The bioeconomy and a future biobased food industry and agriculture sector: **How can workers'organisations shape the change?**

Agreement No VS/2017/0319

Full report

EFFAT

European Commission

with financial support from the European Union

Areté Research & Consulting in Economics

Steering Committee for the project

Jesper Lund-Larsen, Political Advisor, 3F United Federation of Danish Workers, Denmark
Arnd Spahn, Political Secretary Agriculture sector, EFFAT
Estelle Arnette Brentnall, Political Secretary food and drink sector, EFFAT

Project team

Serena Berisio, Areté Research & Consulting in Economics, Italy
Alberico Loi, Areté Research & Consulting in Economics, Italy
Renata Rakic, Areté Research & Consulting in Economics, Italy
Professor Lene Lange, LLa-BioEconomy, Research & Advisory, Denmark
Karen Hamann, IFAU Institute for Food Studies & Agroindustrial Development, Denmark
Claire-Marie Luitaud, Blezat Consulting, France

Acknowledgments

This report is the result of a team effort. The consultants, Areté Research & Consulting in Economics, drafted the report and were responsible for the data collection and empirical analysis, with support from IFAU (Denmark) and Blezat Consulting (France). Valuable inputs were also received from EFFAT member organisations. The assistance of a dedicated small steering committee who facilitated this exercise is gratefully acknowledged. Special thanks are also extended to other EFFAT colleagues who helped in many different ways.

Table of contents

Foreword

The **European Federation of food, agriculture and tourism trade unions, EFFAT**, is a single umbrella organisation serving trade unions throughout the food processing chain in Europe, "from field to fork". Our 120 national member organisations bring together over 2.6 million union affiliates and represent workers in all branches of agriculture, in food processing and its allied industries, and in the hotel, restaurant, catering and tourism sector.

EFFAT is committed to **promoting the rights of workers in food production, agriculture and tourism. Safe, high-quality jobs based on safe food, sustainable agriculture and sustainable tourism and decent work conditions are key objectives** of our work.

The agriculture sector and the food industry are changing as they need to respond to environment, human health and world sustainability challenges. Biological resources need to be better used, so there can be food for more people with less environmental and climate impact per unit produced, and renewable biological material enough to produce the replacement for what we currently get from fossil crude oil. New green technologies are of paramount importance for developing a stronger biobased food industry.

This major change is progressively having an impact on jobs and skills as we currently know them, and does raise many questions for the current and future role of trade unions and workers' representatives in the food industry and the agriculture sector.

This report is the outcome of a project to help food and agriculture trade unions across Europe, including candidate countries, to:

- increase their knowledge in **understanding what the bioeconomy means for their industry, sector, jobs and skills**, and
- increase their capacity in **responding to the change towards a bioeconomy, and being part of industry-relevant and sector-led solutions**.

With **financial support from the EU Commission**, EFFAT food and drink, and agriculture sectors have worked with consultants, Areté Research & Consulting in Economics, to allow food and agriculture trade unions to have the **necessary tools to contribute to EU policy making**, in particular in the field of the greening of the economy, job creation and job matching, quality of work, skills and decent work.

We hope that this report will help everyone who is looking for understanding the bioeconomy, information sharing and common approaches to solving shared problems.

Executive summary

The study is based on information and insights collected through a combination of desk research and interviews with key stakeholders, carried out in the framework of a selection of case studies focusing on a wide range of processes aimed at adding value to biomass. The study mainly focused on the **implications of bioeconomy in terms of job creation / required skills of workers in the food industry**, but also considered the linkages with other activities and industries (including those dealing with non-food products and energy generation).

The European Commission defines **bioeconomy** as "the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products as well as bio-energy". In practical terms, the bioeconomy covers all the sectors of the economy that rely on production and processing of biological resources, like agriculture, fisheries, food, forestry, chemicals, materials, soil improvers and bioenergy.

Bioeconomy is a key contributor to economic growth and employment across the EU. According to the European Commission, the total turnover of bioeconomy sectors in the EU was estimated at 2,259 billion Euros in 2015; in the same year, bioeconomy employed around 18 million workers, mostly in agriculture and in the manufacturing of food, beverages and tobacco. Estimates and projections from authoritative sources suggest that **bioeconomy as a whole has a remarkable potential in terms of prospective employment creation**. According to industry estimates cited in the European Commission *Bioeconomy Action Plan 2018*[1], the EU bioeconomy can create up to one million new green jobs by 2030, in particular in rural and coastal areas. The importance of the contribution of agriculture and of the food industry to total employment in the bioeconomy may decrease in the future, even though this general trend may be offset, at least in part, by increases in employment in the forestry and "blue bioeconomy" (biomass from oceans and inland waters). It is likely that most of the growth in employment will take place in non-food sectors (including liquid biofuels and bioenergy), as well as in support services (logistics, equipment and input production, etc.): this implies that **trade unions representing agriculture and food industry workers** should **pay attention to the development of biobased value chains in non-food industries**, should not overlook the **expansion of support services**, and should **enhance their cooperation with the relevant trade unions**.

