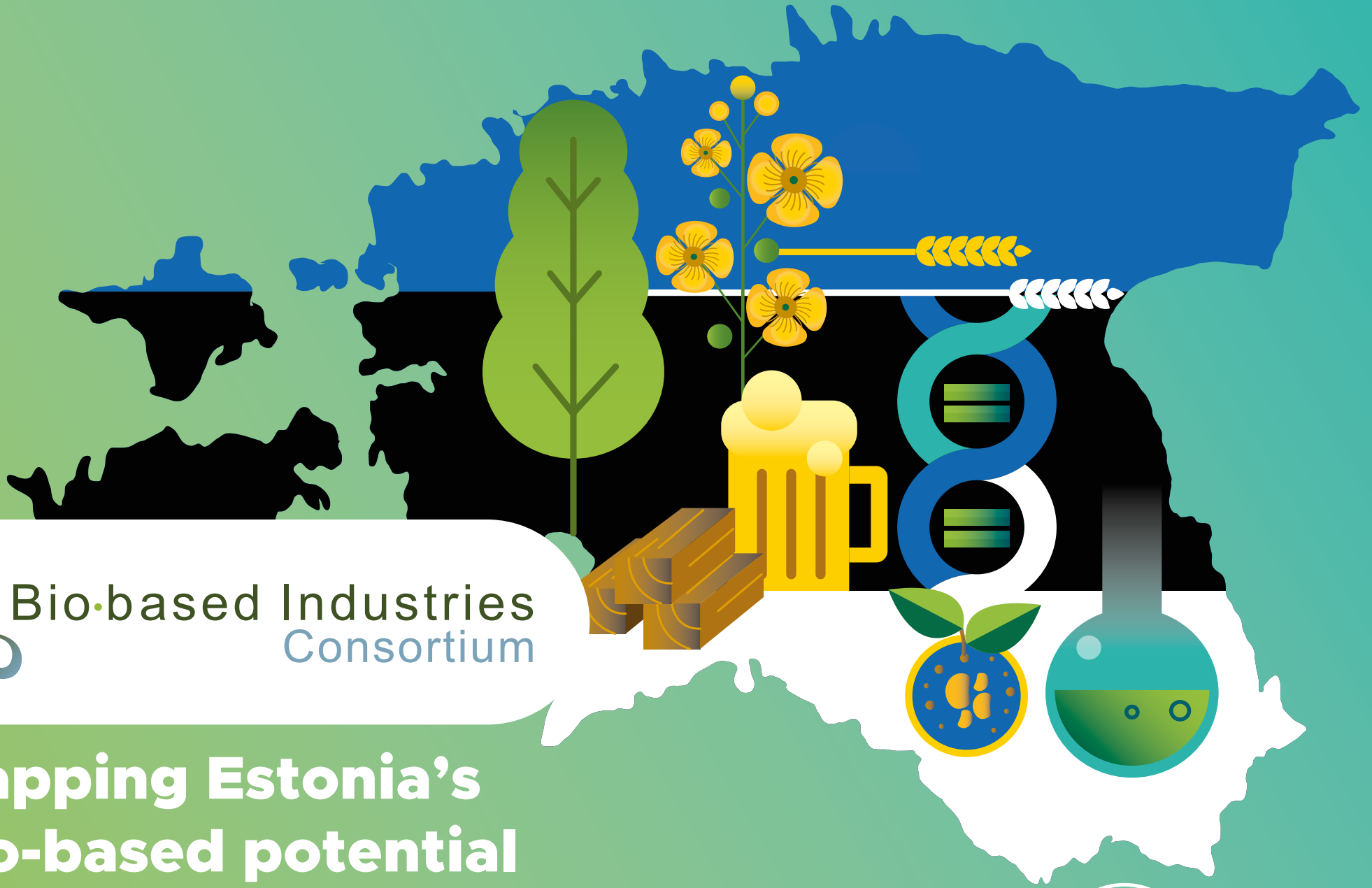


Bio-based Industries Consortium

Mapping Estonia's bio-based potential

Country Report

CONTENTS

EXECUTIVE SUMMARY

Estonia offers substantial opportunities for the bio-based industry. The potential of the country for bio-based activities comes across very clearly from the information gathered from publicly available sources, even though this information is not complete.

Situated on the banks of the Baltic Sea and including over 2000 islands and islets, some of whom of substantial size as the West Estonian archipelago, Estonia's landscape is a mix of plains and low hills. Half of the country is covered by forests, while around a third of the country is arable land.

Agriculture, forest-based and chemical industries are among the strong drivers of Estonia's economy. Also present are healthy food and beverages and wood-processing industries. Among the bio-based sectors, wood processing and agriculture take the leading role in terms of production value.

These industries are a sound basis for a bio-based industry in Estonia. The presence of many international actors in the biotechnology sectors and a well-organised innovation support infrastructure contribute to a significant list of ingredients for a sustainable bio-based sector. In addition, the country is currently drafting a bioeconomy strategy that should be great support for local, regional and national bio-based operations. The country's Smart Specialisation Strategy includes two priorities that are relevant for the bioeconomy: Biotechnology and Health-promoting food; "functionalised wood products" are also mentioned under the "Materials science and industry" priority.

The industrial sectors in Estonia have substantial residual streams and waste, most of which find low-value applications. These streams are relevant feedstocks for bio-based operations in the country.

In terms of residual biomass streams, wood residues from the wood industry are by far the most abundant source of residual biomass, at 450 thousand tonnes/year. Animal dejections from the primary sector come second at 85 thousand tonnes/year.

Other important residual streams are crop residues and sludges from agriculture, effluents from the pulp and paper industry and the organic fraction of MSW. Residual streams from these activities are excellent feedstock for bio-based operations in Estonia. However, precise data on waste generation and management are not available across all industrial sectors, neither on the organic fraction of Municipal Solid Waste.

Estonia is one of the high-tech hubs in North-eastern Europe including biotech (with a specialisation in medicine biotechnology) and has an active national biotechnology association. It also features a solid chemical industry. There is a strong support towards high-tech university spinoffs and start-ups. The country has a network of technology parks and incubators, the main ones located around the cities of Tallinn, Tartu and Narva.

This document is part of the 'strategic outreach programme' of the Bio-based Industries Consortium (BIC). The objective of the programme is to identify opportunities for bio-based industrial activities in European countries where these activities are relatively low. Bio-based activities heavily depend on innovation, and hence are relatively low in 'moderate/modest innovator' countries. This may be the result of insufficient knowledge of the potential for the bio-based industry in these countries, by actors in bio-based activities in these countries as well as by BIC. Additionally, actors in these countries may not be fully aware of the opportunities offered by BIC and the Bio-based Industries Initiative.

Several EU-funded research projects using biomass feedstock and biotechnologies have been running in Estonia in the last few years: notably SWEETWOODS, a Flagship under the Bio-based Industries Joint Undertaking programme, is coordinated by an Estonian company and being constructed in Estonia. This demonstrates the interest and commitment for bio-based activities by the scientific and industrial communities in the country.

This document is part of the 'strategic outreach programme' of the Bio-based Industries Consortium (BIC). The objective of the programme is to identify opportunities for bio-based industrial activities in European countries where these activities are relatively low. Bio-based activities heavily depend on innovation, and hence are relatively low in 'moderate/modest innovator' countries . This may be the result of insufficient knowledge of the potential for the bio-based industry in these countries, by actors in bio-based activities in these countries as well as by BIC. Additionally, actors in these countries may not be fully aware of the opportunities offered by BIC and the Bio-based Industries Initiative.

This report does not pretend to be complete. Nor may it be based on the most recent statistical data. The report is a first draft that has been prepared by collecting and analysing available data by BIC. The report is mainly feedstock-driven, in an effort to use relevant available feedstock for higher values than currently is the case. The Estonian representative in the States Representatives Group of the BBI JU has provided significant assistance in collecting and reviewing data used in this report.

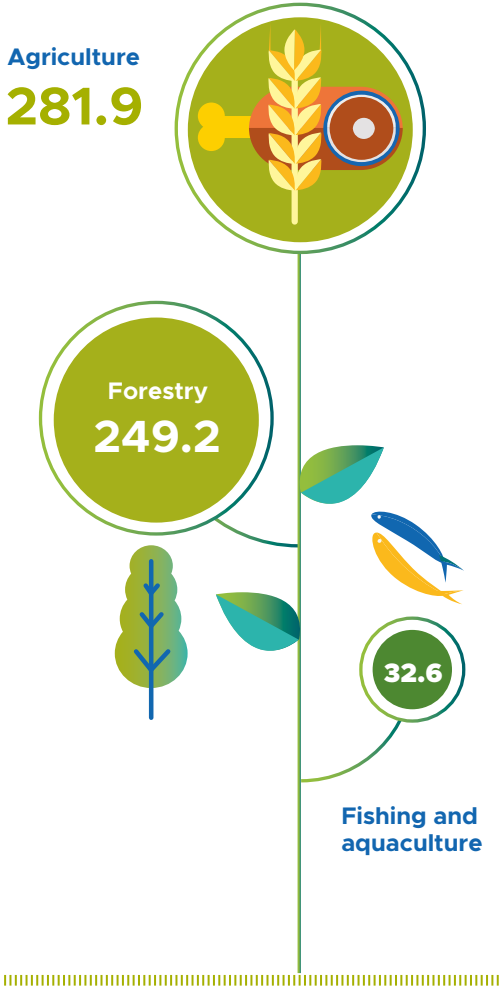
1. CURRENT BASIS OF ECONOMIC ACTIVITIES

Estonian land is largely covered by forests. Wood-based value chains make up a significant part of the country's bio-based economy. Crop agriculture has traditionally played a smaller role than livestock rearing; however, in recent years crops (especially cereals) have grown considerably.

The figures below show the relative importance of bio-based sectors in terms of Gross Value Added (GVA).

For sectors such as textiles and leather, chemicals, pharmaceutical and furniture it is not possible to distinguish between the bio-based and non-bio-based contributions. They are therefore shown in Figure 3 as 'partially bio-based'.

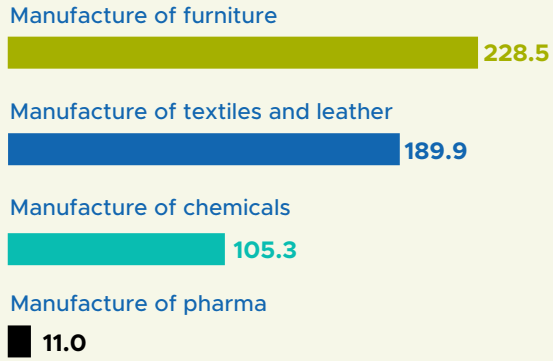
Figure 1. Gross Value Added of bio-based primary sector (M€*, Eurostat, 2017)



* million

Figure 2. Gross Value Added of bio-based manufacturing sector (M€, Eurostat, 2017)

Figure 3. Gross Value Added of partially bio-based manufacturing sector (M€, Eurostat, 2017)



1.1. Agriculture

In the recent years the production value associated with the agricultural sector (i.e. crop cultivation and livestock) has exceeded €500 million (except a slight decrease in 2016, when the overall production value was about €470 million). In particular, crop production covers around 70% of the total production value generated in the agricultural sector.

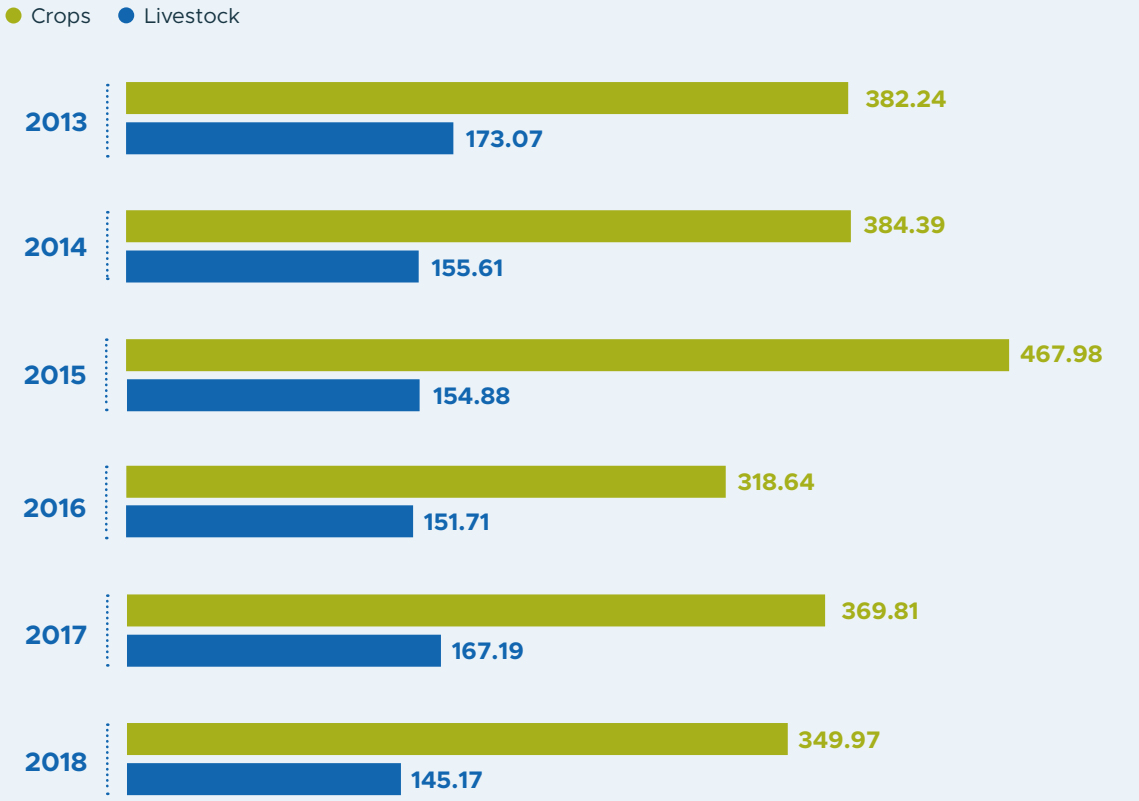
1.1.1. Crop production

Cereals

The overall production of cereals amounted to 1.5 million tonnes in 2015*

Wheat takes up more than half of it (over 800 thousand tonnes). Barley is another notable produce, with around 550 thousand tonnes per year. Other cereals include rye and oats.

