track[49] (shown on figure 23).

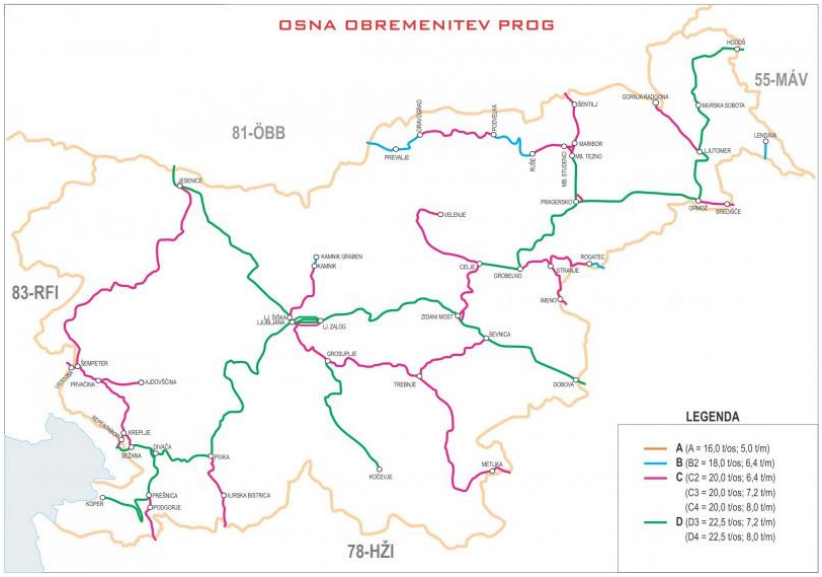

Figure 23: Tracks with the respect of the permissible axle (ton/axle) and length load (ton/m). Tracks marked with green are limited to max permissible load of 22.5 tons per axle or 8 tons per meter. Tracks marked with purple are limited to max permissible load of 20 tons per axle or 7.2 tons per meter [49].

6.2.1. Current investments in railway network

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

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

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

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

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

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

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

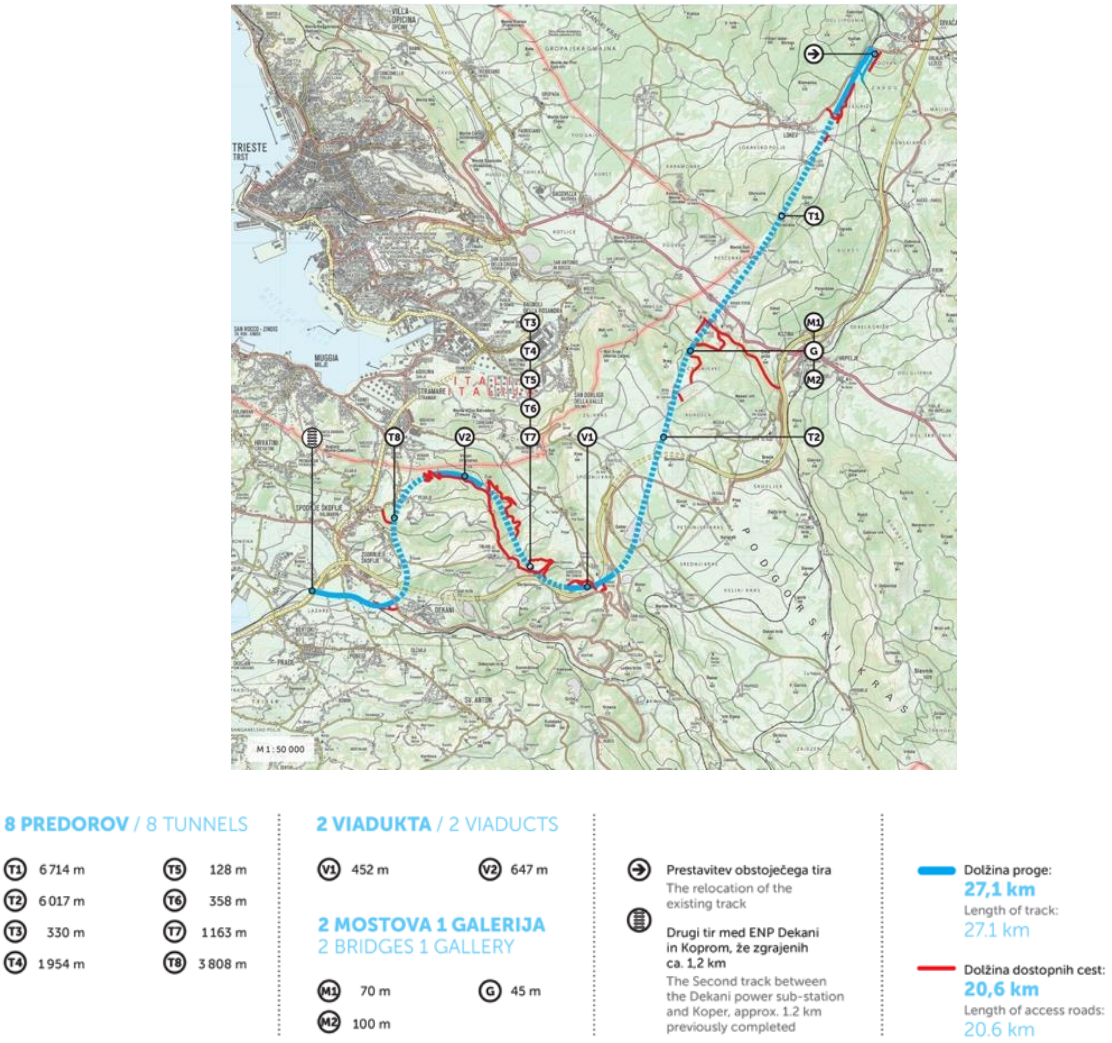

Figure 24: Second railway track from Divača to Koper[50]

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

6.3. Existing road infrastructure

Two important European traffic roads cross Slovenia's territory:

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

In the past 30 years, Slovenia has heavily invested in construction and improvement of the road network. The most important and the most congested part of the road network is the motorway cross, which was completed in 2011. Its brunch A1 runs from Maribor to Koper (the so called Slovenik) and the second branch A2 runs from Jesenice to Brežice (the so called Ilirika) – both shown on figure 25 [51].

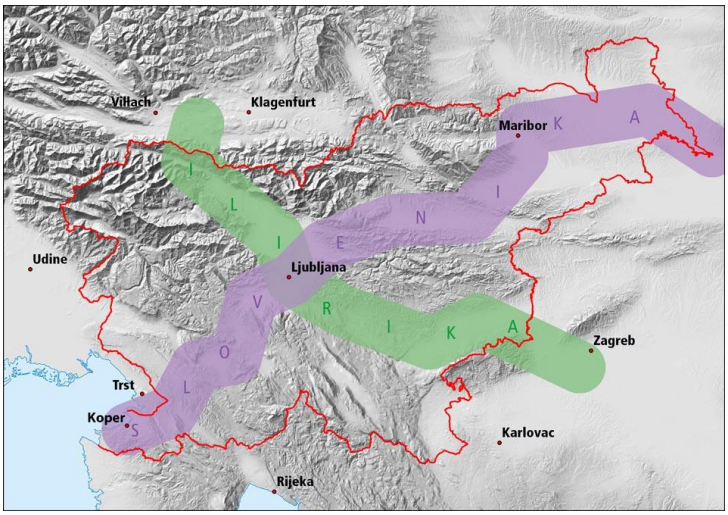

Figure 25: Slovenian motorway cross[51]

Slovenia has approximately 39,000 kilometres of public roads. The public road network is divided into state roads owned by the State and municipal roads owned by municipalities. The total length of state roads is more than 6,500 kilometres (see the table 25). The management, maintenance and development of main and regional roads and the cycle network fall under the responsibility of the Slovenian Infrastructure Agency (DRSI), while the Motorway Company of the Republic of Slovenia (DARS) manages, maintains and plans the development of motorways and expressways [52].

Table 25: Insight into length of state roads [53]

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

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

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

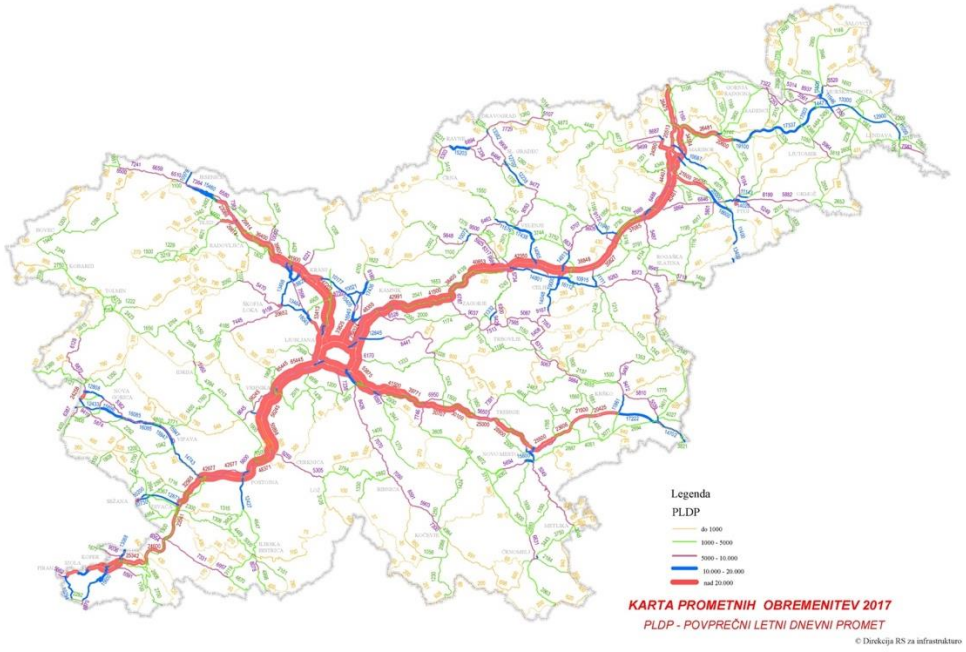

Figure 26: Map of Slovenian road network with the respect of the traffic load. The most traffic loaded is motorway cross marked with red[53].

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

6.4. Energy sector

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

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

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

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

Biogas production in Slovenia is growing in small increments and it is currently behind national goal of 35 MW energy production (cogeneration system for heat and power) by 2020. Main sources for biogas production in the region are: agricultural waste, organic waste on municipal landfills, biodegradable waste from food processing industry, waste

from public utilities and organic kitchen waste. Parallel to biogas use in the energy sector, Slovenia is yet to see increase in biogas or biofuel use in transport sector[56].

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

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

6.5. Summary and conclusions in relation to SWOT elements

Port of Koper is a part of the Trans-European Transport Network (TEN-T). Its strategic geographical position is extremely favourable for supplying markets in Central and Eastern Europe. It is well connected to the Slovenian railway network. Currently the most extensive infrastructural project in Slovenia is focusing on building the second railway track (from Divača to Koper), which will reinforce the connection between port of Koper with interior of the country, as well as with wider European network. Two priority railway freight corridors cross Slovenia: the Baltic-Adriatic Corridor (RFC 5) and the Mediterranean Corridor (RFC 6). Slovenia's territory is also crossed by two important road corridors, namely the 5th Pan-European transport Corridor (links Lisbon via Barcelona and Ljubljana to Kiev) and 10th Pan-European transport Corridor (links Munich via Jesenice and Ljubljana to Belgrade and Istanbul). Slovenia possesses 1,207.70 km of railway tracks and approximately of 39,000 km of public roads. Slovenia has more than 12,000 km of forest roads, which becomes relevant in sense of accessibility and mobilisation of biomass.

Slovenia's priority is to increase the supply of energy from renewable sources and thus strives to replace outdated technologies with more efficient and environment-friendly technologies for using renewable sources. In light of this, the most important renewable energy source in Slovenia is considered to be wood and its by-products. According to Statistical Office of Republic of Slovenia, in 2017 the share of renewable energy sources was 16 %. This amount of renewable energy was further composed of 52 % of energy produced by wood, 30 % of hydro energy, 5 % of geothermal and solar energy and 5 % of waste and biomass.

Table 26. summarises SWOT elements of Infrastructure, logistics and energy sector of Slovenia.

Table 26: SWOT analysis of Infrastructure, logistics and energy sector of Slovenia

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

7. Skills, education, research and innovation potential

7.1. Research infrastructure

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

Considering the equipment of Pulp and Paper Institute[59], the latter spans from the laboratory to pilots.

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

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

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

Faculty of Chemistry and Chemical technology (University of Maribor) is largely invested in separations[61].

Companies, such as Acies Bio also offer the access to pilot equipment operations on a commercial basis.