The study revealed that in many ways **the bioeconomy resembles food processing and the chemical industry**, since these industries make use of highly automated processing equipment, the production is process-oriented, and the industries process biomass into products and materials. The case studies also revealed that **the principles, processes and skills used in the food industry and for processing of biomass are quite transversal**. The study also showed that **besides positive effects in terms of employment creation** (which may be significant), the development of biobased value chains (including non-food ones) can improve the profitability of food companies, and hence **contribute positively to the safeguard of employment levels in the food industry**. The **importance of establishing inter-sectoral linkages** and of **promoting cooperation among diverse groups of stakeholders** as conditions for the development of biobased value chains clearly emerged from the study. These conditions are especially important for developing **large-scale biobased industrial clusters**, which have **significant potential in terms of employment creation**.

[1] European Commission (2018), *Bioeconomy: the European way to use our natural resources – Action plan 2018*, Directorate-General for Research and Innovation - Unit F – Bioeconomy.

The study also revealed that the **development of biobased value chains in the agro-food system** faces a number of **challenges and constraints**: some of these **affect workers**, and have **direct implications for trade unions**:

- With special respect to **job creation**, it should be noted that some biobased processes require substantial capital investments, but relatively limited workforce (capital-intensive processes rather than labour-intensive processes).

- The **sectoral focus of many initiatives for the development of biobased value chains** may prevent them from exploiting inter-sectoral synergies. The biggest potential for job creation, or at least for safeguard of current occupation levels, is offered by an inter-sectoral approach in the development of biobased value chains.

- Finally, there is the issue of the **allocation of value among the various actors** involved in biobased chains, with a special attention for the **share allocated to workers**.

Challenges for **workers** can be addressed by trade unions alone, or through their cooperation/dialogue with other stakeholders (business operators, policymakers, civil society, etc.).

The study showed that **bioeconomy is above all characterised by diversity**. To successfully develop new biobased value chains, such **diversity needs to be taken into account, to be properly understood, and to be adequately dealt with**: failure in doing that can lead to missed opportunities and/or to unaddressed challenges which can put the success of the related initiatives at risk.

The study also highlighted the **critical conditions to be met** to ensure that the potential of bioeconomy in terms of employment creation (or, at least, of safeguard of current employment levels) is fully exploited:

1. The application of the "**cascading approach**"[2] to fully unlock the potential for adding value to biomass without negative environmental side effects.

2. Establishing **inter-sectoral linkages** (between farming and processing; between food and non-food value chains) and c**ooperation among different groups of stakeholders** (business operators; research centres and education centres; institutions and policymakers; civil society; etc.) to fully exploit the aforementioned diversity and to implement the "cascading approach".

3. Establishing an **adequate policy / regulatory framework**, in order to:

   a. Minimise regulatory constraints to full exploitation of biomass in value adding processes, **without prejudice to social standards and environment conservation**

   b. Provide financial support and incentives to business operators, research centres and education centres.

The study findings clearly suggest that trade unions should not only l**ook at the development of the bioeconomy with great attention**, but should **also play a role in shaping that development**. In other words, trade unions should **define a "bioeconomy they want"**, and should **actively contribute to the realisation of a model of bioeconomy which is consistent with their values and goals**.

[2] Cascading involves obtaining the most valuable products in the first stages of biomass processing, and lower-value products only in successive stages; only the residues from biomass processing into biobased products are finally used to generate energy. The cascading approach also allows to minimise waste, with positive implications for the development of an environmentally sustainable bioeconomy.

EFFAT deems that the bioeconomy of the future should be socially, economically and environmentally sustainable.

A SOCIALLY SUSTAINABLE BIOECONOMY

The development of bioeconomy should be an inclusive process: young people and unemployed people should be given a chance to find a job in the bioeconomy. This implies **promoting an adequate educational offer**, including hands-on training in biobased production units.