Figure 4. Agricultural production trends (M€, Eurostat)



* Estonian Statistical Yearbook 2016

Rape and turnip rape

Production of rape and turnip rape (2015)

196 Kt*

Dry pulses

Production of dried pulse grains (2013/2014)

31.5 Kt

Potatoes

Production of potatoes (2016/2017)

90 Kt

* thousand tonnes

Fresh vegetables

Production of fresh vegetables (2014/2015)

66.5 Kt

Oleaginous seeds and fruits

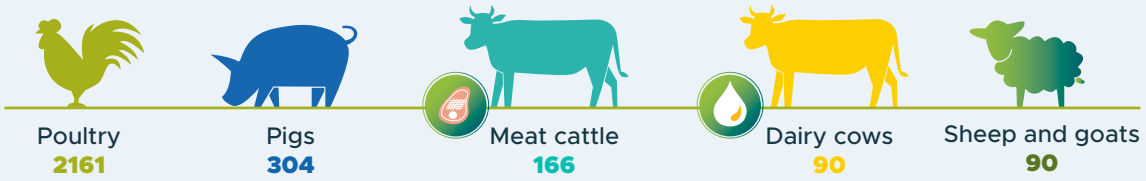
Production of oleaginous seeds and fruits (2015/2016)

196.5 Kt

1.1.2. Livestock

The breakdown of the livestock in Estonia at the end of 2015 is shown in Figure 5:

Figure 5. Animal headcount (K*, 2017)



1.2. Forest

Forests cover nearly half (49%) of the Estonian land territory. In 2014, the total forest area was 2.3 million hectares and the total growing stock was 481 million cubic metres. The most common stands are pine (31% of the total area of stands), birch (29%), spruce (19%) and grey alder stands (9%).

The share of private and state-owned forests is almost equal, with state-owned at 52% and private at 48%.

The felling volume in 2015 was 9.5 million cubic metres. It is estimated that a further 2.5 – 5.5 million cubic metres could be mobilised sustainably.

Forest and wood industries contribute 5% of employment, or **33800 jobs**.

Figure 6. Trend of the Gross Value Added of forestry (M€, Eurostat)

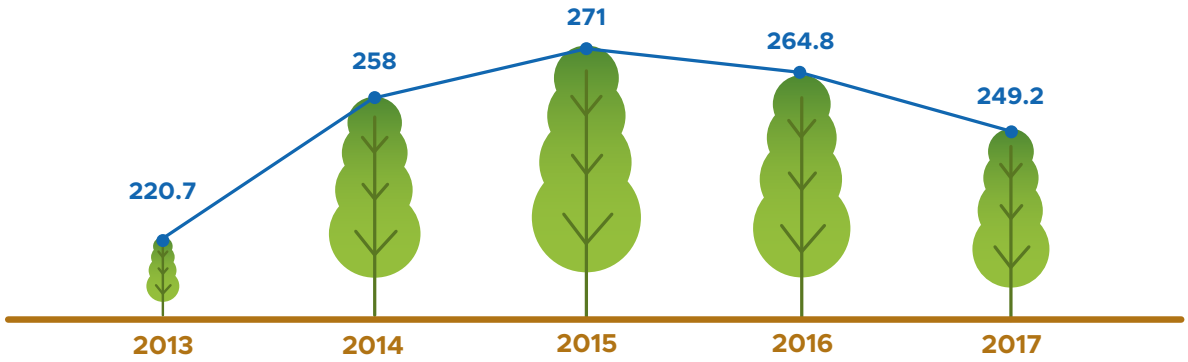
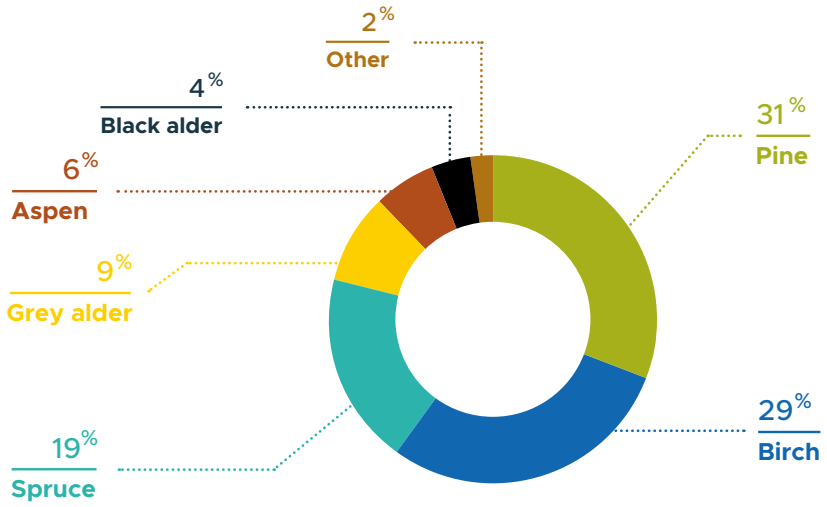


Figure 7. Distribution of tree species in Latvian forests (Estonian Timber, 2016)



1.3. Fisheries, aquaculture and the blue economy

1.3.1. Fisheries

Fish is caught both in sea and inland waters, while aquaculture is performed mainly in fresh water.

Sea catches amounted in 2014

55 Kt

Landing value

€650 M

People employed in fisheries

700

[1] tonnes

[2] OECD Food and Agricultural Reviews, 2018, Innovation, Agricultural Productivity and Sustainability in Estonia

1.3.2. Aquaculture

Aquaculture is small and performed exclusively in inland freshwaters. The most reared species (around 90%) is rainbow trout.

Aquaculture production (2013)

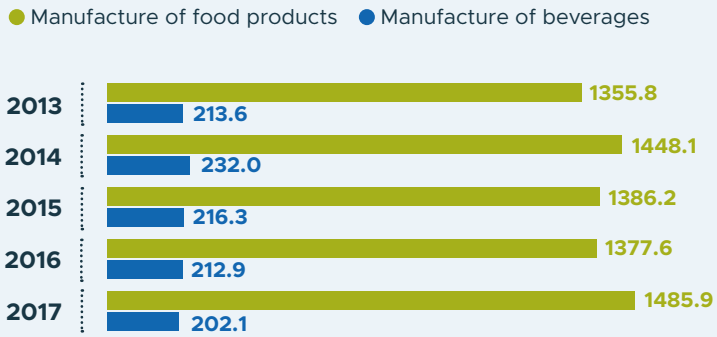
870 T[1]

1.4. Food and beverages

While Estonian exports are growing, the country has a large trade deficit of agricultural and food products due to high imports of processed foods. The composition of Estonia's agro-food trade suggests the food manufacturing industry is not as developed as primary production. Estonia's imports of agro-food products are mainly for household consumption, while the country exports a large share of agro-food products for industrial use. For example, Estonia is a net exporter of cereals, but a net importer of processed cereals, and a net exporter of live animals, but a net importer of meat. (Source: OECD)[2]

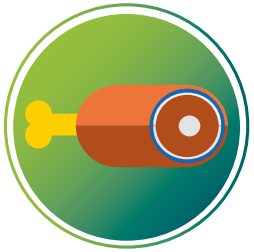
The small domestic market is cited as a possible cause for this mismatch.The top three sectors by turnover and production value are dairy, meat and beverages.

Figure 8. Trend of production value of food and beverages production (M€, Eurostat)



1.4.1. Meat

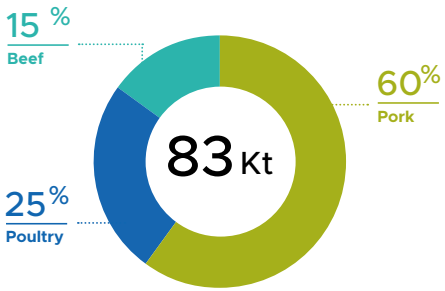
Meat is one of the two most important food industry sectors along with dairy.



Meat annual production value (Eurostat)

€300M

Meat production (2015)[1]



Meat production has increased over the last two decades, by 1.5% per year on average. The highest growth rate was for poultry meat (8.3% per year) and pig meat (1.6%), while beef production declined. Pig meat peaked at 60% of all meat production in 2014, while it declined back to its 1990s value of 55% in 2016 due to an outbreak of African Swine Fever.[2] During the same period, the share of poultry meat increased from 7.3% in 1996 to 18% in 2006 and 25.3% in 2016.

[1] Estonian statistical yearbook 2016

[2] Pig meat production has been swinging in 2014 – 2017 because of outbreaks of African Swine Fever

Main players

- **A-Vorst OÜ** is a producer of beef and pork products located in Alavere. It has a turnover of approximately €2.5 million.
- **Atria Eesti AS** is the second largest pork producer in Estonia.
- **HKScan Estonia AS** is a producer of beef and pork products belonging to the Finnish group HKScan.
- **Kikas OÜ** is a meat processing company working primarily with poultry meat.
- **MAAG Group** is a group incorporating several companies active in livestock rearing, meat processing and dairy production.
- **Saaremaa Lihatööstus OÜ** is a producer of beef and pork products.
- **Snack Time OÜ** and **Snakit Foods OÜ** are producers of beef jerky snacks.
- **Uvic AS** is a producer of frozen meat products.

1.4.2. Fish and aquaculture products

Production value (Eurostat)

€123.1M

68

Companies involved in processing fish, crustaceans or molluscs

Main players

- **DGM Shipping AS** is a supplier of fresh and frozen fish products, focused on export.
- **Ecofarm Farmers' Cooperative** is the association of aquaculture companies. They have a centralised processing centre in Saaremaa, processing fish from farms scattered across the country.
- **HM Seafood OÜ** is a producer of fish preserves, mainly herrings and anchovies.
- **Masekonord AS** is a producer of fish preserves, mainly sprat and herrings.
- **Viru Rand OÜ** is a producer of fish preserves.
- The Lithuanian firm **Viciunai Group**, one of the leading processed fish producers in Eastern Europe, has a production branch in Estonia.

1.4.3. Beverages

The beverage industry is a significant contributor to the national economy. The main sub-sectors by production value are beer, spirits and soft drinks.

Beer brewing turnover

€135.7M

Spirits turnover

€52 M

Soft drinks turnover (Eurostat)

€18.3M

Main players

- **A. Le Coq AS** is the oldest and biggest drinks manufacturer in Estonia. The main product group is beers, followed by juices, waters and soft drinks, ciders, light alcoholic beverages, active juice drinks, sports and energy drinks, syrups and kvass.
- **Auxner OÜ** is a producer of fruit juice (especially berries).
- **Coca-Cola Eesti** is the local branch of the Coca-Cola company.
- **Kadarbiku Köögivili OÜ** is a producer of fruit and vegetable juices.
- **Largo AS** is a producer of fruit juices.
- **Linda Nektar AS** is a B2B producer of fruit wines and ferments for the beverage industry.
- **Liviko AS** is a producer of alcoholic and non-alcoholic beverages, specialising in spirits and energy drinks. Besides producing their own beverages, they import and distribute wines and beers.
- **Orkla Eesti AS** is a large food and drink producer resulting from the merger of two companies, Kalev and Põltsamaa Felix. Besides beverages, it is also active in confectionery. It belongs to the Norwegian group Orkla.
- **Rõngu Mahl AS** is a fruit juice producer specialised in berries.
- **Saku Õlletehase AS** is a large brewery belonging to the Carlsberg group.
- **Viru OLU** is the third main brewery in the country along with A. Le Coq and Saku. It is also active in soft drinks and energy drinks. The three breweries are jointly managing the **Estonian Brewery Association**.

1.4.4. Dairy products

Dairy is the top food industry sector by production value.

Production value (Eurostat, 2016)

€309.4M

751Kt **milk production (Eurostat, 2017)**

Main players

- **Balbiino AS** is a producer of ice cream and frozen products (seafood, vegetables, soups).
- **Esko Talu OÜ** is a producer of ice cream, cheese and yogurt.
- **MAAG Group** operates a dairy business with its company Farmi. The turnover of Farmi is €45 million.
- **Saaremaa Delifood OÜ** is a cheese and yogurt producer.
- **Saaremaa Piimatööstus AS** is a large dairy company specialised in cheese and butter.
- **Premia Tallinna Külmhoone AS** is part of the Latvian dairy giant Food Union group.
- **Valio Eesti AS** is a large dairy company dealing with milk, yogurt, cheese and butter.
- **Vigala Piimatööstus OÜ** is an Estonian company with Italian capital. It is specialised in cheese and desserts.