Combining all key aspects of microbial technology development under one roof is this one of Acies Bio key advantages for rapidly and efficiently generating value of our clients' R&D assets. Interdisciplinary research teams rapidly transfer new findings and successful approaches among production strain improvement, media and bioprocess development, scale up and DSP/isolation development, assuring fastest progress towards final goals. They ensure that all important parameters are considered throughout different stages of the development process, reducing project management burden on the clients' side and assuring timely and professional delivery of milestone targets and products. The list of equipment, available at Acies Bio, is mapped by the Pilots4U project, noting infrastructure.

The InnoRenew CoE[62] is an independent research institute, formally established in the year 2017 in the frameworks of the project InnoRenew CoE. At the InnoRenew CoE they are conducting research about renewable materials and sustainable buildings, and we are transferring our scientific knowledge into industrial practice. They focus our research activities on innovative and interdisciplinary approaches of wood and its use.

Their international team of professionals and scientists have diverse areas of expertise, are active with their Living Laboratory, and are available for everyone who may need it in their work.

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

7.2. Education infrastructure

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

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

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

7.3. Environment for start-ups

Slovenia faces more than a few **challenges** in the realm of start-up company culture, as well as environment.

Considering bio-economy, EIT Climate-KIC Accelerator[66] is one of the most sought for options available.

EIT Climate-KIC Accelerator is the only EU acceleration programme focused on climate impact by cleantech commercialisation.

Technology Park Ljubljana also offers some prospective options, often within various granted projects.

They are largest innovation ecosystem for commercialization of knowledge and technology in SE Europe.

Last but not least, ABC Accelerator[67] offers some opportunities, primarily in the field of (bio)energy.

Through eit InnoEnergy, it is possible to boost the success rate of start-ups or power the growth of scale-ups and SMEs in the field of sustainable energy and/or energy efficiency.

7.4. Public private partnerships

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

GOALS:

1) Long-term public-private partnership

2) Improvement of the material efficiency index / productivity from 1.07 (2011) to 1.5 (2020)

3) Establishment of new value chains with closed material flows

4) New business models

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

7.5. Summary and conclusions in relation to SWOT elements

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

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

Research is in general oriented towards the development of new technologies and products, which will help to ensure the long-term development of Slovenia and which are internationally relevant. At the InnoRenew CoE (H2020 Teaming centre), an independent research institute, they are conducting research about renewable materials and sustainable buildings, with an aim to later transfer their scientific knowledge into industrial practice. They focus on research activities of innovative and interdisciplinary approaches of wood and its use. Another important player is Slovenian Forestry

Institute. Although it doesn't have abundant research infrastructure, they do have an important access to the largest resource map within the country.

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

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

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

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

The main SWOT analysis findings considering the existence of infrastructure/environment are summarised in a table 27.

Table 27: SWOT analysis of Skills, education, research and innovation potential of Slovenia

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

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

8.1. Introduction

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

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

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

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

Bioeconomy is not explicitly stated and mentioned in the Slovenian Smart Specialization Strategy, but the Strategy refers to it implicitly on multiple high-priority fields (shaded fields; see Table 28 below). [69]

Table 28: High-priority fields of the Slovenian Smart Specialization Strategy (S4, 2015)

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

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

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

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

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

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

8.1.2. Transition signpost towards a green economy (2018)

This document is the result of raising awareness and thorough consultations on recognising the opportunities Slovenia has to transition into a circular economy. It summarises the strategic directives and connections between certain measures, namely the Action Plans of SRIP (see above). The priority areas of measures are: sustainable resource management, green growth of the economy, green goods and services, green budget reform, sustainable urban development, green public sector, training and green practices in agriculture.

Agriculture and forest-wood chain are two main areas of focus of this document. It is mentioned that main points for farming are a gap in biological waste treatment, an opportunity in stimulating self-sufficiency and replacing fossil fuels with biomass; for the forest-wood chain the main messages are that there is a good technological knowledge of the companies in the field, good data support (the Slovenian Forestry Institute), and many opportunities, from the furniture industry, green public contracts, to nanotechnology. [68]

Currently, at the time of writing, the Resolution "Our food, countryside and natural resources after 2021" is in the process of being passed. This resolution is about the national program on the strategic directives of the development of the Slovenian agriculture and food industry. [70]

8.1.3. Rural Development Program (2014-2020)

The Rural Development Program (RDP) has several priority areas that address the issue of bioeconomy; it mentions the potential of using biogas and biomass as a renewable source, but it also warns about the danger of excessive energetic exploitation of the forest. Forest wood is defined as a product that is often used inappropriately and in a way that yields too little added value and as a carbon sink. It states that investments in the production of biogas from biological waste from agriculture is justified.

Alongside the conventional use of agricultural and forest biomass, RDP addresses only the last step in the cascade use of biomass, that is energy production. In the future it would be wise to expand the activities in order to bring on effects that come with a more ambitious cascade biomass use. [68]

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8.1.4. General support framework

Research and Innovation Strategy of Slovenia (2011 -2020)

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

Slovenian Industry Policy (2014-2020)

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

Sustainable urban strategies of municipalities,

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

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

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

8.2. Summary and conclusions in relation to SWOT elements

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

Following table 29 summarises SWOT elements of Bioeconomy Policy Framework of Slovenia.

Table 29: SWOT analysis of Bioeconomy Policy Framework of Slovenia

Strengths	**Weaknesses**
• The measures that are present are specific in the field of bioeconomy • Simply mentioning bioeconomy in policies of agriculture etc. is progress, because it shows the understanding that these sectors play a role in Slovenia's transition into a circular economy • There is a growing awareness that structural changes in policies are need for the development of bioeconomy	• No explicit legislative bioeconomy support and stimulation, only measures that contribute to bioeconomy development • Most measures rely on voluntary pledges from the private sector • Limited resources for possible measure implementation • A lack of a circular agricultural policy • A lack of financial incentive/ subsidies to foster bioeconomy development

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Opportunities	Threats
• Future policies should focus on clusters: pairing innovation centres with industry and state • Policies for improved biomass managing, increase in the use of forest wood and stimulation of the use of recognized certificates • Removing administrative issues, e.g. via voucher schemes (proposed in Poly4EmI, 2014)	• No new and bioeconomy-specific policies and legislation (status quo) • Ignoring of the raising awareness of the need for structural change in policy • Continuous relying on voluntary pledges from companies

9. Financing

9.1. Introduction

Pro-business climate in Slovenia manifests as a growing recognition of the importance of FDI (Foreign direct investment in Slovenia) as a source of fixed capital formation to economic growth and performance. This was translated into the government commitment to actively encourage inward investment by streamlining the investment promotion agencies and offering special investment incentives. Under the cost-sharing schemes designed to attract serious investors, funding is available to investors whose projects will build on Slovenia's key selling points: well-developed infrastructure and supporting industries, and clusters of specialised suppliers.

The overall supply chain costs are low in Slovenia thanks to its strategic geographical position at the heart of the market with 500 million customers without any customs and duties, equally convenient to serve east and south-east Europe, as well as Asia.

A database of sectors and companies to target, leasehold and freehold locations to develop, was created by SPIRIT InvestSlovenia, so that potential investors are able to find answers or receive an in-depth customised response to their questions on investing in Slovenia. [71]

Slovenia has international agreements with many other states on tax exemption and preventing double taxation of income and assets of non-nationals. They can apply for this exemption in order to reduce the payment of the tax on income that comes from Slovenia. [72]

Slovenia has a great potential for fostering bioeconomy, mainly because of the high potential for exploitation of solid biomass, namely forest wood. According to the Slovenian Forestry Institute, the potential of wood biomass in Slovenia is around 450.000 tonnes of forest wood per year. [56]

For that reason, there are several policies and general support framework that provide Ministry funding, although not enough to fully realise this potential. Apart from Ministry funding, there is also EU funding for fostering bioeconomy development, including ESIF and H2020.

Ministry funding is provided from policies and strategies, mentioned above under the title General Support Framework; these are the Research and Innovation Strategy of Slovenia (2011-2020), the Slovenian Industry Policy (2014-2020),

Sustainable Urban Strategies for Municipalities, the Government Framework Program for the Transition to a Green Economy and SRIP. The latter, also describes above, means that the Ministry of Economy and the Ministry of Labour disburse funds for cluster formation under the domain of S4. These SRIP funds amount to 25 million euro for the program period.

ESIF, which is EU funding, provides resources for research and innovation and it relates to the Slovenian Smart Specialisation Strategy (S4). For the Thematic Objective no. 1 (TO1), which is titled Research, Development and Innovation, over 210 million euro is allocated for the financial period, however no allocations for particular S4 domains have been reserved as the disbursement of funds relates to tendering procedures. There are three domains of S4 that relate to bioeconomy: 2.1 Circular Economy; 3.1 SI Industry; 4.0 Factories of the Future. In the TRL3-6 call (Ministry of Science) it was assured that one project per S4 domain would be funded, but the same is not true for TRL6-9 (Ministry of Economy); for this segment there is no such provision and projects are selected regardless of the S4 domain. [69]

For the domain 2.1 Circular economy, a cluster exists called SRIP Circular Economy. It has 60 members spanning across six focus areas, including Biomass and Alternative Raw Materials. [36]

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

In terms of funding of the stages of development, there are some evident gaps; Getting innovations up to TRL 4 and providing a laboratory proof of concept generally does not present a major difficulty, however getting them from TRL 4 to TRL 6 is often a financial obstacle. Industrial proof of concept testing is needed for this step, and this is a costly procedure, which can in some cases deter industrial partners.

Another gap is getting innovations from TRL 6 to TRL 9, i.e. to the market. This is also an expensive step, as it requires resources for marketing and launching the product.

A different obstacle, which can also hinder product development is that sometimes the most innovative and novel technologies have the most difficulty in finding financing for industrial proof of concept and on.

A possible solution to bridge these gaps is fostering cluster formation. Pairing innovation centres with the right industry partners can benefit both parties and speed up the process in a safe and reliable way. [69]

9.2. Summary and conclusions in relation to SWOT elements

Slovenia has a great potential for fostering bioeconomy, but the realization of this potential ultimately depends on the financing. Slovenian government has started offering special investment incentives: cost-sharing schemes designed to attract serious investors, as well as promoting the well-developed infrastructure and supporting industries, and clusters of specialised suppliers.

Ministry funding is provided from policies and strategies, whereas EU funding provides resources for research and innovation.

Throughout the stage of development, there are some gaps in available funding, i.e. financing for getting products from TRL 4 to 6 and from TRL 6 to the market.

Table 30 summarises SWOT elements of Financing of bioeconomy of Slovenia:

Table 30: SWOT analysis of Bioeconomy Financing of Slovenia

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

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CELEBio

PART B

BIO-ECONOMY STAKEHOLDERS IN SLOVENIA

D.4.4

SI-68

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10. Introduction

The aim of this report is to present an overview of all actors and actor groups that need to be involved when setting up bioeconomy value chains. Stakeholders listed in this report are considered as current or future users of biomass in Slovenia.

The actors presented can be specific persons, companies, and other type of organisations (e.g. farmers organisations). In case of companies we focused on largest and/or most influential ones in a given sector. The results capitalise on AJPES database of business performance achieved in 2018.