AN ECONOMICALLY SUSTAINABLE BIOECONOMY

The study revealed that **diversification into non-food biobased value chains** can improve the profitability of the involved food business operators, with **positive implications for the safeguard of current employment levels in the food industry**. This finding reinforces the **importance of an inter-sectoral approach to bioeconomy**. The study also showed that new biobased value chains can be successfully implemented at different scales. Even if the potential for employment creation in large-scale industrial clusters is generally much higher, this development model may be unsuitable for some processes, or unfeasible in certain contexts. The **potential for employment creation of smaller biobased production units should hence not be overlooked**, especially where those units can be built in significant numbers.

AN ENVIRONMENTALLY SUSTAINABLE BIOECONOMY

Last but not least, the development of the bioeconomy should **contribute to enhanced environmental conservation and more effective action against climate change**. To these ends, the development of biobased value chains should: i) be supported by a comprehensive analysis of their environmental/climate change implications; wherever these are negative, adequate **mitigating measures** should be taken; ii) **apply the "cascading approach"**, by virtue of its **waste-minimising effects**.

The study allowed the elaboration of **recommendations** aimed at **promoting the development of a socially, economically and environmentally sustainable bioeconomy**, along the lines defined above. To that end, trade unions and workers' representatives should:

1. Undertake initiatives aimed at **improving their knowledge of the bioeconomy**.
2. **Strengthen trade union solidarity and cooperation across sectors**.
3. Consider the possibility to **invest part of the financial resources available to them** (e.g. those related to workers' retirement funds) **in projects for developing new biobased value chains that are socially, economically, and environmentally sustainable**.

4. Contribute actively to the **adaptation of the existing EU-level and national-level instruments** to promote the development of the bioeconomy, as well as to **the elaboration of new ones**.

5. Contribute actively to the **elaboration of EU-level and national-level initiatives aimed at promoting the development of bioeconomy** (e.g. through research and education, granting of financial incentives, minimisation of regulatory constraints, etc.).

In order to **promote employment creation in the bioeconomy**, and to **ensure that workers have adequate skills for working in the bioeconomy**, trade unions and workers' representatives should:

6. Undertake initiatives aimed at: A) **Improving their knowledge of the implications of the bioeconomy in terms of employment and required skills of workers**. B) **Improving awareness of, and general knowledge about bioeconomy among workers** (e.g. through elaboration of informative material). C) **Helping unemployed workers to access technical education in the field of bioeconomy**, with a view to improving their chances of finding a job in the related sectors.

7. Consider the possibility to **invest part of the financial resources available to them** (e.g. those related to workers' retirement funds) **in initiatives aimed at providing workers with technical education in the field of bioeconomy**, always with a view to improving their chances of finding a job in the related sectors.

Glossary of terms

Biobased industrial cluster: combination of separate plants performing technologically linked *biomass processing* (see) activities: the plants are concentrated in the same industrial site, close to one another.

Biobased products: products obtained from *biomass conversion / processing* (see) in a *biobased value chain* (see). These include *biomaterials* (see) and *biofuels* (see).

Biobased value chain: system for adding value to *biomass* (see) through a sequence of processes. Biobased value chains usually see the involvement of different actors (farmers, processors, traders and distributors, service providers, suppliers of production inputs, etc.), each performing specific functions

Biochemicals: chemical products for a wide range of applications (paints, solvents, etc.) obtained from *biomass conversion / processing* (see).

Bioeconomy / biobased economy: production of renewable biological resources (see "biomass") and the conversion of these resources and waste streams into value added products (see "biobased value chain" and "biomass conversion / processing"), such as food, feed, biobased products (see) as well as bioenergy (see).

Bioenergy: energy (heat, electricity or both) obtained from *biomass conversion / processing* (see).

Biofuels: fuels (for heating, for transportation, for industrial uses, etc.) obtained from *biomass conversion / processing* (see). Biofuels include: biodiesel (mostly obtained from vegetable oils); bioethanol (alcohol obtained from *biomass* (see) containing carbohydrates: sugar cane, sugar beet, cereals, cellulose, wood, etc.); biogas (obtained from digestion of *biomass* (see) by microorganisms in particular conditions.

Biomass: renewable raw materials – residues and side streams from production processes, or biological feedstocks from forestry, agriculture, aquaculture and fisheries - which can be converted into several *biobased products* (see) and into *bioenergy* (see). Details on the different types of biomass used in *biobased value chains* (see) are provided at § 1.4 of the study.