1.4.5. Cereal-based foods, bakery, sweets

Bakery products involve over 160 companies, 90% of whom concerned with production of bread, fresh pastry goods and cakes. The overall production value of the sector is €155.7 million (Eurostat, 2016).

Main players

- **Eesti Leivatööstus AS** is a large bakery and producer of confectionery products.
- **Eesti Pagar AS** is a large bakery (it claims to be the biggest in Estonia).
- **Fazer Eesti AS** is the local branch of Finnish Fazer Group, a company producing bread, biscuits and confectionery products.
- **Leibur AS** is a large bakery.
- **Sangaste Linnas AS** is a cereal and grain flake factory marketing its products under the brand Helen.
- **Tartu Mill AS** is a large producer of pasta, cereals and biscuits.
- **The Estonian Association of Bakeries** groups several companies operating in the sector.

1.5. Wood products

The wood sector is the largest bio-based economic sector. Wood-based value chains account for roughly €2.5 billion of production value annually (2016).

Production value (Eurostat, 2016)

€2.5B*

Furniture is the main wood production sub-sector in terms of employment and number of companies, with most companies in the sector being SMEs. Thus, sawmilling and wood products other than furniture account for most of the production value.

The use of wood for pulp and paper is considerably smaller than for solid wood products.

Production value (Eurostat,2016)

€216M

Main players

- **Combimill Sakala OÜ** is a producer of sawn pine timber.
- **Graanul Invest AS** is a large group active in timber pre-treatment, production of wood pellets and biomass power. It is also the Coordinator of a BBI Flagship project, SWEETWOODS, via its subsidiary Graanul Biotech.
- **Lemeks AS** is a forestry and logging company also performing pre- and post-processing of timber.
- **Rait AS** is a producer of profiled boards and construction timber.
- **Tarmeko Spoon AS** is a producer of veneer and plywood and a maker of furniture.
- **Toftan AS** is a producer of sawn timber.
- **Valmos OÜ** is a producer of birch veneer.
- **Vara Saeveski OÜ** is a producer of sawn timber.
- **Estonian Cell AS** is a producer of mechanical pulp.
- Estonia is also home to local branches of **Stora Enso** and **UPM**.

* billion

1.6. Chemical and pharmaceutical industry

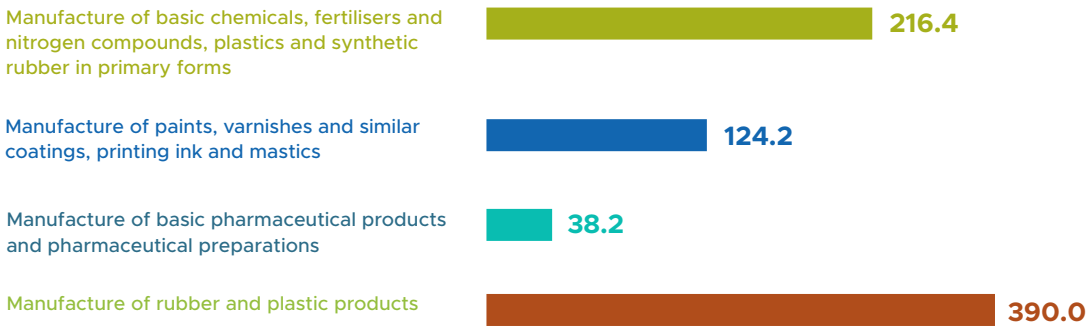
The chemical industry's production value, including rubber and plastic products, is worth €662 million (2016). Rubber and plastics are the top sector in terms of enterprises, turnover and production value. Pharmaceutical industry is small both in terms of number of enterprises and of turnover (less than €40 million in 2017).

According to the **Estonian Chemical Industry Association (ECIA)** up to 85% of the chemical industry production is exported. The chemical industry's share in processing industry is about 5.2% and its contribution to Estonian GDP is 0.8% (2013 data). The ECIA groups the main players of the sector.

Main players

- Estonia is one of the few places in Europe where shale oil is extracted, by the companies **Eesti Energia Õlitööstus AS, VKG Oil AS** and **Kiviõli Keemiatööstus OÜ**. VKG also produces phenols.
- The local branch of **Eastman Specialities** is a producer of benzoic acid, sodium benzoate, and plasticisers.
- **Nitrofert**, belonging to the Ukrainian group Ostchem, produces nitrogen-based fertilisers.
- The main producers of paints, varnishes and other finishing materials are **ES Sadolin** (part of Akzo Nobel), Tikkurila AS, and AS Eskaro.
- The main producers of construction chemicals (sealants, adhesives) are the local branch of Henkel and **Krimelte AS**.
- Other international groups with a presence in Estonia include **3M, GlaxoSmithKline, L'Oreal** and **Unilever**.

Figure 9. Production value of the chemical sector (M€, Eurostat, 2017)



1.7. Biotech industry

Currently there are more than 100 companies active with biotechnology in Estonia, with a focus on medical biotechnology. Many of them are located in Tartu, in the Tartu Biotechnology Park.

Main players

Some Estonian biotechnology companies are:

- **BimKemi Eesti AS** is a chemical specialist company with focus on innovative solutions for the pulp and paper industry.
- **OÜ TBD-Biodiscovery** produces bioluminescence agents and active pharmaceutical ingredients for both human healthcare and veterinary medicines.
- **The Competence Centre on Health Technologies** mainly focuses its research activities in sectors like personal medicine, drug development and both human and veterinary reproductive medicine.
- **GPE GLOBALPHARMA OÜ** is an Estonian-Canadian generic pharmaceutical company with a primary focus on the manufacturing and packaging of pharmaceutical products.
- **Cambrex** is a provider of drug substances, drug products and analytical services across the entire drug lifecycle.
- **Bioexpert** is a provider of food industry products and industrial enzymes, reagents and equipment for scientific laboratories and equipment for potable water treatment.
- **Solis Biodyne** develops and produces life science reagents, including enzymes.

1.8. Clusters & organisations

Estonia has a well-developed cluster structure: most industrial sectors have their own cluster representation.

Clusters relevant to bio-based sectors are:

- **Association of Estonian Food Industry**
- **Estonian Brewery Association**
- **Estonian Waste Management Association**
- **Estonian Association of Fishery**
- **Estonian Association of Chemical Industry**
- **Estonian Association of Bakeries**
- **Estonian Forest and Wood Industries Association**
- **Estonian Timber Cluster**
- **Estonian Furniture Industry Association**

1.9. Academia and research centres

The main universities in the country host incubators and/or technology parks, some of these focus on bioeconomy:

1. **Tartu Biotechnology Park** is a research centre and incubator managed by the University of Tartu alongside academia and enterprise partners. It features a permanent cooperation with the BioCon Valley initiative in Germany (Region Mecklenburg-Vorpommern). The Park also hosts the Estonian Biotechnology Association and the Estonian Centre for Synthetic Biology, who has a cooperation ongoing with the Novo Nordisk Foundation Centre for Bio-sustainability at the Technical University of Denmark.
2. **Estonian University of Life Science**, also based in Tartu, is a leading institution in forest, agronomy and animal science. It is part of the NOVA-BOVA network, a platform for knowledge exchange and cooperation in forestry, veterinary and agricultural fields among universities and research centres of the Nordic countries.
3. **Centre of Food and Fermentation Technologies (CFFT)** is managed by the Tallinn University of Technology and six partner companies. It is an R&D company that focuses on improving quality, functionality and stability of food, as well as developing and introducing new innovative food and fermentation technologies.
4. **Cleantech ForEst** is an Estonian non-profit organisation that funds early stage green technology start-ups, advances environmental education and supports energy experts.

1.10. Research projects

SWEETWOODS - Production and deploying of high purity lignin and affordable platform chemicals through wood-based sugars

Project duration 2018 - 2022

BBI JU Flagship project coordinated by Estonian company Graanul Biotech, aiming at developing a first-of-a-kind bio-fractionation plant in Estonia that uses sustainable hardwood biomass. The process combines innovative pre-treatment technology with enzymatic solutions to provide sugar recovery levels of over 90 per cent with high-quality lignin. The commercial-scale plant will be in operation by 2022.

BIOWAYS - Increase public awareness of bio-based products and applications supporting the growth of the European bioeconomy

Project duration 2016 - 2018

A BBI JU CSA dedicated to public engagement towards the bioeconomy by making available promotional and educational material and activities. Civitta Eesti AS was a partner of the project.

BIOBRIDGES - Bridging Consumers, Brands and Bio Based Industry to improve the market of sustainable bio-based products

Project duration 2018 - 2020

A BBI JU CSA aiming to creating a sustainable multi-stakeholder community involving consumer representatives, BBI and brand owners from different bio-based economy clusters and stimulate dialogue and cooperation. Civitta Eesti AS is a partner of the project.

BIOnTop - Novel packaging films and textiles with tailored end of life and performance based on bio-based copolymers and coatings

Project duration 2019 - 2023

A BBI JU RIA. The project is developing recyclable-by-design cost competitive packaging solutions that can be mechanically recycled, industrially/home composted or are suitable for anaerobic digestion. Wearebio OU is a partner of the project.

VEHICLE - Valorise Extensive quantities of Hemlcellulosic and Cellulosic sugars from Lignocellulosic biomass into high-value End products

Project duration 2019 - 2023

A BBI JU Demo dedicated to valorisation of dilute hemicellulose-containing pre-hydrolysate streams from pulp mills, which are currently waste streams with little value. Graanul Biotech is a partner of the project.

DIABOLO - distributed, integrated and harmonised forest information for bioeconomy outlooks

Project duration 2015 - 2019

Aim of DIABOLO is to establish a methodological framework towards more accurate, harmonised and timely forest information, e.g. on growing stock and stock changes; enable the analysis of sustainable biomass supply derived from multipurpose and multisource national forest inventories; and facilitate forest disturbance monitoring, e.g. on forest fires, storm, drought or insect outbreaks. The Estonian Environment Agency was part of the consortium.

FACCE SURPLUS - Sustainable and resilient agriculture for food and non-food systems

Project duration 2015 - 2020

An ERA-NET action focused on supporting policies for integrated food and non-food biomass production and transformation systems. It is part of the Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE–JPI). The Estonian Ministry for Rural Affairs is part of the consortium.

PROVIDE - Providing smart delivery of public goods by eu agriculture and forestry

Project duration 2015 - 2018

The project delivered a policy toolbox for the utilisation of public resources in agriculture and forestry, trying to balance the needs of economic actors, environment, society and regulations. The Tallinn University is part of the consortium.

RDI2CLUB - rural RDI milieus in transition towards smart bioeconomy clusters and innovation ecosystems

Project duration 2017 - 2020

The project is an Interreg in the Baltic Sea Region, focusing on boosting capacity building and transnational cooperation among rural areas of the Baltic basin. **The Stockholm Environment Institute Tallinn Centre** is a partner of the consortium.

4D4F – Data driven dairy decisions for farmers

Project duration 2016 - 2019

The project focused on the role of animal and environmental sensors in collecting real time information to help make more informed decisions in dairy farming. Eesti Maaulikool was a partner of the project.

BIOVoices - Mobilization of a plurality of voices and mutual learning to accelerate the Bio-based sector

Project duration 2018 - 2020

BIOVoices aims at engaging all relevant stakeholder groups 'voices' (policy makers, researchers, the business community and the civil society) in order to address societal, environmental and economic challenges related to bio-based products and applications. Civitta Eesti AS is a partner of the project.

BlueBio – Unlocking the potential of aquatic bioresources

Project duration 2018 - 2023

The project (an ERA-NET Cofund) aims to identify new and improve existing ways of bringing bio-based products and services to the market and find new ways of creating value in the Blue bioeconomy. Estonian Research Council and Ministry of Rural Affairs are partners of the project.

BioPG - Feasibility of Bio-based Propylene Glycol

Project duration 2016 - 2017

An SME instrument Phase 1 project by Estonian SME Nano OU. It and focused on assessing the feasibility of producing bio-based propylene glycol from agricultural waste in a fermentation process similar to ethanol fermentation.

MOBILE FLIP - Mobile and Flexible Industrial Processing of Biomass

Project duration 2015 - 2018

The project has demonstrated mobile biomass processing units based on pelletizing, torrefaction, slow pyrolysis, hydrothermal pre-treatment and carbonisation. Biogold OU was a partner of the project.

CelESTial - Industrial Cell Factories and Sustainable Bioprocessing for Future Bioeconomy

Project duration 2015 - 2018

Teaming partnership between the Estonian Centre for Synthetic Biology (Estonia) at the University of Tartu and the Novo Nordisk Foundation Centre for Bio-sustainability (Denmark) at the Technical University of Denmark in the framework of a WIDESPREAD CSA.

In this scheme, a recognised RTO from a high performing RDI country (in this case, Denmark) supports the growth of an emergent RTO in a low RDI country (in this case Estonia).