For the actors presented in this report the following information is provided:

1. Entity's name
2. Entity's location in town/municipality
3. Entity's location in region
4. Turnover in millions of EUR
5. Number of employees
6. Sector in which the underlying entity operates

11. Food industry

Meat

Table 31: Main actors in "Meat" sector according to the data provided by AJPES for the business year 2018

Company	Town	Region	Turnover (mio €)	Employees	Sector
PERUTNINA PTUJ	Ptuj	Podravska	164.833	1401	Processing and preserving of poultry meat
CELJSKE MESNINE	Celje	Savinjska	85.107	358	Production of meat, poultry meat products
JATA EMONA D.O.O.	Ljubljana	Osrednje-slovenska	72.478	244	Manufacture of prepared feeds for farm animals, breeding and sell of poultry
PANVITA	Gornja Radgona	Pomurje	61.850	293	Processing and preserving of meat
PIVKA PERUTNINARSTVO	Pivka	Notranjska	43.931	422	Processing and preserving of poultry meat
KRAS D.D.	Sežana	Obalno-kraška	39.932	171	Processing and preserving of meat

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MESO KAMNIK D.D.	Kamnik	Osrednje-slovenska	32.735	130	Processing and preserving of meat

Fruit and vegetables

Table 32: Main actors in "Fruit and vegetables" sector according to the data provided by AJPES for the business year 2018

Company	Town	Region	Turnover (mio €)	Employees	Sector
ETA KAMINK D.O.O.	Kamnik	Osrednje-slovenska	20.332	136	Oth proc., preserv. of fruit, vegetables
PARADAJZ D.O.O.	Turnišče	Pomurje	9.346	70	Growing of vegetables and melons, roots and tubers
EVROSAD D.O.O.	Krško	Posavska	8.625	126	Growing of pome fruits and stone fruits
JERUZALEM ORMOŽ SAT D.O.O.	Ormož	Podravska	4.869	37	Growing of cereals (except rice), leguminous crops and oil seeds
KMETIJSKO GOSPODARSTVO LENDAVA D.D.	Lendava	Pomurje	2.441	30	Growing of cereals (except rice), leguminous crops and oil seeds

Beverages

Table 33: Main actors in "Beverage" sector according to the data provided by AJPES for the business year 2018

Company	Town	Region	Turnover (mio €)	Employees	Sector
PIVOVARNA LAŠKO UNION D.O.O.	Ljubljana	Osrednje-slovenska	153.080	592	Manufacture of beer
RADENSKA D.D.	Radenci	Pomurska	40.151	267	Manufacture of soft drinks; production of mineral waters and other bottled waters
FRUCTAL	Ajdovščina	Primorska	40.080	280	Manufacture of fruit and vegetable juice

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Dairy products

Table 34: Main actors in "Diary products" sector according to the data provided by AJPES for the business year 2018

Company	Town	Region	Turnover (mio €)	Employees	Sector
LJUBLJANSKE MLEKARNE	Ljubljana	Osrednje-slovenska	168.609	606	Operations of diaries and cheese making
INCOM D.O.O.	Ajdovščina	Goriška	65.365	397	Manufacture of ice cream
MLEKARNA CELEIA D.O.O.	Petrovče	Savinjska	61.182	213	Operations of diaries and cheese making
POMURKSE MLEKARNE D.D.	Murska Sobota	Pomurska	35.308	126	Operations of diaries and cheese making
EKOLAT D.O.O.	Vipava	Goriška	12.075	31	Operation of dairies and cheese making
MLEKARNA PLANIKA D.O.O.	Kobarid	Goriška	10.403	70	Operation of dairies and cheese making

Cereal-based foods, bakery, sweets

Table 35: Main actors in "Cereal-based foods, bakery, sweets" sector according to the data provided by AJPES for the business year 2018

Company	Town	Region	Turnover (mio €)	Employees	Sector
ATLANTIC DROGA KOLINSKA D.O.O.	Ljubljana	Osrednje-slovenska	169.226	433	Processing of tea and coffee)
ŽITO	Ljubljana	Osrednje-slovenska	102.313	701	Manufacture of bread and fresh pastry goods
MLINOTEST	Ajdovščina	Primorska	55.322	477	Manufacture of bread and fresh pastry goods
PEKARNA PEČJAK	Škofljica	Osrednje-slovenska	35.542	341	Manufacture of bread and fresh pastry goods
DON DON	Grosuplje	Osrednje-slovenska	31.418	319	Manufacture of bread and fresh pastry goods

Clusters and organisations

Most relevant clusters and organizations in food sector:

- **Chamber of Agricultural and Food Enterprises**[1]

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12. Actors in forestry and wood processing industries

Actors in primary forest sector

Table 36: Main actors in "Forest" sector according to the data provided by AJPES for the business year 2018

Company	Town	Region	Turnover (mio €)	Employees	Sector
SiDG d. o. o.	Kočevje	Osrednjeslovenska	74.810	211	Silviculture and other forestry activities
MERKSCHA d.o.o.	Celje	Savinjska	21.657	176	Logging
EXTRAFORM d.o.o.	Prestranek	Primorsko-notranjska	21.043	24	Support services to forestry
MBS LIST d.o.o.	Stari trg pri Ložu	Primorsko-notranjska	12.830	51	Support services to forestry
GOZDARSTVO GRČA d.o.o., Kočevje	Kočevje	Osrednjeslovenska	9.272	57	Sawing, planing and impregnation of wood
SNEŽNIK d.o.o.	Kočevska Reka	Osrednjeslovenska	9.001	95	Sawing, planing and impregnation of wood

Actors in wood and wood-processing industry

Table 37: Main actors in "Wood and wood-processing" sector according to the data provided by AJPES for the business year 2018

Company	Town	Region	Turnover (mio €)	Employees	Sector
NOVEM CAR INTERIOR DESIGN	Žalec	Savinjska	123.243	753	Manufacturing of luxury wooden parts for automobile interior
INOTHERM d.o.o.	Prigorica	Osrednje-slovenska	59.389	243	Manufacture of other builders' carpentry and joinery
LESONIT	Ilirska Bistrica	Primorsko-notranjska	48.185	137	Manufacture of veneer sheets
ADRIA DOM d.o.o.	Kanižarica	Jugovzhodna	30.422	216	Manufacture of veneer sheets
M SORA	ŽIRI	Gorenjska	28.864	200	Manufacture of other builders' carpentry
LIP LESNA INDUSTRIJA BLED	Bled	Gorenjska	28.962	201	Manufacture of veneer sheets
MARLES HIŠE MARIBOR	Maribor	Podravska	24.206	121	Manufacture of other builders' carpentry

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LIP OPAŽNE PLOŠČE BOHINJ	Bohinjska Bistrica	Gorenjska	22.823	215	Manufacture of veneer sheets
INLES	Ribnica	Notranjska	21.314	250	Manufacture of other builders' carpentry

Clusters and organisations

Most relevant clusters and organizations in forestry and wood processing industry:

- **Furniture and Wood Processing Association**[2]

13. Actors in waste sector

Table 38: Main actors in "Waste" sector according to the data provided by AJPES for the business year 2018

Company	Town	Region	Turnover (mio €)	Employees	Sector
KOSTAK d.d.	Krško	Posavska	69.769	397	Collection and transport of municipal waste
JP VOKA SNAGA d.o.o.	Ljubljana	Osrednje-slovenska	41.126	336	Collection and transport of municipal waste
SAUBERMACHER SLOVENIJA d.o.o.	Murska Sobota	Pomurska	30.662	214	Collection and transport of municipal waste
KOMUNALNO PODJETJE VELENJE, d.o.o.	Velenje	Savinjska	24.349	174	Collection and transport of municipal waste
KOMUNALA KRANJ d.o.o.	Kranj	Gorenjska	20.270	203	Collection and transport of municipal waste
MARJETICA KOPER, d.o.o.-s.r.l.	Koper	Obalno-kraška	18.486	226	Collection and transport of municipal waste
SIMBIO d.o.o.	Celje	Savinjska	17.472	213	Collection and transport of municipal waste
SNAGA d.o.o.	Maribor	Podravska	13.950	228	Collection and transport of municipal waste
KOMUNALA PTUJ d.d.	Ptuj	Podravska	12.960	150	Collection and transport of municipal waste
KOMUNALA Nova Gorica d.d.	Nova Gorica	Goriška	9.876	146	Collection and transport of municipal waste

Clusters and organisations

Most relevant clusters and organizations in waste sector:

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- **Chamber of Public Utilities**[3]

14. Actors in bio-based industries and market

Chemical and petro-chemical industries

Table 39. Main actors in the sector "Manufacture of chemicals and chemical products" according to the data provided by AJPES for the business year 2018

Company	Town	Region	Turnover (mio €)	Employees	Sector
* **AquafilSLO d.o.o.**	Ljubljana	Osrednjeslovenska	246.542	856	Manufacture of man-made fibres
* **Helios TBLUS d.o.o.**	Domžale	Gorenjska	203.205	788	Manufacture of paints, varnishes and similar coatings, printing ink and mastics
CINKARNA Celje, d.d.	Celje	Savinjska	163.960	876	Manufacture of dyes and pigments
* **Frutarom Etol d.o.o.**	Škofja vas	Savinjska	65.631	227	Manufacture of essential oils
TKK d.o.o.	Srpenica	Gorenjska	64.437	214	Manufacture of paints, varnishes and similar coatings, printing ink and mastics
JUB d.o.o.	Dol pri Ljubljani	Osrednjeslovenska	63.280	343	Manufacture of paints, varnishes and similar coatings, printing ink and mastics
* **MELAMIN Kočevje d.d.**	Kočevje	Jugovzhodna	50.882	183	Manufacture of plastics in primary forms
ISTRABENZ PLINI d.o.o.	Koper	Obalno-kraška	46.217	141	Manufacture of industrial gases
FENOLIT d.d.	Borovnica	Osrednjeslovenska	44.891	93	Manufacture of glues
HENKEL SLOVENIJA d.o.o.	Maribor	Podravska	39.911	29	Manufacture of soap and detergents, cleaning and polishing preparations
HENKEL MARIBOR d.o.o.	Maribor	Podravska	38.273	529	Manufacture of perfumes and

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					toilet preparations
Albaugh TKI d.o.o.	Rače	Podravska	36.886	101	Manufacture of pesticides and other agrochemical products
ECOLAB d.o.o.	Maribor	Podravska	34.773	100	Manufacture of soap and detergents, cleaning and polishing preparations
ATOTECH SLOVENIJA d.d.	Podnart	Gorenjska	32.024	71	Manufacture of other chemical products n.e.c.
TKI HRASTNIK, d.d.	Hrastnik	Zasavska	26.620	139	Manufacture of other inorganic basic chemicals
MESSER SLOVENIJA d.o.o.	Ruše	Podravska	23.301	106	Manufacture of industrial gases
NAFTA - PETROCHEM d.o.o. - V STEČAJU	Lendava - Lendva	Pomurska	21.121	114	Manufacture of other organic basic chemicals
*** TANIN SEVNICA d.d.**	Sevnica	Posavska	19.361	117	Manufacture of other chemical products n.e.c.
*** MITOL d.o.o., Sežana**	Sežana	Obalno-kraška	18.354	81	Manufacture of glues
Olma d.o.o.	Ljubljana	Osrednjeslovenska	18.302	32	Manufacture of other chemical products n.e.c
DONIT TESNIT, d.o.o.	Medvode	Osrednjeslovenska	17.816	188	Manufacture of other chemical products n.e.c
EXOTERM-IT d.o.o., Kranj	Kranj	Gorenjska	17.155	40	Manufacture of other chemical products n.e.c
BELINKA PERKEMIJA, d.o.o.	Ljubljana	Osrednjeslovenska	16.780	59	Manufacture of other inorganic basic chemicals
KOZMETIKA AFRODITA d.o.o. Rogaška Slatina	Rogaška Slatina	Savinjska	15.701	137	Manufacture of perfumes and toilet preparations
VITIVA d.d.	Markovci	Podravska	15.189	81	Manufacture of other chemical products n.e.c

Note: Asterisk * denotes companies in chemical sector that deploy substantial part of bio-based activities.

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Pharmaceutical industry

Table 40 Main actors in the pharmaceutical sector according to the data provided by AJPES for the business year 2018

Company	Town	Region	Turnover (mio €)	Employees	Sector
KRKA, d.d., Novo mesto	Novo mesto	Jugovzhodna	1,231.784	5002	Manufacture of pharmaceutical preparations
***Lek d.d.**	Ljubljana	Osrednjeslovenska	1,061.302	3793	(Manufacture of pharmaceutical preparations
SENSILAB d.o.o.	Ljubljana	Osrednjeslovenska	25.985	140	Manufacture of pharmaceutical preparations
MARIFARM d.o.o.	Maribor	Podravska	1.389	95	Manufacture of pharmaceutical preparations

Note: Asterisk * denotes companies in pharmaceutical sector that deploy substantial share of bio-based activities.