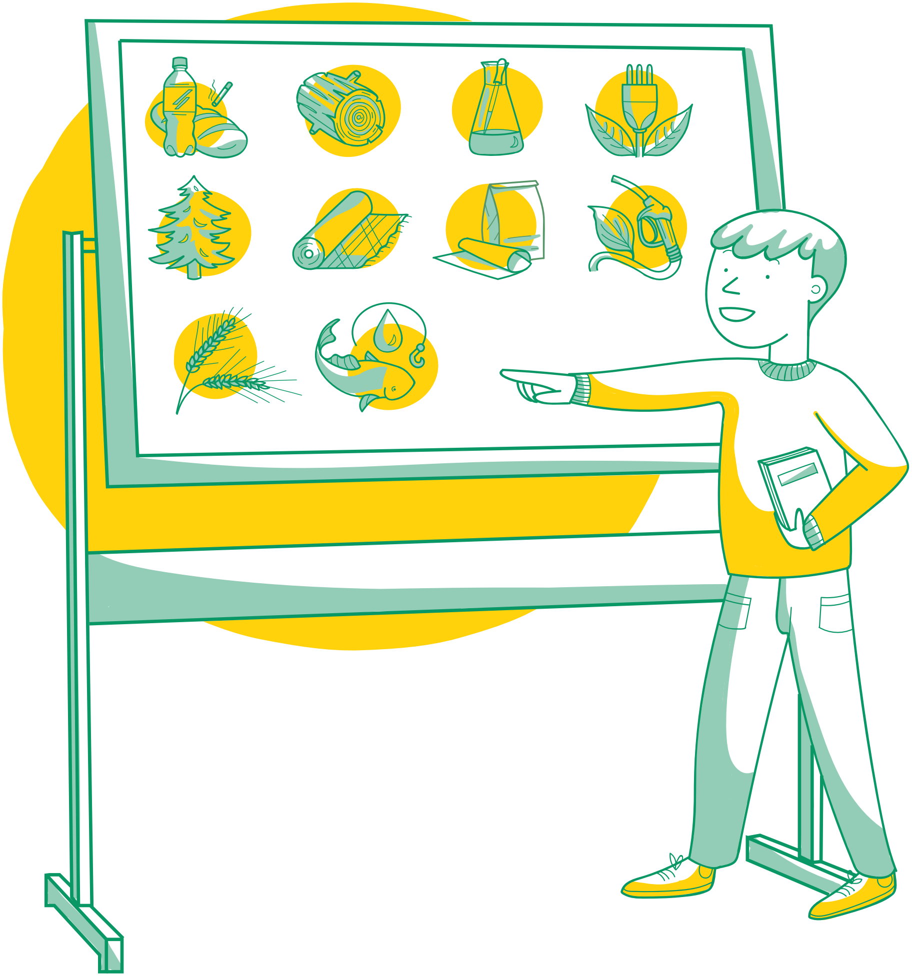
Biomass conversion / processing: combination of activities aimed at obtaining *biobased products* (see) and *bioenergy* (see) from biomass. Biomass conversion can be carried out in a single integrated plant called *biorefinery* (see) or in a combination of technologically linked but separate plants, which may either be concentrated in a *biobased industrial cluster* (see) or located distant from one another.

Biomaterials: materials (for construction, insulation, etc.) obtained from *biomass conversion / processing* (see).

Biorefinery / biorefining: integrated processing plant using *biomass* (see) as raw material. Biorefineries convert biomass into: i) a wide spectrum of *biobased products* (see), such as food and feed, *biomaterials* (see), *biochemicals* (see), *biofuels* (see); *bioenergy* (see). The most advanced types of biorefineries apply the so-called *cascading approach* (see) to unlock the full potential of *biomass conversion* (see). A more detailed explanation of the concept of biorefinery and of its practical applications is provided at § 1.5 of the study.

Cascading approach: the so called cascading approach involves obtaining the most valuable *biobased products* (see) in the first stages of *biomass processing* (see), and lower-value products only in successive stages; only the residues from biomass processing into biobased products are finally used to generate *bioenergy* (see). A more detailed explanation of the concept of cascading approach and of its practical applications is provided at § 1.6 of the study.

1 Understanding the bioeconomy



1.1 Methodological approach

The study is based on information and insights collected through a combination of desk research and interviews with key stakeholders. The study mainly focused on the **implications of bioeconomy in terms of job creation / required skills of workers in the food industry**, but also considered the linkages with other activities and industries (including those dealing with non-food products and energy generation).