2. CURRENT OPPORTUNITIES FOR BIO-BASED ACTIVITIES

This chapter explores the opportunities to expand bio-based industrial activities in Estonia. It lists existing or potentially new feedstocks for the bio-based industry from the industrial sectors covered in chapter 1. These are mainly residual streams and waste that today find a low-value destination. By feeding these streams into bio-based operations, they could be converted into applications that have higher value than their current disposal in the country.

Success of these new developments also depends on regional and national strategies for bioeconomy. Sub-chapter 2.2 lists current strategies and programmes on a national basis and international in the Baltic region.

[1] Sources of loss include both domestic production and imported produce
[2] Last available period was used
[3] Estonia is a net importer of fresh fruit, thus the reason of loss being higher than production

2.1. Bio-based residue: availability and use

2.1.1. Agricultural residues

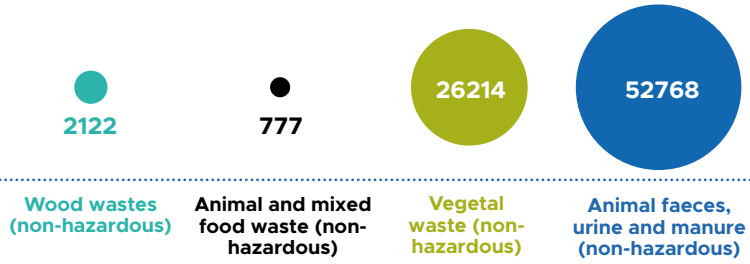
Data from the Estonian statistical institute data show production and loss for several kinds of agricultural biomass:

Figure 10. Agricultural production and loss (T)

Crop produce	Production	Loss[1]	Period[2]
Cereals	1535280	13535	2015/2016
Dry pulses	31433	59	2013/2014
Potatoes	89842	2819	2016/2017
Fresh vegetables	66369	4798	2014/2015
Fresh fruit	5098	8078[3]	2014/2015
Oleaginous seeds and fruit	196408	3144	2015/2016

Unfortunately, information about waste/residual streams is only available in aggregate form.

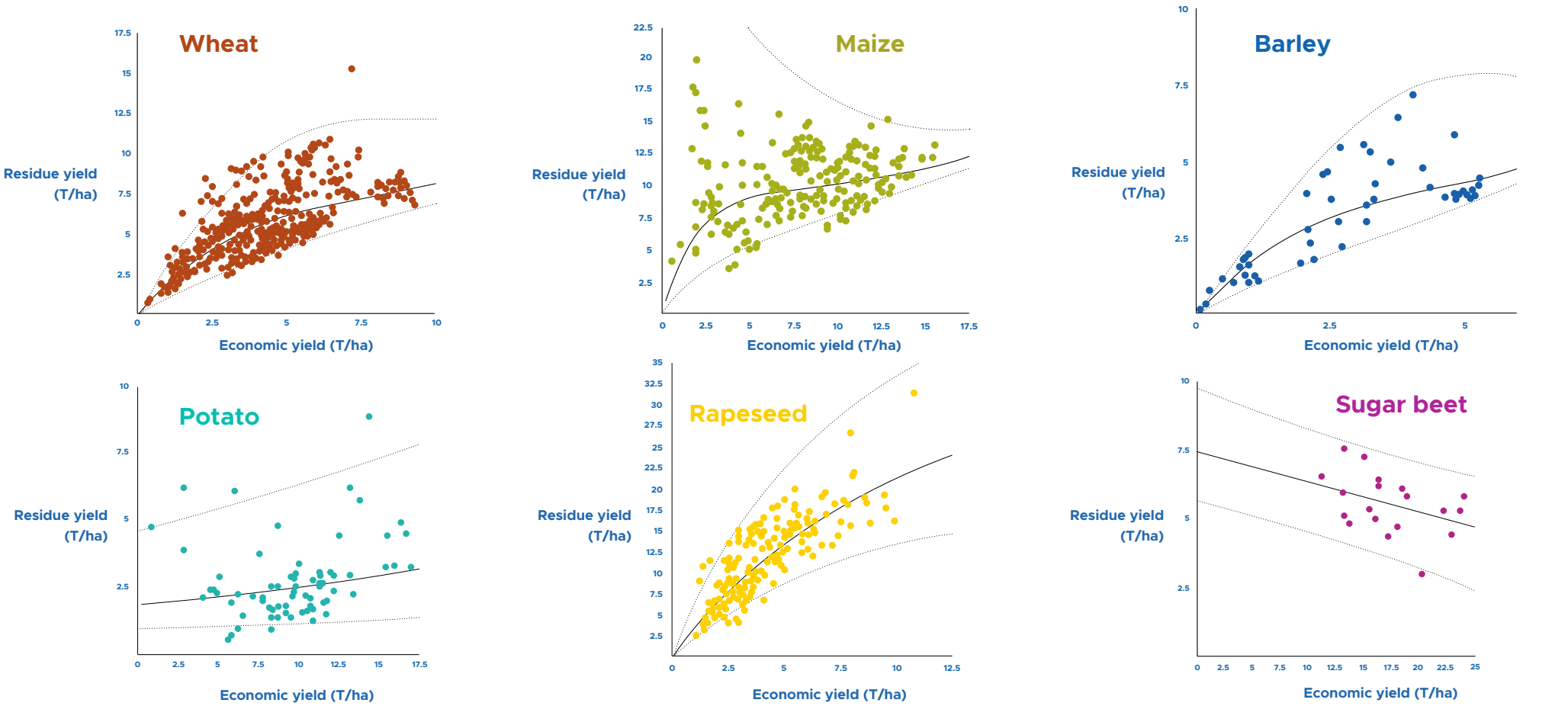
Figure 11. Waste generated in agriculture, forestry and fisheries (T,2016)



Nonetheless, it is possible to estimate the resultant residual streams from the economic production through an empirical 'residual yield' coefficient.The most recent and extensive work in this respect is by JRC, published in 2018 in its 'Biomass production, supply, uses and flows in the European Union'*.

In this report, JRC calculates empirical 'residual yield' coefficients for various crops as a function of the economic yield. This method does not take into account differences in climate or agricultural practices and comes with a rather wide confidence interval for some of the crops (notably potatoes and maize). Nonetheless, it is the most reliable tool for estimating residual biomass production when no actual data are available. In this report, we will use this tool to estimate the residual production from various crops. Figures on this page show the empirical residual yield for the crop studied.

Figure 12. Empirical models for the estimation of residue yields for the crops studied (include economic yield (T/ha) also for wheat)



* Camia A. et al., 2018, Biomass production, supply, uses and flows in the European Union, JRC

Figure 13 shows the calculated residual production from the harvested area with the applied residual yield / economic yield ratio (from Figure 12).

Whereas:

- Err- and Err+ are the lower and upper extremes of residual yield within the 95% confidence interval (dotted lines in the graphs of Figure 12) for the given economic yield;
- Residual production AVG is the value of residual production calculated with the best fitting R/Y ratio (black curve in Figure 12);
- Residual production LOW and HIGH values are the residual production values calculated using the extreme points of the confidence interval for the given economic yield.

Due to the large variance of data points, the range between the minimum and maximum theoretical values of residual production is wide, especially at its upper limit.

Moreover, the relationship for green maize is only available for yield below 17.5 tonnes/ha and becomes unreliable for higher yields, as is the case for Estonia (26.34 tonnes/ha). Thus, the value for this crop needs to be taken as an indication only.

Even with such uncertainty intervals, it can be argued that a sizeable amount of crop residues is available, especially from wheat, barley and rape.

Figure 13. Calculation of crop residues

Crops	Area (T/ha)	Harvested production, KT)	Yield (T/ha)	R/Y ratio	Err -	Err +	Residual production AVG (KT)	Residual production - LOW (KT)	Residual production - HIGH (KT)
Wheat and spelt	154.48	450.27	2.91	4.5	2.6	7.7	695.6	401.9	1190.3
Barley	138.49	347.50	2.51	3.2	1.9	5.4	443.2	263.1	747.8
Potatoes (including seed potatoes)	3.27	58.03	17.75	3.2	1.3	7.8	10.5	4.3	25.5
Rape and turnip rape seeds	72.68	113.59	1.56	5	3	9.5	363.4	218.0	690.5
Green maize	10.55	277.85	26.34	14.6	13.5	15.2	154.0	142.4	160.4

Moreover, non-negligible contributions are expected from other crops, for whom no residual yield / economic yield ratio is available.

2.1.2. Forestry residues

JRC estimates the fraction of residues as 20% in weight of the total wood felled,[1] while other sources vary between 15%[2] and 30%.[3] Of course, the exact fraction depends on many factors, among which are tree species and age, climate and logging practices.

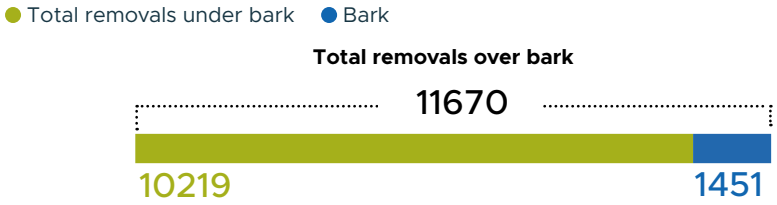
Based on the above, an estimate of the available residues can be made from the removal quantities shown in Figure 14. Since the amount of wood removed is only available as volume, a conversion to weight is necessary. For this calculation, we use an average density of 600 kg/m3 for coniferous trees, and 800 kg/m3 for deciduous ones.

Figure 14. Forest residues availability (estimation from Eurostat data for 2016)

			Residues (thousand tonnes)		
Group of species	Removal (thousand cubic metres)	Removal (thousand tonnes)	15%	20%	30%
Coniferous	5718	3431	515	686	1029
Non-coniferous	4017	3214	482	643	964

An estimation of the quantity of bark available can be extracted from the difference between the removal statistics 'over bark' and 'under bark', both available on Eurostat.

Figure 15. Estimation of the availability of bark (thousand cubic metres)



2.1.3. Residues from bio-based economic activities

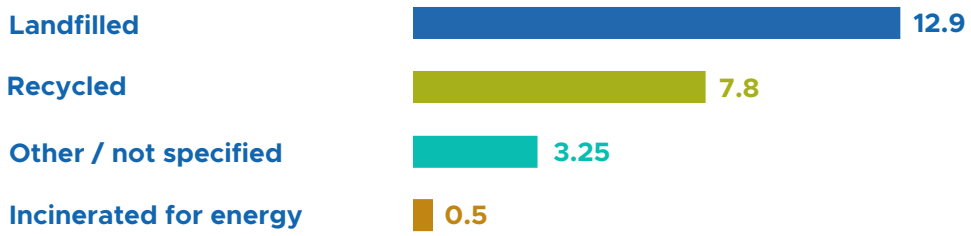
The overall amount of waste generated in Estonia is around 25.2 million tonnes per year, of which 0.5 million tonnes are Municipal Solid Waste. This leaves 24.7 million tonnes/year of industrial waste.

32% of the total is recycled (2016 data; in 2015: 38%), just 2% is incinerated for energy recovery and 52% is landfilled (the destination of the missing 14% is not specified). (Source: Estonian Statistics Office)

No data is available on the specific availability, management and disposal of bio-waste. Nonetheless an indication of the total amount of bio-waste generated (including the organic fraction of MSW) can be drawn from the overall statistics on waste generation.

Out of the total waste generated, 9 categories and 7 sectors were singled out as being at least partially bio-based. The contribution of these categories and sectors to the overall generation of waste is shown in Figure 17.

Figure 16. Waste treatment in Estonia (MT, 2016, Estonian Statistics Office)



[1] Camia A. et al., 2018, Biomass production, supply, uses and flows in the European Union, JRC
[2] Meuleman, B., L. Kuiper, G. J. Nabuurs, 2005, Effect: EU forest for renewable energy to mitigate climat, Ecofys, Utrecht
[3] Smith et al., 2009, Forest resources of the United States, 2007: a technical document supporting the forest service 2010 RPA Assessment.

Figure 17. Waste generation by kind of waste and economic activity, bio-based sectors (2014)

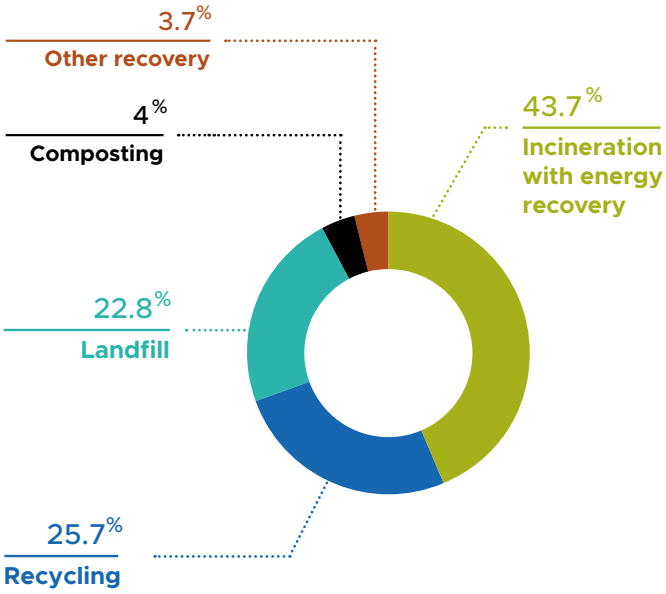
Economic activity (EMTAK 2008)	Agriculture, forestry, fishing and aquaculture	Manufacture of food products and beverages	Manufacture of textiles, wearing apparel and leather products	Manufacture of wood and wood products	Manufacture of pulp, paper and paper products; printing and reproduction of recorded media	Water collection, treatment and supply, sewerage	Waste collection, treatment and disposal activities, materials recovery
Kind of waste	**Annual waste generation (T)**						
Industrial effluent sludges (non hazardous)	0	57	0	1	17402	7717	97
Sludges and liquids from waste treatments (non hazardous)	5903	0	0	0	0	445	10534
Health care and biological wastes (non hazardous)	0	0	0	0	0	0	0
Paper and cardboard wastes (non hazardous)	115	2713	849	394	21061	10	20183
Wood wastes (non hazardous)	5661	1578	160	450405	29939	1	14648
Textile wastes (non hazardous)	0	0	937	0	0	0	61
Animal and mixed food waste (non hazardous)	563	17530	0	0	0	7	96
Vegetal waste (non hazardous)	3820	1767	2	43	0	0	2551
Animal faeces, urine and manure (non hazardous)	85176	2970	0	0	0	0	0

2.1.4. Organic fraction of Municipal Solid Waste

Municipal solid waste amounts to little over 500 thousand tonnes/year (514 thousand tonnes in 2017). (Source: Estonian Statistics Office)

Unfortunately, no data of the organic fraction of the total are available. OECD data, reported in Figure 13, describe the management of MSW as a whole.