Textiles

Table 41: Main actors in "Textile" sector according to the data provided by AJPES for the business year 2018

Company	Town	Region	Turnover (mio €)	Employees	Sector
BOXMARK LEATHER d.o.o.	Kidričevo	Podravska	151.915	1552	Manufacture of luggage, handbags and the like, saddlery and harness
FILC d.o.o.	Škofja Loka	Gorenjska	85.317	341	Manufacture of non-wovens and articles made from non-wovens, except apparel
ALPINA, d.o.o.	Žiri	Gorenjska	50.088	327	Manufacture of footwear
DANI AFC d.o.o.	Slovenj Gradec	Koroška	46.942	358	Tanning and dressing of leather, dressing and dyeing of fur
INTERSOCKS d.o.o., Kočevje	Kočevje	Osrednje-slovenska	38.562	115	Manufacture of knitted and crocheted hosiery
PREDILNICA LITIJA d.o.o.	Litija	Zasavska	32.317	237	Preparation and spinning of textile fibers
PLANIKA TURNIŠČE d.o.o.	Turnišče	Pomurska	30.268	225	Manufacture of footwear
KONUS KONEX d.o.o.	Slovenske Konjice	Savinjska	27.839	157	Manufacture of non-wovens

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					and articles made from non-wovens, except apparel
TREVES d.o.o.	Trebnje	Dolenjska	23.324	141	Manufacture of carpets and rugs
LISCA d.d. Sevnica	Sevnica	Posavska	22.648	247	Manufacture of underwear

Pulp and paper industry

Table 42 Main actors in "Pulp and paper" sector according to the data provided by AJPES for the business year 2018

Company	Town	Region	Turnover (mio €)	Employees	Sector
Količevo Karton, Proizvodnja kartona, d.o.o.	Domžale	Osrednje-slovenska	166.566	389	Manufacture of paper and paperboard
Papirnica Vevče d.o.o.	Ljubljana - Dobrunje	Osrednje-slovenska	108.029	143	Manufacture of paper and paperboard
VIPAP VIDEM KRŠKO d.d.	Krško	Posavska	96.877	338	Manufacture of paper and paperboard
Paloma, higienski papirji, d.d.	Sladki Vrh	Podravska	81.964	549	Manufacture of household, sanitary and toilet articles of paper
Goričane, tovarna papirja Medvode, d.d.	Medvode	Osrednje-slovenska	73.536	212	Manufacture of paper and paperboard
DS SMITH SLOVENIJA d.o.o.	Krško	Posavska	69.764	192	Manufacture of corrugated paper and paperboard and of containers of paper and paperboard
PAPIRNICA VEVČE PROIZVODNJA d.o.o.	Ljubljana	Osrednje-slovenska	49.036	420	Manufacture of paper and paperboard
TOSAMA d.o.o.	Domžale	Osrednje-slovenska	37.903	214	Manufacture of household and sanitary goods and of toilet requisites
RADEČE PAPIR NOVA, d.o.o.	Radeče	Posavska	28.861	419	Manufacture of paper and paperboard

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Energy

RCERO Ljubljana is the most modern plant in Europe for the treatment of biological waste. Each year, the facilities produce 60,000 tonnes of solid fuel, 35,000 tonnes of digestate (material remaining following the breakdown of mixed municipal waste), 7,000 tonnes of compost and 25,000 tonnes of waste that can be recycled to generate raw materials. It also generates 17,000 megawatt hours (MWh) of renewable electrical energy and 36,000 MWh of heat energy from biogas [4].

Koto d.o.o. is another company oriented into production of green energy. Their biogas plant has a production of 1.8 million m^3 of biogas per year. It produces 4,000 MWh of electrical energy annually [5].

Panvita Ekoteh d.o.o. manages three biogas plants, Nemščak, Motvarjevci, and Jezera. Furthermore, it takes care of the environmental processes in the Panvita Group. The electricity produced is sold on the market, and the thermal energy is used to heat farms in Nemščak and Motvarjevci and for the heating of the Jezero settlement and Murska Sobota General Hospital. In 2018, they produced 27,091.6 MWh of electricity which was sold on the market, and 5839.6 MWh of thermal energy [6].

Clusters and organisations

Most relevant clusters and organizations in chemical and pharmaceutical industry:

- **Association of Chemical Industries of Slovenia**[7]

Most relevant clusters and organizations in textile sector:

- **Textiles, Clothing and Leather Processing Association**[8]

Most relevant clusters and organizations in pulp and paper sector:

- **Association of Paper and Paper Converting Industry**[9]

Most relevant clusters and organizations in energy sector:

- **Energy Industry Chamber of Slovenia**[10]
- **Slovenian Energy Association**[11]

15. Actors in knowledge and innovation

Campus, incubators and technology parks & hubs

Technology park Ljubljana is the largest innovative ecosystem for commercialization of knowledge and technology in SE Europe. It spans over the 75.000 m2 of high quality infrastructure and hosts over 300 member companies with more than 1.500 employees [12].

Research and innovation organisations

At **University of Ljubljana**, there is a number of engineering (e.g. pharmaceutics, chemical engineering, mechanical electrical engineering) and applied life science studies (e.g. wood processing, food technology, biotechnology) that

provide a solid knowledge basis for bio-based R&I and industries. The most visible faculties in that sense are Faculty for Chemistry and Chemical Technology in Ljubljana, Biotechnical Faculty, Faculty of Mechanical Engineering etc.

Also Faculty of Chemistry and Chemical Technology of **University of Maribor** is actively engaged in R&I in bio-based sector[13].

Pulp and Paper Institute, with its Laboratory and the Pilot equipment represents the only papermaking infrastructure centre in the area of SE Europe. Laboratory equipment enables the study and characterization of input materials, the characterization of paper and paper products, waste water, solid waste and the evaluation of the production process.[14]

National Institute of Chemistry primarily relates to the production of various bio-based chemicals/materials. Research is oriented towards the development of new technologies and products, which will help to ensure the long-term development of Slovenia and which are internationally relevant. Industry is an important partner to the Institute in these endeavours[15].

Scientists at **The Jožef Stefan Institute** also conduct, among other, some research work oriented into applications in field of bio-based products[16].

The **InnoRenew CoE** is an independent research institute, formally established in the year 2017 in the frameworks of the project InnoRenew CoE.
Focus of the InnoRenew CoE is to conduct research about renewable materials and sustainable buildings, and transfer scientific knowledge into industrial practice. Research activities are orientated to innovative and interdisciplinary approaches of wood and its use[17].

16. Government and semi-government organizations and NGOs

Most relevant **government organizations** for fostering and development of bioeconomy in Slovenia:

- **Strategic Research and Innovation Partnership (SRIP) – Networks for the transition into circular economy**[18]
- **Ministry of Agriculture, Forestry and Food**[19]
- **Ministry of the Environment and Spatial Planning**[20]
- **Ministry of Economic Development and Technologies**[21]

Most relevant **non-governmental organizations** supporting growth of bio-based industry sector:

- **Chamber of Commerce and Industry of Slovenia (CCIS)**[22]
- **Chamber of Craft and Small Business of Slovenia (OZS)**[23]

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17. Market actors: brand owners and consumer groups

Table 43: Largest brand owners in field of bioeconomy in Slovenia

Company	Town	Region	Turnover (mio €)	Employees	Sector
LJUBLJANSKE MLEKARNE	Ljubljana	Osrednje-slovenska	168.609	606	Operations of diaries and cheese making
PERUTNINA PTUJ	Ptuj	Podravska	164.833	1401	Processing and preserving of poultry meat
PIVOVARNA LAŠKO UNION D.O.O.	Ljubljana	Osrednje-slovenska	153.080	592	Manufacture of beer
ŽITO	Ljubljana	Osrednje-slovenska	102.313	701	Manufacture of bread and fresh pastry goods
CELJSKE MESNINE	Celje	Savinjska	85.107	358	Production of meat, poultry meat products
PANVITA	Gornja Radgona	Pomurje	61.850	293	Processing and preserving of meat
MLINOTEST	Ajdovščina	Primorska	55.322	477	Manufacture of bread and fresh pastry goods
RADENSKA D.D.	Radenci	Pomurska	40.151	267	Manufacture of soft drinks; production of mineral waters and other bottled waters
KRAS D.D.	Sežana	Obalno-kraška	39.932	171	Processing and preserving of meat
PEKARNA PEČJAK	Škofljica	Osrednje-slovenska	35.542	341	Manufacture of bread and fresh pastry goods
ETA KAMINK D.O.O.	Kamink	Osrednje-slovenska	20.332	136	Oth proc., preserv. of fruit, vegetables

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CELEBio

PART C
GUIDELINES FOR SLOVENIA ACTION PLAN

D.4.4 SI-81

18. Guidelines for Slovenia Bioeconomy Action Plan

The aim of the chapter is to present a set of specific, attainable, relevant biobased value chains and time-based Action Plan for the development of bioeconomy in Slovenia. The work has capitalised on the findings of the work in CELEBIO [2] and is structured in four sections.

The first presents the current state of bioeconomy, discusses the country's comparative strengths and opportunities, and provides an overview of the existing policy regime per value chain stage (i.e. biomass production, conversion, distribution, end use).

The second introduces the Bioeconomy Vision, the value chains selected by national stakeholders and outlines how they fit to the three main priorities3 from the 2018 Update of the European Bioeconomy Strategy4:

Strengthen and scale-up the bio-based sectors, unlock investments and markets.

Deploy local bioeconomies rapidly across Slovenia.

Understand the ecological boundaries of the bioeconomy.

The third provides facts tailored to each value chain in terms of current exploitation of biomass raw materials, future actions that could steer innovative and resource efficient market uptake for biobased products, potential interventions and expected added value. This information has resulted from the consultation with national stakeholders within the duration of the project. This section also includes information on the relevance to the UN Strategic Development Goals (SDGs), selected relevant projects and markets for the biobased products that will derive from each value chain.

Finally, the fourth part provides an implementation plan, jointly developed with stakeholders, which includes time specific goals for reaching the Vision.

[2] Slovenia-Country-Report.pdf (celebio.eu)
[3] https://ec.europa.eu/research/bioeconomy/pdf/bioeconomy_line_actions.pdf#view=fit&pagemode=none
[4] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0673&from=EN

19. Bioeconomy in Slovenia

19.1. Current state

Bioeconomy in Slovenia had an annual turnover of seven billion Euros in 2017 which translates to 67,000 Euros per person employed in the sector with the EU27 average figure being 127,000 Euros.

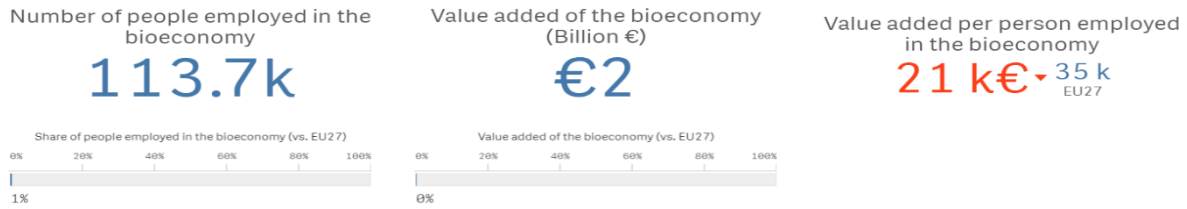

Figure 27 Jobs and wealth in the Slovenian bioeconomy in 2017 (source: datam.jrc.ec.europa.eu)

The value added from the bioeconomy sector in the country was 2 billion Euros and in the same year there were 113,700 people employed.

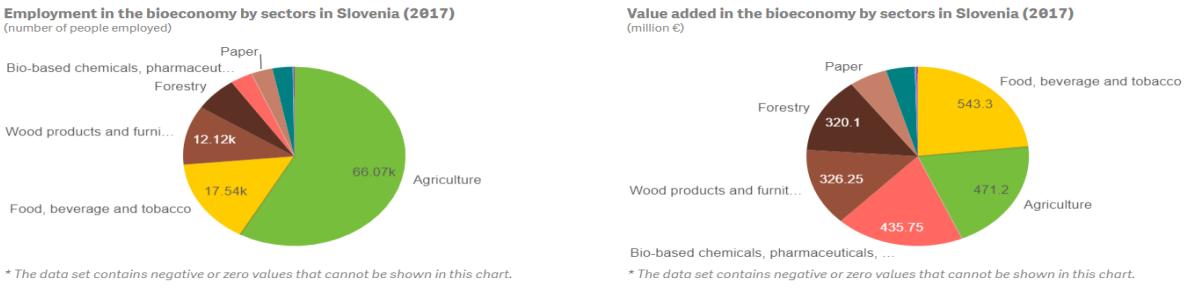

Figure28 Employment and value added in the bioeconomy by sectors in Slovenia in 2017 (source: datam.jrc.ec.europa.eu)

The Agriculture remains the biggest sector in terms of employment (59% of the total number of people employed) with food, beverage, and tobacco as well as wood products and furniture following with much smaller shares (15.4% and 10.7% respectively). In terms of value added the aggregate category of forestry, wood products and furniture is first with 0,65 billion Euros (32% of total value added- TVA) food, beverage, and tobacco contribute follow with 0.54 billion Euros (27% of TVA), agriculture is third with 0.47 billion Euros (23.6% of TVA) and biobased chemicals, pharmaceuticals follow with 0.44 billion Euros (21.7% of TVA).

Based on JRC biomass balances (https://datam.jrc.ec.europa.eu/datam/mashup/BIOMASS_FLOWS/index.html) the main biomass supply (quantities below are all expressed in million tons of dry matter) is primary wood biomass (2.65), crops (2.33) and grazed biomass (0.682). The production of biomaterials and bioenergy is not as prevalent in Slovenia as food production. Wood biomass is the main export and greatest supply in Slovenia. Biofuels are not produced from crop residuals. Almost half of the wood produced is exported as roundwood (1.17) and the other half is converted to heat and power bioenergy (1.32), solid wood products (0.939) and wood pulp (0.33).

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19.2. Strengths, opportunities and barriers

	• Accelerated generational renewal – improved age and education/skills structure • Accelerated investment cycle – improved technological and economic performance • Quality professional institutions and organizations in the field of research, education and consulting • Suitable conditions for irrigation (availability of water, precipitation) • Production systems with moderate intensity, resulting in quality products and solid environmental performance	• Promoting access to specialized advisory services • Increasing demand for sustainably produced local product of higher quality and products from above standard breeding. • Promotion of organic farming • Weak horizontal (eg. producer organisations) and vertical (eg. Value hains) integration in agri-food sector renders it difficult to organise biomass efficiently	• Agriculture in general is not very attractive to younger generations • Poor economic and environmental performance and high exposure to climate change • Restructuring is slow due to lack of own resources to co-finance investments
	• Forestry abundance (58 % of surface is covered by forest) • Good accessibility (forest roads) • Availability of up-to-date data on forests (Slovenian Forest Service, Slovenian Forestry Institute, Wood Chain Manager) and strong support at sustainable management of forests	• Development of innovative and high-added value products • Job creation • Consolidation of local markets • Increased competitiveness of the country	• High dispersion and fragmentation of forest ownership hampering devoted management • Extensive export of wood instead of creating high value-added products within the county • Lack of owners' willingness to mobilise forest feedstock
	• Awareness and willingness of citizens to separately collecting waste • Presence of the most modern regional waste management centre in Europe (RCERO)	• Development of innovative and high-added value products • Job creation • Increased competitiveness of the country • Reduction of landfill costs • Extension of landfill's lifetime	• Lack of better capabilities to treat broader spectrum of waste • Waste accumulation

19.3. Policy mechanisms relevant to bioeconomy in Slovenia

Slovenia does not have a strategy for the purpose of fostering bioeconomy, however there are regulations, developmental goals and priorities that are encompassed in the nation strategy called the Slovenian Smart Specialization Strategy (S4). It directs the use of funds in the context of Operational Programme for the execution of the European cohesion policy for the 2014-2020 period. The S4 also applies to other funds and instruments of the developmental policy. An important document is "Transition signpost towards a green economy (2018)"[5] (Slo. "Kažipoti prehoda v zeleno gospodarstvo (2018)"), which is more recent and up to date. It deals with bioeconomy as an integral part of the circular economy; another noteworthy program is the Rural Development Program.

There are several other frameworks that serve as a general support for bioeconomy in Slovenia, and they include both funding from the EU, as well as from the Ministries[6].

Errore. L'origine riferimento non è stata trovata. the policy mechanisms that are currently operational in Slovenia.

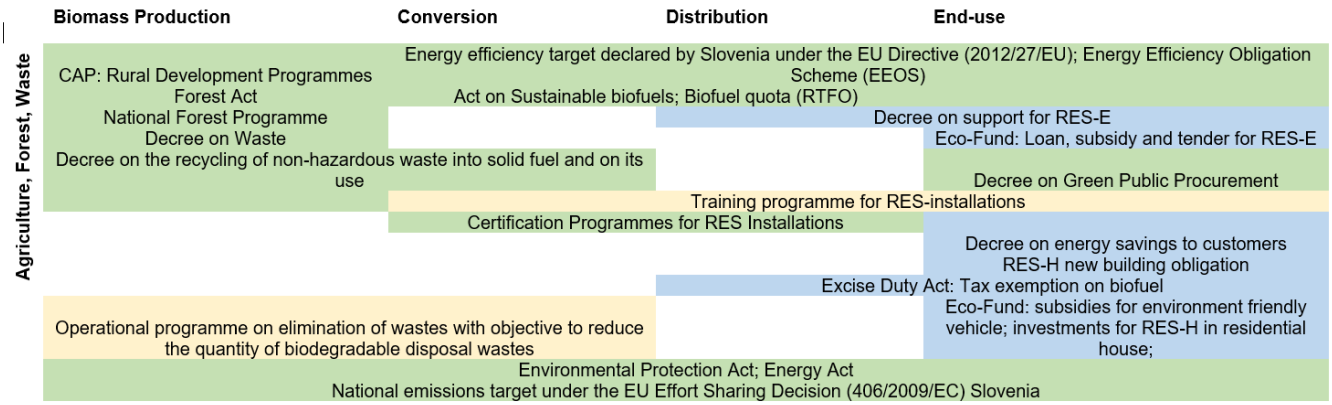

Figure 29. Policy mechanisms relevant to bioeconomy in Slovenia (green: regulations; blue: financing; beige: information provision)

[5] Lovec M, Juvancic L, Mesl M. Družbeni kontekst prehoda v biogospodarstvo / Social context of the transition into bioeconomy. BRIDGE2BIO.
[6] Brkanovic S. Case Study Report [Slovenia]. Mapping the EU Member States' / regions' Research and Innovation plans & Strategies for Smart Specialisation (RIS3) on Bioeconomy.

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20. Vision and implementation plan

The aim of the Vision for the Slovenian Bioeconomy is to:

- ✓ ***BOOST PRODUCTIVITY AND VALUE ADDED IN LAGGING BIOECONOMY SECTORS (IN PARTICULAR AGRICULTURAL PRODUCTION)***
- ✓ ***CONSOLIDATE ECONOMIC AND ENVIRONMENTAL PERFORMANCE OF CONVENTIONAL BIOMASS MANUFACTURING SECTORS (FOOD & DRINKS, WOOD PROCESSING, PULP & PAPER) BY TECHNOLOGICAL ADVANCING AND BY CLOSING LOCAL BIOMASS FLOWS AND CASCADING USE OF BIOMASS***
- ✓ ***CAPITALISE R&D EXCELLENCE IN TECHNOLOGICAL INNOVATIONS READY TO DEPLOY BY BIOBASED INDUSTRIES IN SLOVENIA, IN PARTICULAR FOR MORE EFFICIENT BIOMASS USES AND LOW- BULK & HIGH-VALUE APPLICATIONS.***
- ✓ ***ESTABLISH A MODULAR NETWORK OF BIOREFINERY CAPACITIES TO INCREASING THE LEVEL OF INDUSTRIAL SYMBIOSIS BETWEEN CONVENTIONAL AND NOVEL BIOECONOMY SECTORS.***

20.1. Strengthen and scale-up the bio-based sectors, unlock investments and markets

This section focuses the Slovenian Action Plan on value chains selected by national stakeholders as promising ones that have significant potential for market uptake of domestic raw materials and are suitable to foster innovation for the existing industrial infrastructure.

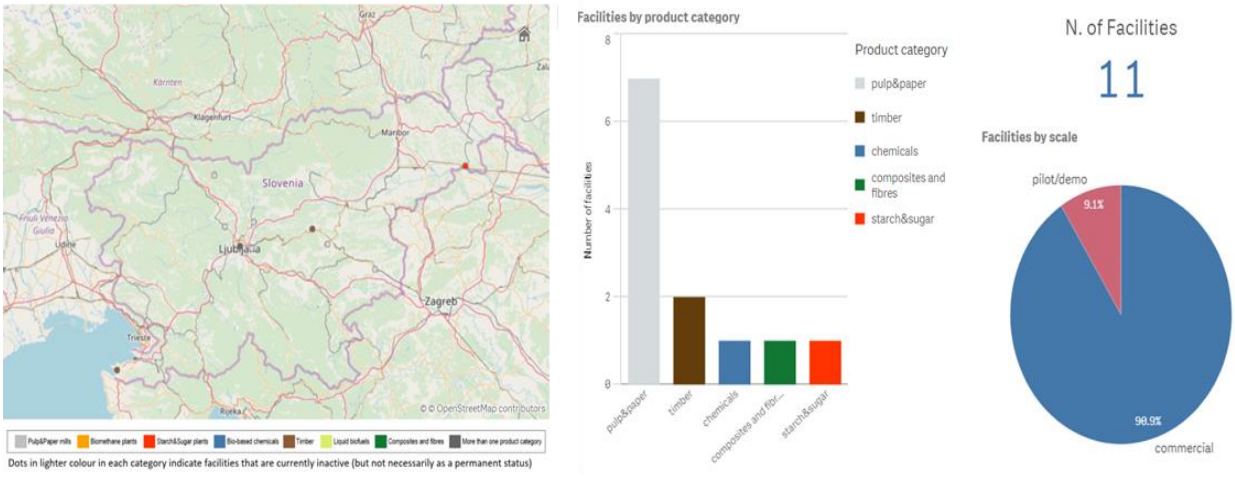

Figure 30. Biobased industry plants in Slovenia

(source: https://datam.jrc.ec.europa.eu/datam/mashup/BIOBASED_INDUSTRY/index.html)

Figure 30. Biobased industry plants in SloveniaProvides and overview of the biobased industry plants in Slovenia. There are currently eleven facilities operating in the country within the pulp and paper, timber, chemicals, composites and fiber. In addition to other industrial sectors, domestic chemical industry is particularly inclined towards going biobased. Spectrum of bio-based product is quite broad, covering polymers for textile industry, various coatings, resins, wood-derived chemicals, plant extracts, biological drugs etc. One of the most vital issues impeding extension of bio-based industry is lack of commercial bio-refineries in Slovenia.

A few regional bio-based initiatives are already in place, among whom SRIP Circular Economy is in the lead, while CEL.CYCLE is the largest research, development, and innovation project. Similarly to CELEBio project, the nationally funded project Bridge2Bio provides the quantitative evidence on various biomass potentials, motivates stakeholders to better exploit the bioeconomy potentials, and develops recommendations to decision-makers (policy, industry associations). This effort is integrated with macro-regional activities, most notably the BIOEAST initiative and its BIOEASTsUP CSA project. However, there are few international flagship bio-based projects (InnoRenew CoE, https://innorenew.eu/sl/) at present or even domestic at high TRLs. According to future biomass valorisation the bio-refining is much of an interest. A Slovenian (additional) „Valley of death" is due to lacking basic/commodity chemicals.

Work in CELEBIO has suggested that a large-scale biomass bio-refinery may not be optimal for Slovenia. Better fit seems to be achieved by local (hence smaller) bio-refinery concept. There is an ongoing initiative led by NIC and PPI, promoting a network of local (modular, potentially mobile) biorefinery operations, capable of processing diverse and mixed residual (lignocellulosic) biomass as a feedstock for locally-sourced materials' production. The technological platform has been developed and is ready for installation at demo-scale.

CELEBIO has also engaged with national stakeholders to understand their perspectives of the Slovenian bioeconomy and select value chains with strong potential to uptake indigenous raw materials, foster the development of innovative products and contribute to the development of Slovenian bioeconomy.

21. Deploy local bioeconomies rapidly across Slovenia

The value chains mentioned above and selected by national stakeholders fit well the regional distribution of biomass raw materials across Slovenian regions.

21.1. Value chains from agriculture & food industry

Agricultural production in Slovenia is determined by natural conditions for agricultural production. Grassland is by far the prevailing land use with 58%, followed by arable area (36%) and perennial crops (6%). For this reason, ruminant-based livestock production prevails in agricultural production (predominantly cattle breeding – dairy, beef). Another livestock sector with significant output and solid organisation is poultry. As for the plant production, the most widely cultivated crops are maize (fodder) and cereals while leguminoses (soya) and oil crops (sunflower, rape and turnip rape seeds) are cultivated in a smaller area. The predominant permanent crops are fruit crops, grapes, and olives.

Southern Slovenia is the region with the highest concentration of forest biomass (almost 8 million tonnes per year), central Slovenia, Savinja and Gorizia (with almost 7 million tonnes per year) and Drava and Upper Carniola and Goritzia following with quantities ranging around 6 million tonnes per year.