Figure 18. Management and disposal of MSW (OECD, 2018)



2.2. Bioeconomy strategies and programmes

2.2.1. National strategy

According to the Ministry of Rural Affairs, Estonia features 'an abundance of bio-resources (arable land, forest and marine resources)' but at the same time 'a lack of smart, value-adding and sustainable value-chains, and a bioeconomy strategy between their components' [bold in the original document – Ed.]. This prompted the Ministry, in conjunction with Ministry of Environment, to launch a consultation for development of an 'Estonian Bioeconomy Strategy to 2030'.

At the moment of writing this report, the strategy has not been published yet on the Ministry's website (the document was reported as under discussion in September 2017).

Nonetheless, its main objectives are stated in the 2015 proposal statement document:

- Put to best possible use the country's land, using most effective solutions;
- Exploit untapped resources for food production, both to ensure internal food security and for export;
- Reduce dependency on non-renewable resources;
- Increase recovery of resources from waste and reduce landfilling, also in view of population growth;
- Promote R&D in biotechnology and realise its potential;
- Mitigate climate change and global warming, which can directly impact Estonia's competitiveness.

The strategy is organised along six value chains (and their relations):

1. Agriculture;
2. Forestry (including wood industry, paper / cellulose);
3. Fisheries (including aquaculture);
4. Food industry;
5. Other industries related to the bioeconomy (biochemicals and plastics, enzymes, biofuels).

The main bottlenecks hindering the development of Estonian bioeconomy were highlighted in a 2016 document by the Ministry of Rural Affairs: low value added per employee (€25 thousand versus the EU average of €61 thousand) and inefficient use of resources (**e.g. 11% of agricultural land is out of production**). A further obstacle slowing down the preparation of the strategy is the need to take into account and harmonise over **20 national policies**.

In April 2018 the Estonian Government published an update of the programme of national reforms named **'ESTONIA 2020'**. The programme was launched in 2011 and is updated annually. One of the pillars of the programme is 'environmentally sustainable economy and energy sector'.

The country's **Smart Specialisation Strategy (2013)** features two pillars related to the bioeconomy:

- Biotechnology, particularly regarding medical applications, and
- Health-promoting foods, which combines agriculture, food processing and nutraceuticals.

'Functionalised wood products' are also mentioned under the 'Materials science and industry' priority.

Several sectoral strategies are currently in place in agriculture:

- The **Estonian Dairy Strategy 2012–20**, whose main goals are to increase the volume of dairy production (to at least 1 million tonnes) and processing, to ensure the developmental capabilities of the Estonian dairy sector, to increase: dairy products export value (especially value-added products), small-scale dairy production and processing preservation; organic production, joint promotion activities, and dairy consumption.

- The **Estonian Organic Farming Development Plan 2014–20**, whose goal is to improve the competitiveness of organic farming and to promote the consumption of local organic food.

- The **Development Plan of Seed Business 2014–20**, aiming to increase the competitiveness of the seed and seed potato sector and to increase the use of certified seeds.

- The **Estonian Cereal Sector Development Plan 2014–20**, covering cereals, oilseeds and legume plants. Its main objective is to increase and maintain cereal production at a minimum of 1.5 million tonnes a year by rising yields to 4.5 tonnes per hectare in 2020.

- The **Estonian Development Plan of the Horticultural Sector for 2015–20** aims to increase the level of self-sufficiency of vegetables grown in Estonia from 58% to 75%, and the fruits and berries self-sufficiency level from 10% to 15% by 2020.

- The **2016 national development plan Estonian Food**, to increase the competitiveness of local food products and to promote the Estonian food industry.

- The **Vision paper for the Estonian beef sector 2016-20**, whose goals are to promote export sales, achieve a uniform quality of beef meat, increase beef meat consumption, increase the involvement of research and development institutions and promotion in cooperative activities.

- The **Estonian Fisheries Strategy 2014 – 2020**, in the framework of the European Maritime and Fisheries Fund.

2.2.1. International cooperation in the Baltic Sea Region

The Baltic Sea Region is a highly connected region, hosting several international initiatives.

2.2.1.1. Interreg Baltic Sea Region Programme

The Interreg Baltic Sea Region Programme is an agreement between EU member states Denmark, Estonia, Finland, Latvia, Lithuania, Poland, Sweden and the northern parts of Germany as well as partner countries Norway, Belarus and the northwest regions of Russia.

2.2.1.2. EU Strategy for the Baltic Sea Region

Policy Area Bioeconomy in EU's Baltic Sea Region Strategy covers sustainable use of biomass, agriculture, forestry, fisheries and rural development. It is coordinated by the Nordic Council of Ministers (based in Denmark).

Bioeconomy projects in the Baltic States

Proteins - The Green Gold of Baltic Sea Region Bioeconomy

Partner(s) from Latvia: Latvian Farmers Union

Developing cross-cutting stakeholder involvement for realising the bioeconomy

Partner(s) from Estonia: Estonian Forest Industry Association, Estonia Chamber of Commerce and Industry, Stockholm Environment Institute in Tallinn

Bio-resources for innovative and sustainable non-food uses

Partner(s) from Latvia: Latvian State Institute of Wood Chemistry

Factsheet plant protein arena

Partner(s) from Lithuania: Lithuanian Research Centre for Agriculture and Forestry, UAB Eko Farm

Partner(s) from Latvia: Pure Horticultural Research

Partner(s) from Estonia: Estonian Crop Research Institute

Factsheet Integrated Blue Biotechnology Strategy for the Baltic Sea Region

Partner(s) from Lithuania: Coastal Research and Development Institute, Klaipeda Science and Technology Park

Partner(s) from Latvia: Latvian Institute of Aquatic Ecology, Latvian Biotechnology Association, Riga Planning Region

Partner(s) from Estonia: Tartu Biotechnology Park, Ida-Viru Region

Local Capital - Realising the Bioeconomy in the BSR

Partner(s) from Latvia: Dzintars Vaivods SIA “Latvijas Lauku konsultāciju un izglītības centrs”

Markets for woody biomass and wood-based energy around the Baltic Sea Region

Partner(s) from Lithuania: Vytautas Magnus University Agriculture Academy

Partner(s) from Latvia: Latvia University of Agriculture

2.2.1.3. Other initiatives

The Baltic Sea States Sub-Regional Cooperation (BSSSC) brings together regional authorities from all the countries in the Baltic Sea Region. The Conference of Peripheral Maritime Regions (CPMR) and its Baltic Sea Commission brings together the peripheral maritime regions of the Baltic Sea Region.

The Union of the Baltic Cities (UBC) is a network for municipalities and cities in the Baltic Sea Region. There are many networks covering specific fields such as the Baltic Development Forum (BDF).

3. POTENTIAL USE/VALORISATION OF BIO-BASED STREAMS

This chapter offers some possible opportunities for converting the residual streams and waste listed in Chapter 2 into high-value sustainable products and applications. These opportunities can be derived from successfully completed or running projects using similar or comparable feedstocks as those present in Estonia. Among these projects, is 'SWEETWOODS', a flagship project granted under the BBI JU programme and coordinated by the Estonian company Graanul Biotech.

The chapter focuses on the Bio-based Industries Joint Undertaking (BBI JU) programme, executing the strategic innovation and research agenda (SIRA) of the Bio-based Industries Consortium (BIC).

The BBI JU is an industry-led PPP between BIC and the European Commission. BIC and the Commission agree on annual work programmes that will be opened as annual calls for proposals to any and all actors in the bioeconomy fields. BBI JU started under Horizon 2020 (2014-2020) and since 2014 and through the 2018 call there are 101 granted projects at different technology readiness levels. The objective of the programme is to assist an accelerated commercialisation of excellent, innovative solutions for societal challenges towards a sustainable future. The commercialisation is to materialise in the country itself, on a local, regional or national basis.

Along with offering examples of projects on comparable bases as those present in Estonia, BIC also offers its European and international network and events to assist local actors in establishing partnerships for bio-based activities, both in Estonia and in Europe.

3.1. BBI JU projects of interest

Estonia has substantial residual biomass available from agriculture, forestry fisheries and aquaculture, manufacture of food products and beverages and OFMSW. The pulp and paper sectors provide substantial amounts of sludge, paper and wood wastes.

The following sub-chapters contain an outline of ongoing or completed BBI projects utilising the same or comparable biomass feedstock as the abovementioned streams, to show their potential use.

3.1.1. Crop residues

LIGNOFLAG: Converting wheat straw into bioethanol

Project description

lignoflag-project.eu

Type of action : IA - Flagship

Duration : 06/2017 - 05/2022

Overall budget : €34.9M

Pilot plant location(s) : Romania

The LIGNOFLAG project demonstrates an integrated and whole value chain-oriented approach to drive forth the bio-based production of ethanol as sustainable transport fuel or chemical building block. The project approach involves the collaboration of the relevant actors along the whole value chain – from feedstock (straw) supply and logistics via process co-products (lignin as biochar, sludge as fertilizer) utilisation and valorisation to advanced bio-ethanol production and product distribution. The core part of the project is the first-of-a-kind commercial flagship plant for lignocellulosic feedstock to ethanol conversion (60000 tonnes/year) that serves to showcase the techno-economic viability of an innovative bio-refinery concept and shall boost EU bio-ethanol production.

Coordinator : Clariant (Germany)	Biomass(es) : Wheat straw	Process(es) : Enzymatic conversion

Product(s) : Primary product: bioethanol/ Secondary product: biochar, fertilisers

OPTISOCHEM: Converting wheat straw into green chemicals

Project description

optisochem.eu

Type of action : IA – Demo

Duration : 06/2017 - 05/2021

Overall budget : €16.3M

Pilot plant location(s) : Germany

OPTISOCHEM goal is to demonstrate the performances, reliability as well as environmental and socio-economic sustainability of the entire value chains, for the transformation of excess wheat straw into bio-Isobutene (bio-IBN) derivatives. To achieve these goals a team of 6 partners, leaders in their field, originating from 4 EU-member states, will join efforts. OPTISOCHEM consists in showcasing the technical accessibility and economical sustainability of the value chains, from wheat straw to 2 different families of chemicals derived from bio-based Isobutene (IBN). These compounds, oligomers (DIB, TIB, TeIB) and polyisobutylenes (PIBs) are currently used in a wide range of applications such as lubricants, adhesives, sealants, flavours & fragrances and substituted phenols. This large market is today supplied entirely by products derived from fossil-based isobutene. Products derived from bio-based IBN, using the same process as fossil-based IBN, and with at least as good performances, would provide a renewable supply.

Coordinator : Global Bioenergies (France)	Biomass(es) : Wheat straw	Process(es) : Biocatalysis

Product(s) : Bio-Isobutene and derivatives: lubricants, adhesives, sealants, flavours and fragrances and substituted phenols

EXCORNSEED: Separation, fractionation and isolation of biologically active natural substances from corn oil and other side streams

Project description

excornseed.eu

Type of action : RIA

Duration : 06/2018 – 11/2021

Overall budget : €4.5M

Pilot plant location(s) : Italy, Slovakia

The EXCornsEED project will combine chemistry, biology, engineering and biotechnology tools and expertise to develop and validate processes for recovering a range of bioactive compounds from bioethanol and biodiesel refinery side streams, specifically corn oil/thin stillage from bioethanol and rapeseed meal.

It will valorise the potential of the side streams of these two growing sectors at a time when changes in legislation on liquid biofuels are likely to strongly increase demand for biofuels will maximise the value of biofuels production and make them increasingly competitive.