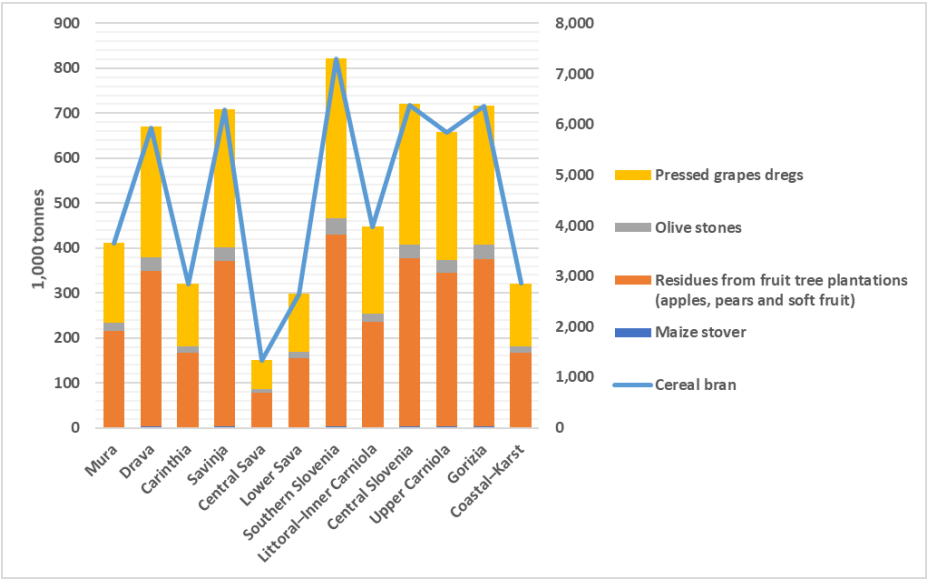

Figure 31. Biomass potential from agriculture and food industry in Kton d.m. (S2Biom Base 2020 potential)

Slovenia had over seven hundred (733) registered food processing enterprises in 2017, and this number has been growing for at least the last five years. The most common types of such enterprises are in the field of Manufacture of bread, manufacture of fresh pastry goods and cakes (322/733), followed by production of meat and poultry meat products (53/733), processing and preserving of meat (42/733) and manufacture of beer (32/733). The biggest employer is Perutnina Ptuj d.d. (poultry production), the enterprise with the highest net sales revenue in Slovenia and in foreign markets is Droga Kolinska d.d.(food-processing) and the enterprise with the highest total added value is Pivovarna Laško d.o.o. (brewery).

Residues from food and fruit processing represent an excellent opportunity to improve cost efficiency of agro-food processing companies. While food processing industry is generally well-adapted and able to keep up the pace with the technological development, the strongest potentials for valorisation of biomass side-strams are in the largest and most consolidated sectors, ie. the brewing industry, dairy industry and manufacture of grain mill products.

The value chains selected by the national stakeholders are:

- manure (550,000 t d.m. annually) -> biogas installations -> energy -> organic fertilisers
- residues from cereal processing (e.g. beer pomace, residues in the processing of cereals) -> extraction / biotechnological processes -> enzymes, bioactive compounds -> food & feed additives, ; biorefinery (bioactive compounds, platform chemicals) -> biobased materials (bioplastic, bio-composites) -> biogas plants -> energy
- residues from dairy production (mainly sour whey) -> extraction / biotechnological processes -> food additives, enzymes / biorefinery -> platform chemicals -> biobased materials
- slaughter residues, residues from meat processing -> thermal processing -> processed fats (oleochemical industry, cosmetics) / proteins (animal feed) -> biogas installations -> energy -> organic fertilisers

21.2. Value chains from forestry

Southern Slovenia is the region with the highest concentration of forest biomass (almost 1.2 million tonnes per year), Savinja (with almost 0.8 million tonnes per year) and Drava, central Slovenia, Upper Carniola and Goritzia following with quantities ranging around 600,000 ktonnes per year.

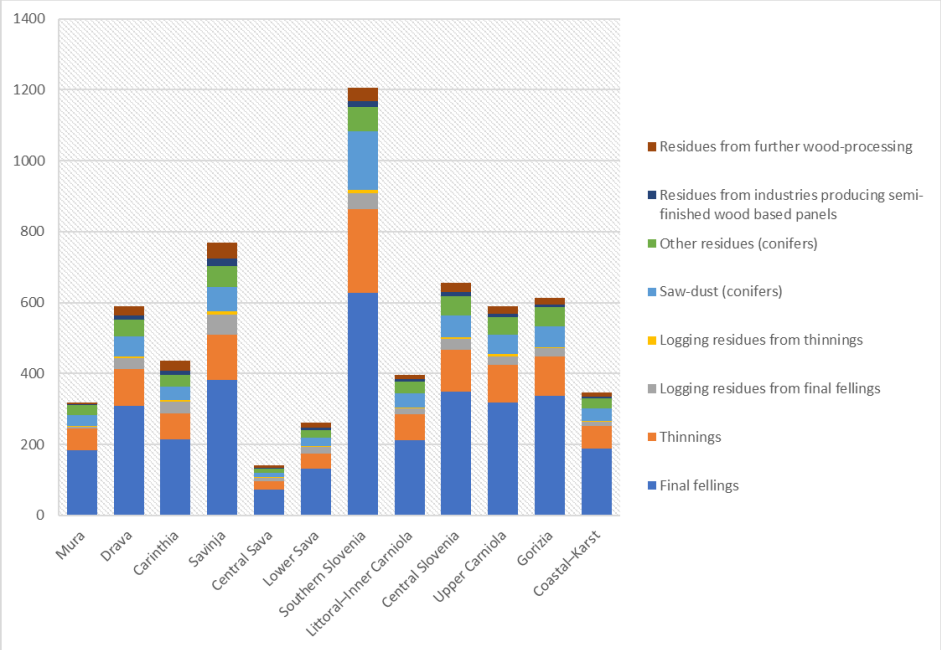

Figure 32. Biomass potential from forests and forest industry in Kton d.m. (S2Biom Base 2020 potential)

With regard to the fact that 58% of the country area is covered with forests and that the annual felling reaches up to 6 million m3 (70% of which is attributed to conifers), wood biomass represents by far the most perspective biomass stream. In national economy terms, the current use of wood biomass is unfavourable. 75% of conifers
Is exported as logs, logs, pulpwood and boards account for a further 20%. More than half of deciduous wood (56%) is currently used for firewood, the rest is evenly divided between cellulose wood and boards and logs. The most important exporting countries are Italy and Austria[18]. Only a small fragment is exported as added-value products such as chemicals, pulpwood, fibreboard, and particleboard. The sector offers great opportunities for bioeconomy in the field of replacing products of the fossil fuel industry with bio-based products mainly through the development of chemical digestion of lignocellulosic biomass. With the introduction of modern chemical wood processing, changes in the market are also expected, in terms of resource efficient and innovative consumption of low-quality wood and wood residues, as well as investments in bio-refineries.

The value chains selected by the national stakeholders are:

- Logging residues (tree bark, tree knots) -> extractives (eg. tannins, polyphenols) -> green chemistry, food additives
- Wood processing residues (industrial processing eg. plywood / pulp & paper industry / biorefinery -> platform chemicals for biobased materials)

21.3. Value chains from wastes

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

The highest potential of biowaste source was assigned to Osrednjeslovenska region. Since Ljubljana is located in that region, the estimates seem to be logic, because of the high population density in this area a lot of waste is generated. Distribution of biowaste potential across the country is also presented on figure 33

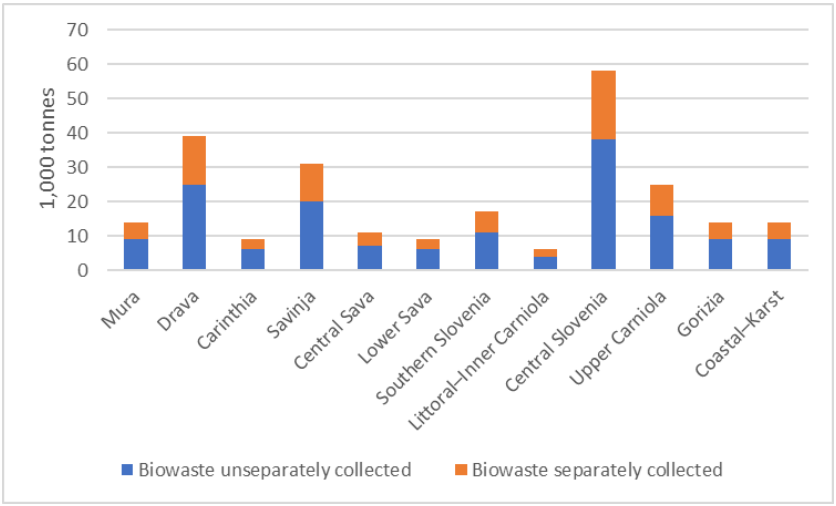

Figure 33. Biomass potential from biowastes in Kton d.m. (S2Biom Base 2020 potential)

The value chains selected by the national stakeholders are:

- urban waste -> biogas installations -> energy -> composting
- food waste -> minimizing food waste -> the inclusion of usable discarded food for human consumption -> use of discarded food for animal consumption -> use of discarded non-food related food / biogas plant as probably the most rational alternative

22. Understand the ecological boundaries of the bioeconomy

22.1. Land use change

Land use is related to raw material production. Emissions from land use change can be significant in some circumstances, however, the simple notion of land use change emissions is not sufficient reason to exclude biomass from the list of worthwhile technologies for climate change mitigation, bioeconomy and circular economy.
The value chains selected for the Slovenian bioeconomy comprise of residual and waste fractions so there is no risk expected from their mobilisation and future exploitation.

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22.2. Biodiversity

Forest biomass: High risks can be anticipated. Loss of dead wood and stumps may negatively influence species diversity and soil fauna. Contrary to this, leaving them all on the ground may result in increased fertilisation (N and wood ash) and negative impacts on vegetation

Agricultural biomass: medium risks can be anticipated without sustainable practices.
Biodiversity loss when harvesting too many crop residues
Absence of fertilisation with animal manure would reduce microbiological activity

Biowastes: Positive in regions where it avoids landfill

22.3. Soil & Carbon stock

Forest biomass: Increased risk of soil erosion; risk to loose soil organic carbon; risk to loose nutrients and risk of reduced soil fertility and soil structure when overharvesting forest residues
There are debates that using the wood in panel boards, creates a carbon stock in comparison to combustion of the wood

Agricultural biomass: Moderate risk to loose soil organic carbon when overharvesting crop residues; risk to loose nutrients when overharvesting
Absence of fertilisation with animal manure would reduce soil organic matter and soil nutrients,
Reduction of soil organic matter and soil nutrients

Biowastes: Positive in regions where it avoids landfill;
Digested organic waste is a source of soil improving material.

22.4. Water

Forest biomass: No effect on the quantity; If no removal leads to increased fertilisation the leaching on N to water may increase

Agricultural biomass: Reduction of soil water retention capacity, increasing risk of water erosion
Reduction of soil water retention capacity due to lower microbiological activity

Biowastes: Lower risk of water pollution in regions where it avoids landfill

23. Value chains for the Slovenian bioeconomy

The third provides facts tailored to each value chain in terms of current exploitation of raw materials, future actions that could steer innovative and resource efficient market uptake for biobased products, potential interventions and expected added value. This information has resulted from the consultation with national stakeholders within the

duration of the project. This section includes information on the relevance to the UN Strategic Development Goals (SDGs), selected relevant projects and markets for the biobased products that will derive from each value chain.

Agriculture

Main aim of the selected value chains is to:

- Support livestock and crop production; Involvement of rural citizens in rural development
- Exploit high residue potential; Local food processing industries offer opportunities as the negative balance of food export and import is growing

Forestry

Main aim of the selected value chains is to:

- Development of rural business activities by mobilising new value chains in the context of circular economy
- -New legislation divide State and non-state forests and makes access to funds from state easier (?)
- -Research and Innovation activities towards higher added value products from forest biomass and to increase the share of RES

Wastes

Main actions (based on Opportunities):

- -Increasing efficiency of metal processing and of electricity generation from waste could increase overall resource efficiency

23.1. Manure for biogas & organic fertilisers

Value chain	SDGs	Examples of relevant projects
Manure for biogas & organic fertilisers		  https://www.4p1000.org/

Current exploitation of biomass raw materials

- Manure utilization is approximately 10% of the known potential.
- The existing network of biogas plants (those of the order of 1 to 4 MW predominate) consists of oversized installations, causing excessive environmental loads (too little area for fertilization with digestate of biogas plants)

Future actions

Establishment of smaller biogas installations (range of 250 kW) on larger agricultural holdings, or in cooperation with other users (eg local communities) in collective investments

Potential interventions

Climate & Energy Fund: Subsidy schemes for biogas installations

Standards for agricultural biomass

Introduce premiums for manure

Regulation on agricultural raw materials for biofuels and bioliquids

Expected added value

Reduced nitrates in the soil.