Coordinator : Università degli studi di Roma La Sapienza (Italy)	**Biomass(es) : Corn oil, rapeseed meal, bioethanol stillage**
Process(es) : Separation, fractionation and isolation	
Product(s) : Proteins, polyphenols, amino acids, fibers, lipid compounds, alkaloids and tannins	

AGRIMAX: Converting crop and food residues into several products

Project description

agrimax-project.eu

Type of action : IA - Demo

Duration : 10/2016 – 09/2020

Overall budget : €15.5M

Pilot plant location(s) : Spain, Italy

Approximately one third of all food produced globally is wasted every year throughout the whole value chain-from farmers to consumers. To extract the significant amounts of valuable compounds contained in these wastes, AgriMax will combine affordable and flexible processing technologies (ultrasound assisted and solvent extraction, filtration, thermal and enzymatic treatments) for the valorisation of side streams from the horticultural culture and food processing industry to be used in a cooperative approach by local stakeholders. Through the selection of case-scenarios previously developed to a pilot scale by the participating RTOs and their industrial transfer in new applications as food additives, packaging and agricultural materials among others, the project will disclose the holistic potential of four new agro-value chains (residues and by products from the culture and processing of tomato, cereals, olives, potato). Any by-product generated along the production cycle will be valorised in a cascade manner to reach over 40% of high value use of the waste.

Coordinator : IRIS (Spain)	**Biomass(es) : Residues of tomato, cereals, olives, potato**
Process(es) : Ultrasound extraction, filtration and enzyme treatment	
Product(s) : Primary products: food additives, packaging and agricultural materials / Secondary products: fibres, biogas and fertilisers	

PROMINENT: Proteins from cereal side-streams

Project description

prominent-protein.eu

Type of action : RIA

Duration : 01/2015 – 10/2018

Overall budget : €3.1M

Pilot plant location(s) : Finland

There is a global need, from sustainability, food security and also health perspective, to increase dietary intake of plant protein. Side streams from wheat and rice processing offer large under-exploited raw material potential, and we will work throughout the agro-industrial value chain to valorise that. The main aim of PROMINENT is to develop techno-economically and environmentally viable protein-based ingredients and foods from cereal processing side streams. We will concentrate on novel fractionation and extraction technologies, such as bioprocessing, supercritical carbon dioxide (SC-CO_2) -extraction, thermo-mechanical technologies, wet and dry fractionation, and expanded bed adsorption as well as their combinations as novel hybrid processing technologies.

Coordinator : VTT (Finland) | **Biomass(es) : Wheat, rice** | **Process(es) : Bioprocessing, supercritical carbon dioxide extraction, thermo-mechanical technologies, wet and dry fractionation, and expanded bed adsorption**

Product(s) : Protein additives for pasta, biscuit, cake and beverage

3.1.2. Forest residues

SWEETWOODS: High purity lignin and platform chemicals from wood-based sugars

Project description

sweetwoods.eu

Type of action : IA - Flagship

Duration : 06/2018 – 05/2022

Overall budget : €43.2M

Pilot plant location(s) : Estonia

The objective of the SWEETWOODS project is to demonstrate on an industrial level successful and profitable production of high purity lignin as well as C5 and C6 carbohydrates from hardwood by establishing a biorefinery having throughput capacity 80 bone-dry tonnes/day. Unlike existing biorefinery concepts, SWEETWOODS plant utilises all the fractions of the biomass feedstock, with min. 95% of its initial carbon content utilised.

Coordinator : Graanul Biotech (Estonia) **Biomass(es) : Hardwood**

Process(es) : Fractionation, enzymatic conversion

Product(s) : From lignin: elastomer foams for tube insulation, rigid polyurethane foam panels for insulation, and polymer compounds intended for injection moulding / From C5 and C6 sugars: glucose, xylose and fructose, bio-isobutene, xylitol

EXILVA: Microfibrillated cellulose from wood

Project description

h2020-exilva.com

Type of action : IA - Flagship

Duration : 05/2016 – 04/2019

Overall budget : €44.6M

Pilot plant location(s) : Norwegian

Microfibrillated cellulose (MFC) is a revolutionary product, with potential in a huge range of applications, including personal care, cosmetics, home care, pharmaceutical excipients, adhesives and sealants, composites and resins, agricultural chemicals, oil field, fish, bait, concrete, and CO_2 capture. It also has the potential to replace many fossil-based products.

However, commercialisation of MFC has proved to be challenging, particularly making industrial quantities with sufficient running efficiency and stability. In addition, drying the MFC fibres in a cost-effective manner without losing significant performance is a major challenge.The EXILVA project sets out to change this, by transferring technology from the existing pilot production and eventually scaling up to commercial levels.

Coordinator : Borregaard (Norway) | **Biomass(es) : Wood (Norwegian spruce)**

Product(s) : From microfibrillated cellulose: adhesives, coatings, agricultural chemicals, personal care products, home care products, construction materials

3.1.4. Organic Fraction of Municipal Solid Waste (OFMSW)

PERCAL: Chemical building blocks from MSW

Project description

percal-project.eu

Type of action : RIA

Duration : 07/2017 – 06/2020

Overall budget : €3.4M

Pilot plant location(s) : Spain, Germany, Greece

PERCAL will use Municipal Solid Waste (MSW) as a feedstock for developing intermediate chemical products, producing high yield with high purity, making it attractive for industry. These will be complementary to the bioethanol (existing PERSEO Bioethanol ® technology), thus creating a cascade of valorisation of the MSW components.

PERCAL aims to produce three main compounds: i) Lactic acid, which can be used to make eco-friendly ethyl lactate. This can be used in cleaning products, in ink and for hot-melt adhesives for cardboard; ii) succinic acid, as an intermediate building block for the production of polyols for the polyurethane industry and iii) biosurfactants from the remaining fraction of the MSW fermentation.

Coordinator : Industrias Mecanicas Alcudia (Spain) | **Biomass(es) : OFMSW** | **Process(es) : Enzymatic pre-treatment, fermentation, extraction via membrane electrolysis**

Product(s) : From lactic acid: solvents, inks, adhesives / From succinic acid: polyols / From proteins and lipids: biosurfactants

URBIOFIN – Conversion of MSW into chemical building blocks and biopolymers

Project description

urbiofin.eu

Type of action : IA - Demo

Duration : 06/2017 – 05/2021

Overall budget : €14.6M

Pilot plant location(s) : Spain

Today in Europe, each inhabitant generates, on average, 0.5 tonnes of MSW per year, increasing at an annual rate of 10%. Around 40-50% of it correspond to organic waste. This organic fraction contains mainly carbohydrates, proteins and lipids, which are all useful raw material that can be converted into valuable products. Its valorisation will help to solve environmental pollution but also contributes to the transition from a linear to a renewable circular economy.

Digestion and composting have contributed to the reduction of the biodegradable fraction of MSW sent to landfill. The low economical value of compost and biogas is limiting the sustainable implementation of separate sourcing systems since increasing citizen environmental (waste) taxes is then needed to tackle important logistic costs. New bio-based products can help to improve the environmental and socio-economical sustainability of waste treatment.

The aim of URBIOFIN project is to demonstrate the techno-economic and environmental viability of the conversion at semi-industrial scale (10 tonnes/d) of the organic fraction of MSW (OFMSW) into: chemical building blocks (bioethanol, volatile fatty acids, biogas), biopolymers (polyhydroyalkanoate and biocomposites) or additives (microalgae hydrolisated for bio-fertilisers). By using the biorefinery concept applied to MSW (urban biorefinery), URBIOFIN will exploit the OFMSW as feedstock to produce different valuable marketable products for different markets: agriculture, cosmetics, etc.

Coordinator : Industrias Mecanicas Alcudia (Spain) | **Biomass(es) : OFMSW** | **Process(es) : Hydrolysis, fermentation**

Product(s) : Chemical building blocks (bioethanol, volatile fatty acids, biogas), biopolymers (polyhydroyalkanoate and biocomposites) or additives (microalgae hydrolisated for biofertilisers)

NEWFERT – Mineral fertilisers from biowaste

Type of action : RIA

Duration : 07/2105 – 12/2018

Overall budget : €2.4M

Pilot plant location(s) : Spain

Project description

newfert.org

Most fertilisers currently rely heavily on fossil mineral resources for nutrient supply. The idea behind the NEWFERT project was to build up an innovative concept for the fertiliser industry that essentially turns ashes of different origins and livestock effluent into a new generation of fertilisers.

Researchers identified and analysed more than 45 different types of biowaste from different areas of Europe and selected 10 for introduction into the fertiliser production process based on their physical and chemical properties. Ashes containing high phosphorous or potassium content and nutrient availability were used directly for fertiliser production. In the case of ashes with insoluble nutrients, NewFert partners developed new biorefining technologies with low input and energy cost to increase nutrient recovery such as phosphate.

Furthermore, to free phosphate minerals (struvite) and nitrogen from pig slurry in a more cost-effective way, the scientists developed a new process. This reduced costs by substituting the traditional reagent with the action of bacteria that grow naturally in the medium and building a more efficient electrolysis cell for nitrogen recovery.

Coordinator : Fertiberia (Spain) | Biomass(es) : Biowaste of municipal and industrial origin

Process(es) : Microbial electrolysis

Product(s) : Fertilisers

3.1.5. Food industry residues

GREENPROTEIN: Valorisation of vegetable processing industry residues into functional proteins

Type of action : IA – Demo

Duration : 09/2016 – 02/2021

Overall budget : €5.5M

Pilot plant location(s) : The Netherlands

Project description

greenproteinproject.eu

The economic costs of food waste are reckoned to total around €705 billion globally. There are also significant hidden environmental and social costs. RuBisCO protein is found in all green vegetables and plants and represents around 50 percent of the total protein content of green leaves.

GreenProtein is an industrial demonstration project that aims to produce high-added value, food grade proteins and other ingredients from vegetal food waste streams. The primary objective will be to extract and purify food-grade, fully functioning, RuBisCO protein isolate on an industrial scale using discards from the vegetal processing industry.

Coordinator : Royal Cosun (The Netherlands) | Biomass(es) : Green residues from vegetable processing (mainly of sugar beet)

Process(es) : Extraction

Product(s) : Food-grade functional RuBisCo protein and other ingredients

PULP2VALUE: Conversion of low value sugar beet pulp into chemicals and biomaterials

Project description

pulp2value.eu

Type of action : IA - Demo

Duration : 07/2015 – 06/2019

Overall budget : €11.4M

Pilot plant location(s) : The Netherlands

Europe produces around 13 million tonnes of sugar beet pulp each year. Currently, most of this pulp finds its way into low value feed, bio-fertiliser or it is used for creating green fuel gas. By using multiple extraction techniques, PULP2VALUE will extend the high value products extracted from sugar beet side streams, isolating microcellulose fibres (MCF), arabinose (Ara) and galacturonic acid (GalA). The project will demonstrate an integrated and cost-effective cascading bio-refinery system to refine sugar beet pulp and identify applications for approximately 65% of its mass in high value markets, increasing its current value by as much as 20-50 times.

Coordinator : Royal Cosun (The Netherlands)	**Biomass(es) : Sugar beet pulp**
Process(es) : Extraction	
Product(s) : From microcellulose fibres: rheology modifiers for detergents, paints and coatings, composites /From arabinose: flavours and food additives / From galacturonic acid: personal care and chemical products	

PRO-ENRICH: Conversion of food industry side streams into food additives and chemical products

Project description

pro-enrich.eu

Type of action : RIA

Duration : 05/2018 – 04/2021

Overall budget : €4M

Pilot plant location(s) : Denmark

Pro-Enrich will develop a flexible biorefinery approach capable of processing a range of agricultural residues (rapeseed meal, olives, tomatoes and citrus fruits) in response to the increasing global demand for alternative sources of protein and phenolic product streams, tailored to the cross-sectoral requirements of industry.

Pro-Enrich will optimise existing biomass fractionation technologies and validate novel extraction approaches beyond the current state of the art (from TRL 2 through to TRL 4-5) to isolate and purify proteins, polyphenols, dietary fibres and pigments. The products being targeted are food ingredients, pet food, cosmetics and adhesives.

Coordinator : Danish Technological Institute	**Biomass(es) : Rapeseed meal, olives, tomatoes and citrus fruits**
Process(es) : Fractionation, extraction	
Product(s) : Proteins, polyphenols, dietary fibres and pigments	

3.2. Local actors already active in BIC or BBI JU projects

Graanul Invest is a BIC Full Member and coordinator of a BBI Flagship (Sweetwoods) via its controlled company Graanul Biotech. Civitta Eesti AS is involved in two BBI CSA projects related to acceptance and dissemination of bio-based products. Unviersity of Tartu is a BIC Associate Member.

3.3. Link to existing/ emerging bio-based activities

Estonian players are present in a number of bioeconomy RDI projects in BBI and elsewhere, notably the Sweetwoods Flagship that is being built by Graanul Biotech in the framework of the BBI JU project with the same name.

The Estonian Centre for Synthetic Biology at the University of Tartu has a cooperation ongoing with Novo Nordisk Foundation Centre for Bio-sustainability at the Technical University of Denmark.

University of Tartu also hosts the Tartu Biotechnology Park, who features a permanent cooperation with the BioCon Valley initiative in Germany (Region Mecklenburg-Vorpommern).

3.3.1. Investment plan for Europe - the 'Juncker plan'

The European Commission launched the Investment Plan for Europe (also known as the Juncker Plan) in 2015, which aims to mobilise at least €315 billion investment until 2020.

The Juncker Plan is a collective, coordinated effort at European and Member State level to encourage investment through three strategic targets:

- Boosting job creation and economic growth
- Meeting the long-term needs of the economy and increase competitiveness
- Helping strengthen Europe's productive capacity and infrastructure

In this view, the Investment Plan for Europe has operated through three main initiatives:

1. **The European Fund for Strategic Investments (EFSI)**

   - to overcome current market failures by addressing market gaps and mobilising private investment. It is jointly run by the European Investment Bank, the European Investment Fund and the European Commission. It supports strategic investments in key areas such as infrastructure, education, research and innovation, as well as risk finance for small businesses;

2. **The European Investment Advisory Hub (EIAH)**

   - to strengthen support for project development and preparation across the Union. The EIAH supports projects which may be eligible for financing by the EIB (either under EFSI or otherwise), and it is not limited to EIB-financed projects;

3. The European Investment Project Portal (EIPP)

– An online marketplace where worldwide investors and EU project promoters can meet. It offers EU-based private and public project promoters a convenient way to boost the visibility of their investment projects by filling in and submitting a project form. EIPP will showcase these projects aiming at attracting investors worldwide.

The Juncker plan will find its continuation as InvestEU in the period 2021-2027. The new plan is expected to mobilise at least €650 billion in additional investment between 2021 and 2027.

€158M Mobilised from EFSI in Estonia

€1.3B Additional investment expected to be triggered as a result

16 Projects approved in the country

Two of the projects are categorised under 'bioeconomy':

Company : DASOS CAPITAL OY

Type of business : Forestry

EIF Financing : EIB loan

Financial intermediary : -

Title : DASOS TIMBERLAND FUND III

Description
Equity fund investing in sustainable forestry and biomass mainly in the EU. The fund will only invest in certified or certifiable forestry assets.

Company : PIIMANDUSUEHISTU E-PIIM

Type of business : Food industry

EIF Financing : EIB loan

Financial intermediary : -

Title : E-PIIM DAIRY EXPANSION

Description
The project scope is the construction of a greenfield dairy plant located in Paide, Estonia. The new plant will process milk and produce high value-added dairy products such as hard and semi-hard cheese, pasteurised cream and sweet whey powder. The new plant will process up to 1150 tonnes per day of milk, as well as 85 tonnes per day of whey concentrate, and it will produce per year: (i) 32600 tonnes of hard and semi-hard cheese, (ii) 11600 tonnes of fresh pasteurised cream; (iii) 26800 tonnes of sweet whey powder.

3.3.2. European Circular Bioeconomy Fund (ECBF)

The **European Circular Bioeconomy Fund (ECBF)** will provide access to finance, in the form of equity, debt or quasi-equity, to innovative circular bioeconomy companies and projects of various sizes. ECBF management will raise funds from public and private investors with a target fund volume of €250 million. Reaching the target fund volume was scheduled for a first close in Q1 2020.

3.3.3. Country-specific EIF initiatives

EIF is advising, sponsoring or managing a number of equity Funds-of-Funds and guarantee / debt funds on behalf of third-party investors, including national and regional governments as well as private strategic investors.

In Estonia, it is supporting the Baltic Innovation Fund (BIF), a Fund-of-Fund initiative launched by the EIF in close cooperation with the Governments of Lithuania, Latvia and Estonia. BIF represents a €52 million investment by EIF with each Baltic Government committing €26 million through their respective national agencies (INVEGA in Lithuania, KredEx in Estonia and Altum in Latvia).

3.3.4. European Structural and Investment Funds (ESIF)

The ESIF includes five different funds, all covered by the Common Provisions Regulation – Regulation (EU) No 1303/2013 of the European Parliament and of the Council:

- The **European Regional Development Fund (ERDF)** provides financial support for developing and restructuring regional economies and aims to facilitate economic change, enhance competitiveness and boost territorial cooperation throughout the EU.
- The **European Social Fund (ESF)** supports workers and companies by boosting access to employment and participation in the labour market, focusing on social inclusion of disadvantaged people, combatting discrimination and creating partnerships to manage employment reform.
- The **Cohesion Fund (CF)**, aims to reduce economic and social disparities and promote sustainable development.
- The **European Agricultural Fund for Rural Development (EAFRD)** aims to strengthen the EU's agriculture, forestry sector and boost rural areas.
- The **European Maritime and Fisheries Fund (EMFF)**, supports the implementation of the reformed Common Fisheries Policy (CFP) and the EU Integrated Maritime Policy.

Funds related to the ERDF are managed locally according to the Smart Specialisation Strategy that each region in the EU has published. In the following pictures, regions with bioeconomy research and innovation (R&I) priorities in agriculture, waste processing and biorefineries during the funding period 2014-2020 are highlighted.

Estonia is eligible for projects under theme 'agriculture', while no Estonian region has set 'waste management' or 'biorefinery' as a theme in its SSS.

Figure 19. EU Regions with Bioeconomy R&I Priorities

● Agriculture ● Waste Processing

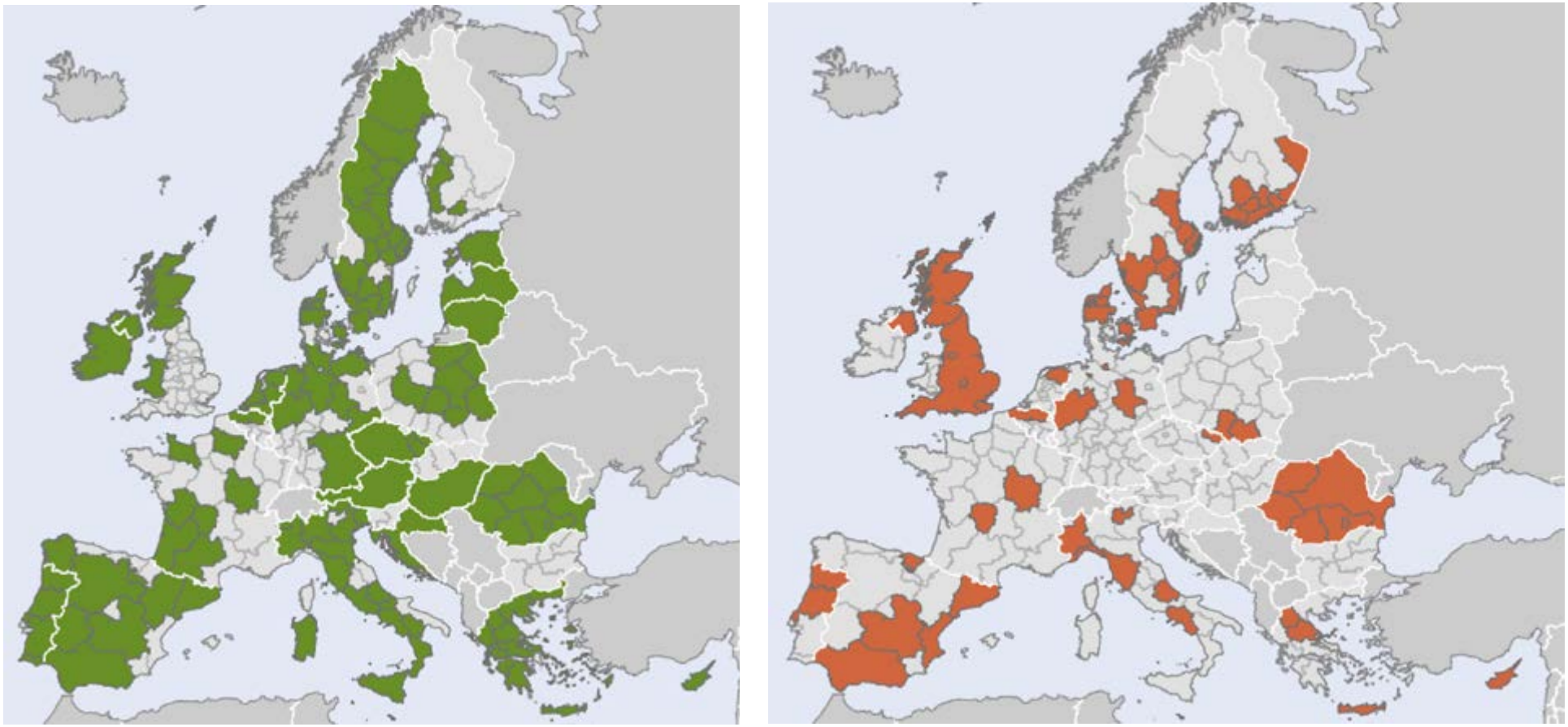
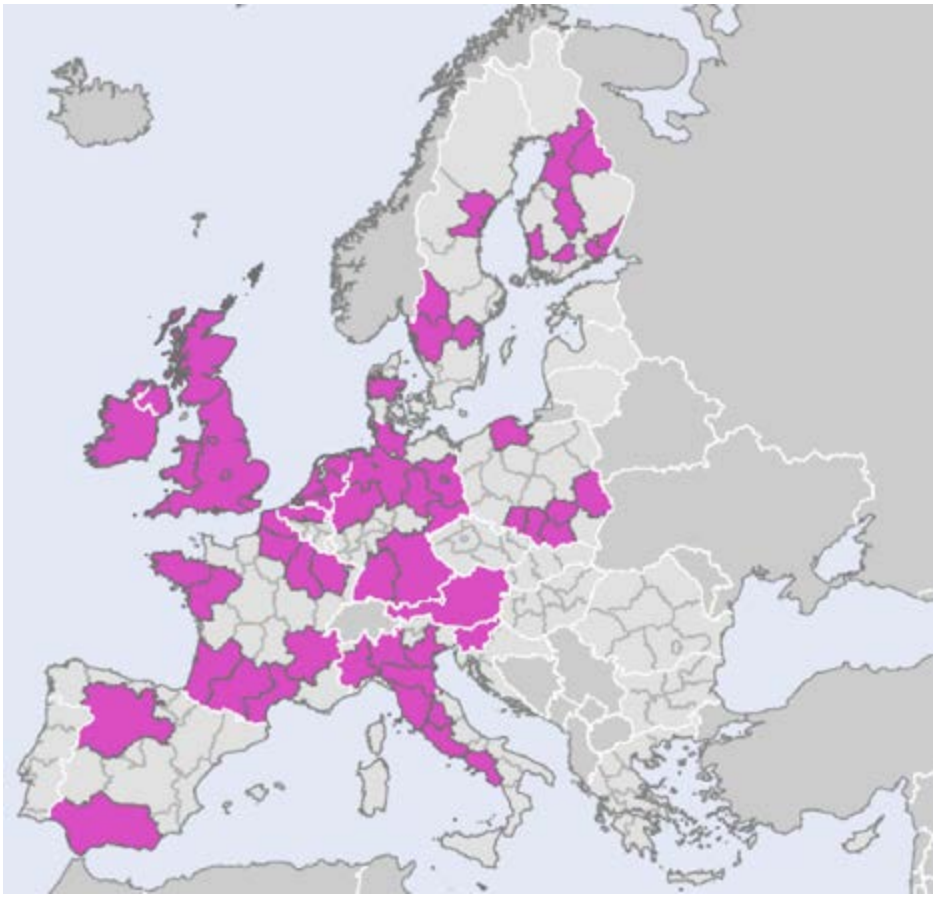


Figure 19. EU Regions with Bioeconomy R&I Priorities

● Biorefinery



3.3.5. European Bank for Reconstruction and Development (EBRD)

The European Bank for Reconstruction and Development (EBRD) is an international financial institution with a mandate to promote the transition to well-functioning market economies. The Bank finances projects and promotes policy dialogue in 37 countries from Central-Eastern Europe, Central Asia and the wider Mediterranean region.

In 2015, the Bank launched its **Green Economy Transition approach (GET)** to bolster innovative technologies by addressing market opportunities and failures related to resource use and environmental degradation.

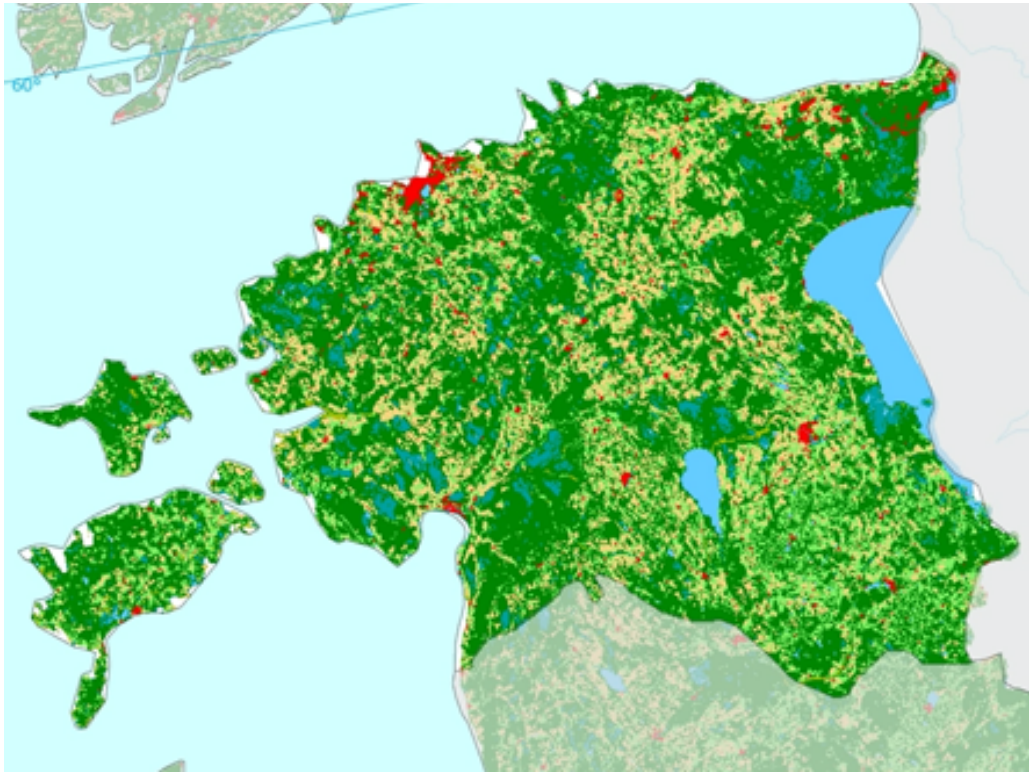
The EBRD can offer the bioeconomy sector:

- **A broad range of financial products** such as of loans, equity, guarantees or hybrid structures which are tailored to each client.
- **Technical expertise and resources for structuring and implementation support** such as technical feasibility and market studies, project design improvement, project management and implementation support, as well as potential concessional co-financing or grants drawn from donor support
- **Rapid project scoping, approval and delivery**, moulded around a business-oriented banking structure.