Sustainable energy

Soil carbon sequestration

Product Group	Market size
Agro-chemicals Fertilisers	M 1,000 – 10,000 kt
Sustainable Energy	L >10,000 kt

23.2. Residues from agri- food industries

Value chain	SDGs	Examples of relevant projects
dairy production (mainly sour whey) – > extraction / biotechnological processes -> food additives, enzymes / biorefinery -> platform chemicals -> biobased materials		
slaughter residues, residues from meat processing -> thermal processing -> processed fats (oleochemical industry, cosmetics) / proteins (animal feed) -> biogas insallations -> energy -> organic fertilisers		
residues from cereal processing (eg. beer pomace, residues in the processing of cereals) -> extraction / biotechnological processes -> enzymes, bioactive compounds -> food&feed additives, ; biorefinery (bioactive compounds, platform chemicals) ->		

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biobased materials (bioplastic, biocomposites) -> biogas plants -> energy		

Current exploitation of biomass raw materials

Currently most of the dairy residues end up as waste, putting strong pressure on the water treatment facilities

Future actions

- Processing of dairy production residues: extraction of individual fractions (eg lactose, proteins, bioactive peptides), or through biotechnological processes, related extraction of platform chemicals (eg alcohols, polysaccharides, organic acids, biosurfactants, biologically active components and enzymes) or as a raw material for microbial production biomass (eg meat substitute)
- Specialised installation for management of side streams from meat productions, technologically advanced processing with relatively high added-value products; currently, the main challenge is more efficient and environmentally sustainable use of digestate from biogas plant.

Potential interventions

Standards for agricultural biomass

Introduce innovation financing for food SMEs and industries

Regulation on agricultural raw materials for bioeconomy

Expected added value

- Less wastes from food-processing, use of side streams and reduction of negative impact on the environment. Subsequently, improved revenues of all the involved stakeholders.
- Untapped potentials in obtaining functional components and materials (bioactive components, fibrous materials) before energy use

Product Group	Market size
Cosmetics	S <1,000 kt
Paints & coatings	
Plant based-chemicals	M 1,000 – 10,000 kt
Fertilisers	
Sustainable Energy	L >10,000 kt

23.3. Forest based value chains

Value chain	SDGs	Examples of relevant projects
Lower quality wood assortments (industrial processing eg. plywood / pulp & paper industry / biorefinery -> platform chemicals for biobased materials)		BIOFOREVER Web site https://www.bioforever.org EFFORTE Web site https://www.luke.fi/efforte/
Quality wood assortments (furniture production / construction -> wood composites / biorefinery use of side streams -> platform chemicals for biobased materials -> energy)		

Current exploitation of biomass raw materials

- Increased logging (5-6 mill. m3 annually), largely on account of emergency logging due to damaged forest stands (climatic events, pests), emergency logging. 75% of coniferous wood (70% of timber harvested) sold as logs, other pulp&paper, plywood. 56% of deciduous wood used as firewood; From the point of view of the long-term perspective, this is a category that will gain in importance with changes in forest stands (growing share of beech). On the long-run (due to climate change), beech production will increase, bringing additional potential for biorefining processes and the subsequent production of new bio-based materials.
- Low value-added of timber harvested in Slovenian forests;
- Fragmented ownership structure, which makes it difficult to establish efficient supply chains; 76% of forests in Slovenia are privately owned, 314,000 owners, average size of forest holding is 2.9 hectares.

Future actions

- Increased commercial use of roundwood within Slovenia, strengthening technologically more advanced alternatives to the energy use of lower quality wood assortments; optimization of logistics flows, primary processing at the local level and biorefining.

Potential interventions

- Forest Certification
- Introduce innovation financing for food SMEs and industries
- Regulation on agricultural raw materials for bioeconomy

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Expected added value

- Bring lower quality wood to better use than energy use, i.e. bio-based processes (biorefinery)

Product Group	Market size
Cosmetics Paints & coatings	S <1,000 kt
Plant based-chemicals	M 1,000 – 10,000 kt
Sustainable Energy	L >10,000 kt

23.4. Value chains based on biowastes

Value chain	SDGs	Examples of relevant projects
residues in the paper industry (primary sludge, in particular) -> biofuels / fertilisers (in case of primary sludge with high carbohydrate contents) / construction materials (in case of primary sludge with prevailing inorganic fraction) urban waste -> biogas installations -> energy -> composting	6 CLEAN WATER AND SANITATION; 7 AFFORDABLE AND CLEAN ENERGY; 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE; 12 RESPONSIBLE CONSUMPTION AND PRODUCTION; 13 CLIMATE ACTION; 15 LIFE ON LAND	B-Ferst Web site https://bferst.eu/ DEEP PURPLE Web site http://deep-purple.eu/ PERCAL Web site http://www.percal-project.eu
food waste -> minimizing food waste -> the inclusion of usable discarded food for human consumption -> use of discarded food for animal consumption -> use of discarded non-food related food / biogas plant as probably the most rational alternative		

Current exploitation of biomass raw materials

High cost of disposal of sludge due to cross-border transport (no disposal capacity in Slovenia)

Future actions

- Awareness raising about waste sorting and collection.
- Development of biogas plants that would utilize untapped waste streams. Communication with all relevant stakeholders on improving the legislative framework

Potential interventions

- Incentives for the use of waste for biogas production (subsidies) and fostering the development of clean and renewable energy production. This could include penalties and rewards for energy production, depending on their environmental impact.

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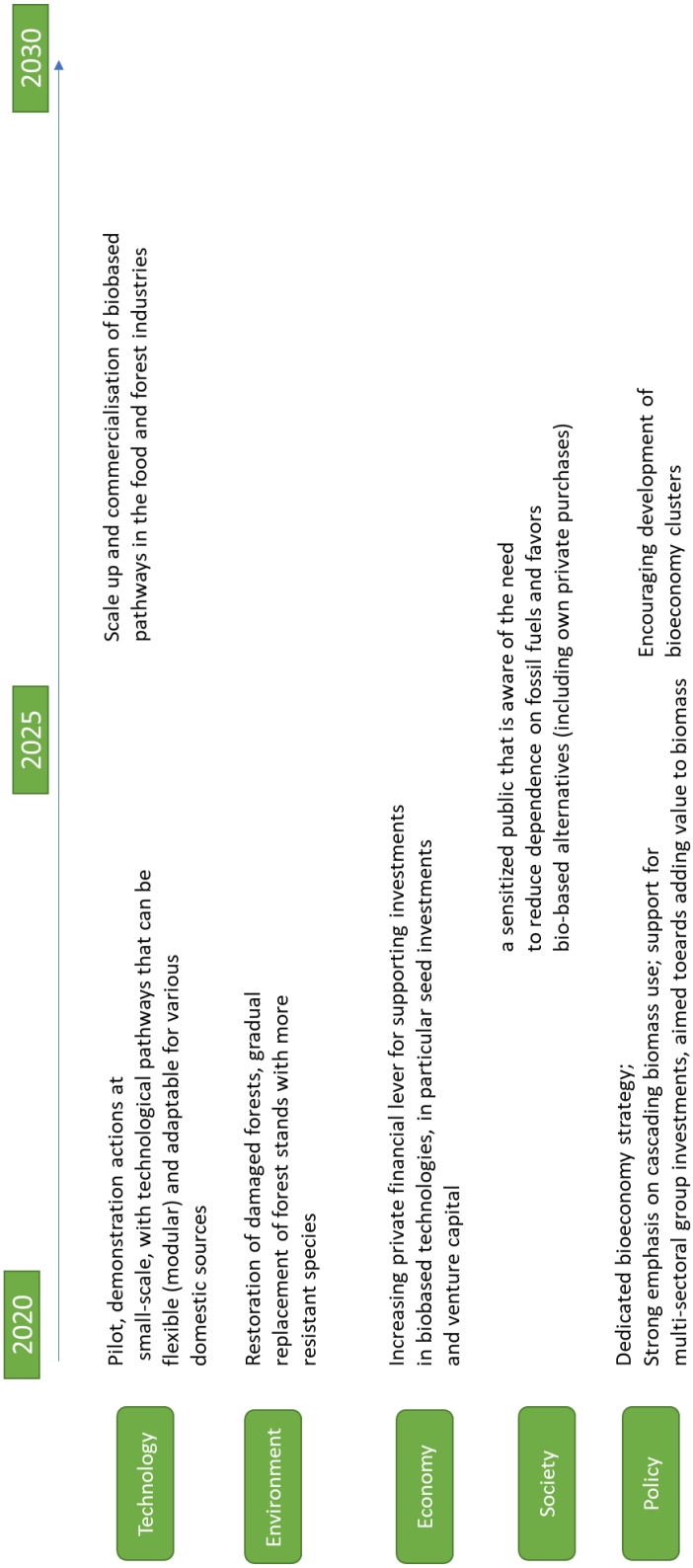
Expected added value

- Increased use of urban/municipal waste, cleaner energy, reduced environmental impact, potential to improve revenue of all stakeholders
- Efficient system of urban waste collection, improvements possible in higher share of energy utilisation (biogas)

Product Group	Market size
Cosmetics	S <1,000 kt
Paints & coatings	
Plant based-chemicals	M 1,000 – 10,000 kt
Fertilisers	
Sustainable Energy	L >10,000 kt

24. Implementation plan



24.1. Actors and funding opportunities

Action[7]	Actors involved	Indicative cost	Funding instruments
Pilot, demonstration actions at small-scale, with technological pathways that can be flexible (modular) and adaptable for various domestic sources (T)		2020-2025: 10 milion € 2025- 2030: 20 milion €	Eco-Fund: Loan, subsidy and tender for RES-E RES-H new building obligation
Scale up and commercialisation of biobased pathways in the food and forest industries (T)		2025- 2030: 50 milion €	Next Generation EU Action Plan on financing sustainable growth
Restoration of damaged forests, gradual replacement of forest stands with more resistant species (Env)		2020-2025: 10 milion €	Action Plan on financing sustainable growth CAP
Increasing private financial lever for supporting investments in biobased technologies, in particular seed investments and venture capital (Econ)		2020-2030: 50 milion € private funds	
Informed citizens that are aware of the need to reduce dependence on fossil fuels and favors bio-based alternatives (S)		2020-2030: 5 milion €	Action Plan on financing sustainable growth
Dedicated bioeconomy strategy; Strong emphasis on cascading biomass use; support for multi-sectoral group investments, aimed toeards adding value to biomass (P)		2020-2030: 1 milion €	Action Plan on financing sustainable growth
Encouraging development of bioeconomy clusters (P)		2020-2030: 10 milion €	Action Plan on financing sustainable growth

[7] T: Technology; Env: Environment; Econ: Economy; S: Society; P: Policy

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REFERENCES AND TABLES

D.4.4 SI-100

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

References

Part A

1. Studies on the TEN-T Core Network Corridors and Support of the European Coordinators: BALTIC-ADRIATIC CORRIDOR - Final Study Report, https://ec.europa.eu/transport/sites/transport/files/bac_corridor_study.pdf; Accesed on November 9, 2019
2. Poročilo o stanju na trgu lesnih proizvodov v Sloveniji. http://wcm.gozdis.si/strokovni-prispevki/porocilo-o-stanju-na-trgu-lesnih-proizvodov-v-sloveniji; Accessed on November 9, 2019.
3. SiStat - SURS, https://pxweb.stat.si/SiStatDb/pxweb/en/30_Okolje/; Accessed on November 10, 2019
4. EC: Statistical Factsheet - Slovenia (June 2019).
5. Republic of Slovenia Statistical Office. Stat'O'Book. Statistical Overview of Slovenia 2018, https://www.stat.si/StatWeb/File/DocSysFile/10179/STATOBOOK_2018.pdf; Accessed on November 1, 2019
6. S2BIOM - Benchmarking Factsheets. https://s2biom.wenr.wur.nl/web/guest/data-downloads; Accessed on November 13, 2019.
7. Eurostat - Agriculture. https://ec.europa.eu/eurostat/web/agriculture/data/database; Accessed on November 13, 2019.
8. Zrakić M, Hadelan L, Prišenk J, Levak V, Grgić I. Tendencije proizvodnje kukuruza u svijetu, Hrvatskoj i Sloveniji. Glas zaštite bilja. 2017. doi:10.31727/gzb.40.6.9
9. SURS: Number of trees and gross area by training systems and fruit varieties, Slovenia, 2017. https://pxweb.stat.si/SiStatDb/pxweb/en/30_Okolje/30_Okolje__15_kmetijstvo_ribistvo__04_rastlinska_pridelava__04_15P65_popis_sadovnjakov_2012/15P6510S.px/; Accessed on November 12, 2019.
10. Poročilo o stanju kmetijstva, živilistva, gozdarstva in ribištva - Agricultural institute of Slovenia. https://www.kis.si/Porocila_o_stanju_v_kmetijstvu_OEK/; Accessed on November 15, 2019
11. S2BIOM - D1.6 A spatial data base on sustainable biomass cost supply of lignocellulosic biomass in Europe - methods & data sources. https://www.s2biom.eu/en/publications-reports/s2biom.html; Accessed on November 14, 2019.
12. S2BIOM - Task 9.3.2: Strategic case study Assessment of biomass production potential from short rotation crops (SRC) on unused agricultural land for use in biomass power plants in Croatia. https://s2biom.wenr.wur.nl/doc/S2biom---T932---SCS-Croatia---report.pdf; Accessed on November 13, 2019.
13. Strategija izkoriščanja biomase iz kmetijstva in gozdarstva ("Agriculture and forestry biomass exploitation Strategy"). 2011;http://arhiv2014.skupnostobcin.si/fileadmin/sos/datoteke/pdf/Barbara/PREDLOGI_PREDPISOV/Kmetijstvo/Strategija_biomasa_priloga.pdf; Accessed on November 16, 2019
14. Scarlat N, Dallemand J-F, Fahl F. Biogas: Developments and perspectives in Europe. Renew Energy. 2018;129:457–472.
15. Food processing industry in Slovenia in 2017. https://www.nasasuperhrana.si/wp-content/uploads/2018/09/brosura-zpi_ENG_v2.1.pdf; Accessed on November 14, 2019.
16. S2BIOM - Tools for Biomass Chains. https://s2biom.wenr.wur.nl/web/guest/biomass-cost#_48_INSTANCE_bNEOGMUfuY37_%3Dhttps%253A%252F%252Fs2biom.wenr.wur.nl%252Fbiomasscostsupplyviewer%252Findex.html%253Fmode%253Dcost%2526; Accessed on November 14, 2019.
17. Slovenia forest service. http://www.zgs.si/eng/slovenian_forests/forests_in_slovenia/forestation_and_variety_of_forests/index.html; Accessed on November 6, 2019
18. Wood flows. http://wcm.gozdis.si/en/wood-flows-and-prices; Accessed on November6, 2019
19. Zavod za gozdove Slovenije. Poročilo Zavoda za Gozdove Slovenije o gozdovih za leto 2018. http://www.zgs.si/fileadmin/zgs/main/img/PDF/LETNA_POROCILA/2018_Porocilo_o_gozdovih.pdf; Accessed on November 6.