Estonia is eligible for EBRD funds.

4. APPENDIX: FIGURES

Figure 4.1. Map of land use in Estonia



CORINE Land Cover types - 2016

- Artificial areas
- Arable land & permanent crops
- Forest land
- Water bodies
- Pastures & mosaics
- Semi-natural vegetation
- Open spaces/ bare soils
- Wetlands

4.1. Agriculture

Figure 4.2. Land use in Estonia (Source: Estonian Timber Association)

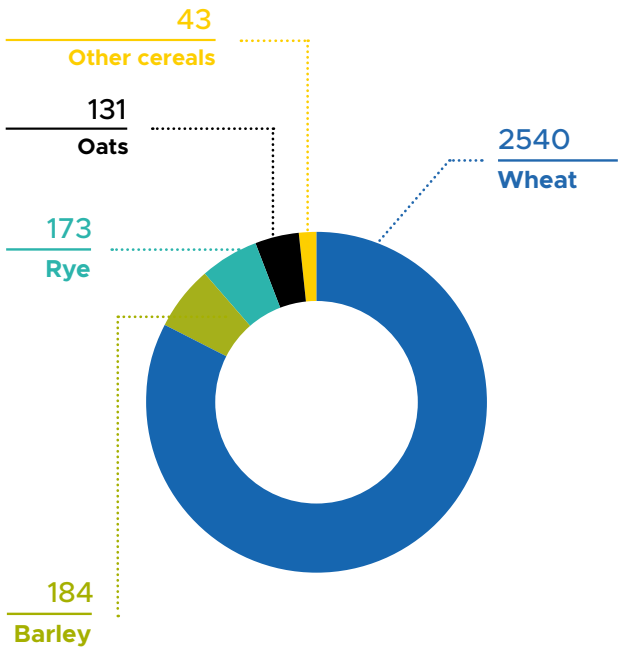
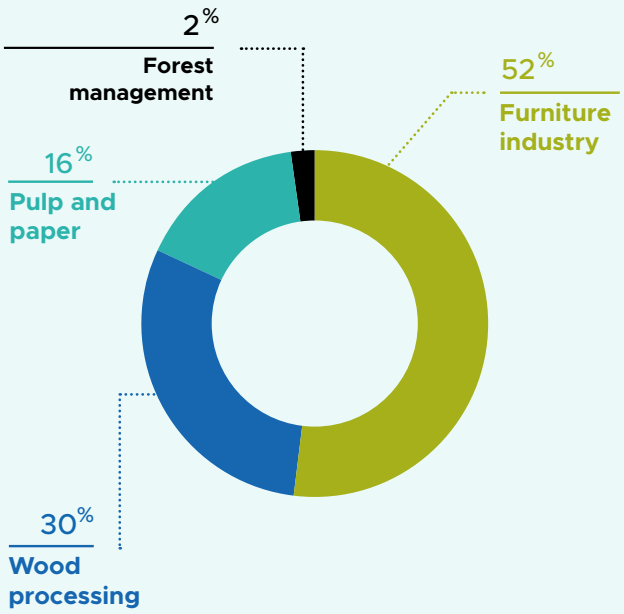


Figure 4.3. Crop production (Kt)

	Area (cultivation/harvested/ production,T/ha)	Harvested production in EU standard humidity (Kt)	Yield in EU standard humidity (T/ha)
Wheat and spelt	154.58	450.27	2.91
Barley	138.49	347.50	2.51
Oats	39.65	78.38	1.98
Dry pulses and protein crops for the production of grain (including seed and mixtures of cereals and pulses)	46.81	70.97	
Potatoes (including seed potatoes)	3.27	58.03	17.75
Oilseeds	76.27	116.44	
Rape and turnip rape seeds	72.68	113.59	1.56
Green maize	10.55	277.85	26.34
Other cereals harvested green (excluding green maize)	9.63	62.93	

4.2. Forest

Figure 4.4. Forest and wood industry employment



4.3. Food and beverages

As in most European Countries, the structure of Estonia's food processing sector is dualistic: in 2014, Estonia had 10 (2%) large (≥ 250 employees) enterprises, for which gross sales comprised 32% of the aggregate gross sales of food manufacturing industry.

Estonia's agricultural output is dominated by milk production (around 30% in value), but cereal and oilseed production is increasing at a fast rate, while milk production is flat or just slightly increasing. Meat production has increased by 1.5% per year on average over the last two decades.

Figure 4.5. Trends of milk, cereal and meat production volumes, 1998 - 2017

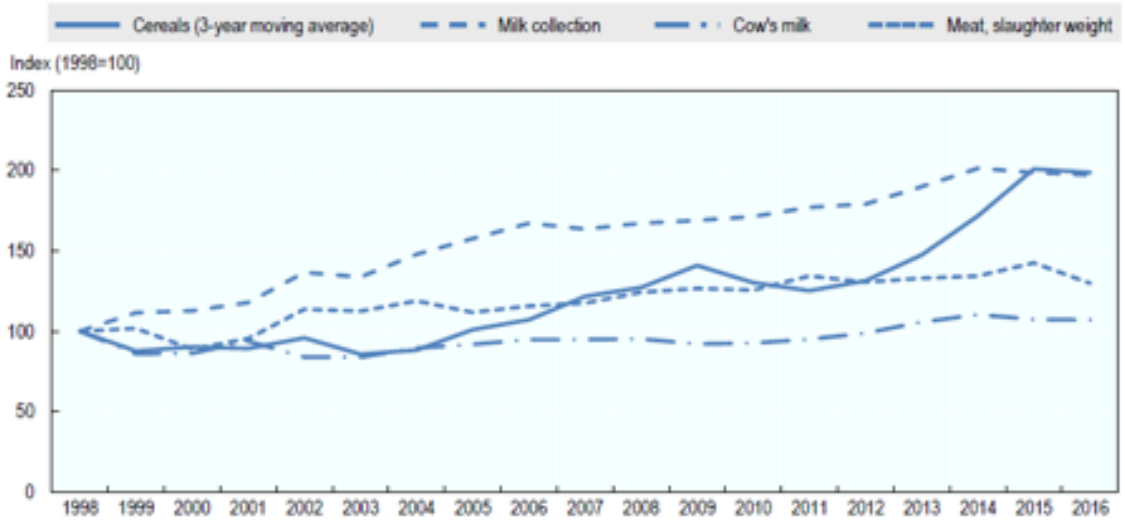


Figure 4.6. Food sector scenario (Kt, Eurostat)

	No of entreprises	Turnover of gross premium written (M€)	Production value (M€)
Manufacture of food products	597	1533.8	1377.6
Processing and preserving of meat and production of meat products	70	306.8	303.4
Processing and preserving of fish, crustaceans and molluscs	68	126.6	123.1
Processing and preserving of fruit and vegetables	66	99.4	94.2
Manufacture of dairy products	34	331.0	309.4
Manufacture of bakery and farinaceous products	162	174.5	155.7
Manufacture of other food products	154	257.5	242.7
Manufacture of beverages	86	256.3	212.9

4.4. Wood products

Figure 4.7. Wood-based subsectors

	Enterprises - number	Turnover or gross premiums written (M€)	Production value (M€)
Sawmilling and planing of wood	393	864	835.3
Manufacture of products of wood, cork, straw and plaiting materials (other than furniture)	693	1138.2	1114.7
Manufacture of furniture	719	550.8	522.0

4.5. Chemical and pharmaceutical industry

Figure 4.8. Chemical industry subsectors

	No of entreprises	Turnover of gross premium written (M€)	Production value (M€)
Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms	17	191.1	161.9
Manufacture of pesticides and other agrochemical products	0	0	0
Manufacture of paints, varnishes and similar coatings, printing ink and mastics	20	178.1	143.5
Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	52		
Manufacture of other chemical products	21		
Manufacture of man-made fibres	0	0	0
Manufacture of basic pharmaceutical products and pharmaceutical preparations	15		
Manufacture of rubber and plastic products	223	257.5	356.7

4.6. Waste streams

Figure 4.9. Management and disposal of MSW (Kt, 2017)

Total MSW generated	513.6
Recycling	126.5
Composting	18.9
Incineration with energy recovery	217.1
Other recovery	30.7
Landfill	98.4
Other disposal	0.3
Other / not known	21.7

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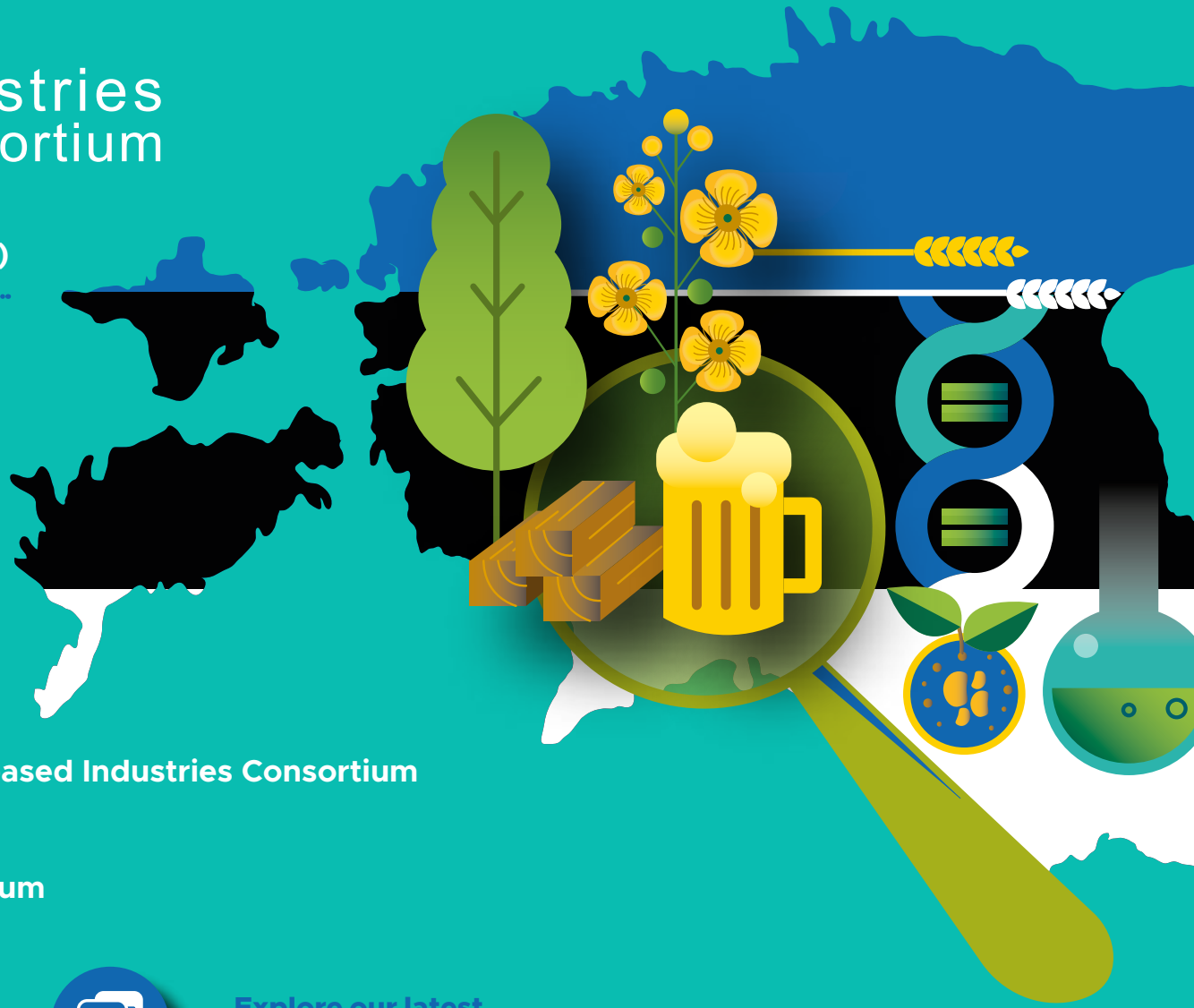

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