20. Roundwood export and import, Slovenia 2017. https://www.stat.si/StatWeb/gl/News/Index/7660; Accessed on November 6, 2019
21. Trg gozdnih lesnih sortimentov v Sloveniji v 2018. http://wcm.gozdis.si/strokovni-prispevki/trg-gozdnih-lesnih-sortimentov-v-sloveniji-v-2018; Accessed on October 23, 2019
22. Infrastructure for waste management, Slovenia, 2016. https://www.stat.si/Statweb/En/News/Index/7501; Accessed on November 8, 2019
23. Waste, Sloveina, 2018. https://www.stat.si/StatWeb/en/News/Index/8419, accessed on November 8, 2019
24. SiStat. https://pxweb.stat.si/SiStat; Accessed on November 13, 2019
25. From recycling to zero waste: how Ljubljana rethought its rubbish. https://www.theguardian.com/cities/2019/may/23/zero-recycling-to-zero-waste-how-ljubljana-rethought-its-rubbish; Accessed on November 7, 2019.
26. Upgraded waste management facilities for central Slovenia. https://ec.europa.eu/regional_policy/en/projects/slovenia/upgraded-waste-management-facilities-for-central-slovenia; Accssed on November 13, 2019
27. Aquafil Slovenia. https://www.aquafil.com/where-we-are/slovenia/; Accessed on November 13, 2019.
28. BBI: Project EFFECTIVE. https://www.bbi-europe.eu/projects/effective; Accessed on November, 2019.
29. Helios Slovenia. https://www.helios-group.eu/; Accesed on November 13, 2019.
30. Tanin Sevnica. http://www.tanin.si/; Accessed on November 13, 2019.
31. Tanin Sevnica - bio-based. http://www.tanin.si/2_biobased; Accessed on November 13, 2019.
32. Grozd Plasttehnika Slovenia. http://giz-grozd-plasttehnika.si/index.php/en/; Accessed on November 13, 2019.
33. SRIP HRANA. https://www.gzs.si/srip-hrana/vsebina/english; Accessed on November 13, 2019.
34. SiDG. https://www.sidg.si/index.php/o-sidg/poslanstvo/about-sidg; Accessed on November 13, 2019.
35. BSW Slovenia. https://www.bsw.co.uk/locations/slovenia; Accessed on November 13, 2019.
36. SRIP Circular Economy. https://srip-circular-economy.eu/; Accessed October 10, 2019
37. CELL.CYCLE. https://celkrog.si/?lang=en; Accessed on November 13, 2019.
38. AGRIMAX. https://www.bbi-europe.eu/projects/agrimax; Accessed on November 13, 2019.
39. SUSFERT. https://www.bbi-europe.eu/projects/susfert; Accessed on November 13, 2019.
40. Slovenska Strategija Pametne Specializacije (S4). 2017.
41. National Institute of Chemistry. https://www.ki.si/en/; Accessed on November 13, 2019.
42. Pulp and Paper Institute. http://icp-lj.si/?lang=en; Accessed on November 13, 2019.
43. Kiriazids T, Kiriazidis T. Maritime transport. In: European Transport: Problems and Policies. ; 2018:76-89. doi:10.4324/9780429447693-5
44. Annual report of Luka Koper Group. https://www.luka-kp.si/eng/annual-reports, Accessed on October 7, 2019. Published 2018.
45. ECORYS. Study on Strategic Evaluation on Transport Investment Priorities under Structural and Cohesion funds for the Programming Period 2007-2013: Country Report Slovenia. 2006.
46. Poslovne cone in subjekti inovatinvnega okolja. http://178.238.236.24/cone/client/; Accessed on November 14, 2019
47. Rail transport. https://www.gov.si/en/policies/transport-and-energy/rail-transport/; Accessed on October 3, 2019.
48. Railway transport, Slovenia, 2017. https://www.stat.si/StatWeb/en/News/Index/7523, Accessed on October 7, 2019.
49. Železniška infrastruktura. https://www.gov.si/teme/zelezniska-infrastruktura/, Accessed on October 7, 2019.

50. Building the second track - a new railway line from Divača to Koper. http://www.drugitir.si/en; Accessed on October 3, 2019.
51. Prometna lega in prometne povezave. https://eucbeniki.sio.si/geo9/2629/index4.html; Accessed on October 13, 2019
52. Road transport. https://www.gov.si/en/policies/transport-and-energy/road-transport/; Accessed on October 6, 2019.
53. Cestna infrastruktura. https://www.gov.si/teme/cestna-infrastruktura/; Accessed on October 6, 2019.
54. Road goods transport, Slovenia, 2018. https://www.stat.si/StatWeb/pr/News/Index/8074; Accessed on October 7, 2019.
55. Energy industry sector. https://www.gov.si/en/policies/transport-and-energy/energy-industry-sector/; Accessed on October 7, 2019.
56. Anteja EGG d.o.o. Country Report Slovenia, DanuBioValNet, Interreg. http://www.interreg-danube.eu/approved-projects/danubiovalnet/outputs?page=3; Accessed on October 6, 2019
57. Heating and cooling in Slovenia. https://www.coolheating.eu/en/slovenia.html; Accessed on October 7, 2019.
58. Faculty of Chemistry and Chemical Engineering, University of Maribor. https://www.fkkt.um.si/en; Accessed on November 13, 2019.
59. Pulp and Paper Institute - infrastructure. http://icp-lj.si/institut/infrastructure/?lang=en; Accessed on November 13, 2019.
60. KET4CP. https://www.ket4sme.eu/; Accessed on November 13, 2019.
61. Faculty of Chemistry and Chemical Engineering - separations. https://www.fkkt.um.si/en/node/542; Accessed on November 13, 2019.
62. InnoRenew CoE. https://innorenew.eu/; Accessed on November 13, 2019.
63. Slovenian Forestry Institute. http://en.gozdis.si/home/; Accessed on November 13, 2019.
64. Competence Centres for Human Resources Development. http://www.sklad-kadri.si/en/human-resources-development/competence-centers-for-human-resources-development/; Accessed on November 13, 2019.
65. BioEnergyTrain. http://www.bioenergytrain.eu/; Accessed on November 13, 2019.
66. EIT Climate-KIC Accelerator. https://www.climate-kic.org/programmes/entrepreneurship/accelerator/; Accessed on November 13, 2019.
67. ABC Accelerator. https://abc-accelerator.com/; Accessed on November 13, 2019.
68. Lovec M, Juvancic L, Mesl M. Družbeni kontekst prehoda v biogospodarstvo / Social context of the transition into bioeconomy. BRIDGE2BIO.
69. Brkanovic S. Case Study Report [Slovenia]. Mapping the EU Member States' / regions' Research and Innovation plans & Strategies for Smart Specialisation (RIS3) on Bioeconomy.
70. SPIRIT - Invest Slovenia. https://www.investslovenia.org/; Accessed on October 10, 2019.
71. International Taxation - Tax Exemptions. https://www.fu.gov.si/en/taxes_and_other_duties/areas_of_work/international_taxation/; accessed on the 10th of October.
72. Hoepffner N, Garcia-Conando S. Biomass production, supply, uses and flows in the European Union. EU Publ. 2018.
73. Biomass production, supply, uses and flows in the European Union. https://publications.europa.eu/en/publication-detail/-/publication/358c6d4b-1783-11e8-9253-01aa75ed71a1/language-en/format-PDF/source-search; Accessed on November 13, 2019

Part B

1. Chamber of Agricultural and Food Enterprises. Available at: https://www.gzs.si/zbornica_kmetijskih_in_zivilskih_podjetij. Accessed on May 6, 2020.
2. Furniture and Wood Processing Association. Available at: https://www.gzs.si/zdruzenje_lesne_in_pohistvene_industrije. Accessed on May 6, 2020.
3. Chamber of Public Utilities. Available at: https://www.gzs.si/zbornica_komunalnega_gospodarstva. Accessed on May 6, 2020.
4. RCERO Ljubljana. Available at: https://ec.europa.eu/regional_policy/en/projects/slovenia/upgraded-waste-management-facilities-for-central-slovenia. Accessed on May 22, 2020.
5. Koto d.o.o. Available at: http://www.koto.si/en/Products/Green-energy. Accessed on May 22, 2020.
6. Panvita Ekoteh, d.o.o. Available at: https://srip-circular-economy.eu/directory-members/listing/panvita-ekoteh-d-o-o/. Acessed on July 9, 2020.
7. Association of Chemical Industries of Slovenia. Available at: https://www.gzs.si/zdruzenje_kemijske_industrije. Accessed on May 6, 2020.
8. Textiles, Clothing and Leather Processing Association. Available at: https://www.gzs.si/zdruzenje_za_tekstilno_oblacilno_in_usnjarsko_predelovalno_industrijo. Accessed on May 6.
9. Association of Paper and Paper Converting Industry. Available at: https://www.gzs.si/zdruzenje_za_papirno_in_papirno_predelovalno_industrijo. Accessed on May 6.
10. Energy Industry Chamber of Slovenia. Available at: https://ezs.si/en/home-2/. Accessed on May 6, 2020.
11. Slovenian energy association. Available at: https://www.sze.si/en/. Accessed on May 22, 2020.
12. Technology Park Ljubljana. Available at: https://www.tp-lj.si/en. Accessed on May 7, 2020.
13. Faculty of Chemistry and Chemical Engineering - separations. Available at: https://www.fkkt.um.si/en/node/542. Accessed on May 7, 2020.
14. Pulp and paper Institute. Available at: http://icp-lj.si/?lang=en. Acessed on May 7, 2020.
15. National Institute of Chemistry. Available at: https://www.ki.si/en/. Accessed on May 7, 2020.
16. The Jožef Stefan Institute. Available at: https://ijs.si/ijsw/V001/JSI. Accessed on May 7, 2020.
17. InnoRenew CoE. Available at: https://innorenew.eu. Available at: https://innorenew.eu. Accessed on May 7, 2020.
18. Strategic Research and Innovation Partnership (SRIP). Available at: https://srip-circular-economy.eu . Accessed on May 22, 2020
19. Ministry of Agriculture, Forestry and Food. Available at: https://www.gov.si/en/state-authorities/ministries/ministry-of-agriculture-forestry-and-food/. Accessed on May 6, 2020.
20. Ministry of the Environment and Spatial Planning. Available at: https://www.gov.si/en/state-authorities/ministries/ministry-of-the-environment-and-spatial-planning/. Accessed on May 6, 2020.
21. Ministry of Economic Development and Technology. Available at: https://www.gov.si/en/state-authorities/ministries/ministry-of-economic-development-and-technology/. Accessed on May 6, 2020.
22. Chamber of Commerce and Industry of Slovenia. Available at: https://eng.gzs.si. Accessed on May 7, 2020.
23. Chamber of Craft and Small Business of Slovenia. Available at: https://www.ozs.si/english. Accessed on May 6, 2020.

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

Table of Illustrations

FIGURES

TABLES