Relevant literature was reviewed to explain the basic concepts behind the bioeconomy (§ 1.2 to § 1.6), to provide an overview of its current importance in the EU (§ 2.1) and to outline the key elements of the related policy framework (§ 2.2). It is important to underline that the focus of the study was not the elaboration of original EU-wide estimates of the current and future importance of the bioeconomy in terms of employment creation. Nevertheless, the study provides some insights on the potential of the bioeconomy in that respect by reporting some figures from authoritative sources.

Case studies covering a wide range of concrete applications of biobased technologies in the development of new value chains (§ 3) allowed to investigate on the related organisational solutions, on changes in production processes stemming from the bioeconomy, on its effects on the use of labour, and on the new skills required to work in the bioeconomy.

The case study findings allowed to draw **conclusions** (§ 4) on the challenges and opportunities of the bioeconomy in the EU agribusiness system, on the application of skills for working in the bioeconomy and on how those skills can be obtained, and on future prospects of working in the bioeconomy.

The knowledge base developed in the study allowed to formulate a number of **operational recommendations** (§ 6) aimed at promoting the development of a **"bioeconomy model"** (§ 5) which is consistent with EFFAT's mission and institutional objectives.

1.2 What is bioeconomy?

Bioeconomy is at the same time a traditional concept and a new one. In fact, even if the term "bioeconomy" is relatively new, it involves the oldest economic sectors which have been central to the development of the humanity, like agriculture, food production, fuel production and bioenergy (heat and electricity) production by combustion. However, it is also a new sector because it is centred on research, innovation and biotechnologies, with a view to using biological resources better and wasting less. In this light, bioeconomy focuses on new opportunities in both traditional and emerging biobased sectors, including health promoting ingredients, food, feed, textiles, paper and pulp, biofuels, biogas and soil improvers.

A single **definition of bioeconomy** is difficult to establish, given the wide concept which is behind this term. In general, the concept of bioeconomy can be described as an economy where the feeding blocks are derived from renewable biological resources[3]. For the European Commission, bioeconomy is "the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products as well as bio-energy".

Bioeconomy covers all the sectors of the economy that rely on production and processing of biological resources, like agriculture, fisheries, food, forestry, chemicals, materials, soil improvers and bioenergy. Since bioeconomy has its roots in several sectors, it also involves cross-sectoral aspects of policies (e.g. environment, climate change, circular economy, waste, industrial policies, innovation and regional policies, etc.[4].

1.3 Why bioeconomy?

The agro-food system is generally considered as a major responsible for several problems emerged or under discussion in the last decade: climate change (by CO2 and methane emissions), biodiversity loss, use of natural resources (e.g. water), increasing pollution (pesticide residues in drinking water and surplus nutrients ending up in rivers, lakes and coastal shallow waters), and leading to increased occurrence of antibiotic resistance. In addition, other global challenges like the increasing world population and the changing consumption patterns in several areas of the world, contribute to increasing the pressure on natural resources. It is therefore of utmost importance to enable a more efficient use of resources and to minimise waste, unlocking the full potential of biological resources.

[3] McCormick, K., Kautto, N.(2013), "The Bioeconomy in Europe: An Overview", in *Sustainability* 2013, 5, 2589-2608.
[4] Mainar-Causapé, A.J., Philippidis, G. (Eds.) (2018), *BioSAMs for the EU Member States. Costructing social accounting matrices with detailed disaggregation of the bio-economy*, Euroepan Commission – Joint Research Centre.

Bioeconomy is generally identified as a **potential solution to major global/regional threats**:

- **Feeding the world´s rapidly growing population:** according to the United Nations, the current world population of 7.6 billion is expected to reach 8.6 billion in 2030, 9.8 billion in 2050 and 11.2 billion in 2100. In addition, the changing consumption patterns can have negative implications on the demand of food, land and water, creating a pressure on the global agro-food production system.

- **Mitigating climate change:** according to the United Nations, 17 of the 18 warmest years on record have occurred in the twenty-first century. Agriculture is both a contributor to the climate change and the most vulnerable sector to the negative effects of climate change: in fact, agriculture accounts for 10–12% of global greenhouse gas emissions but, for example, up to 84% of the economic impacts of drought are felt within the agricultural sector[5].

- **Reduced EU industrial competitiveness and loss of jobs, in particular in rural areas:** according to the European Investment Bank[6], Europe has experienced a two-decade long decline in competitiveness and productivity growth. The EU began to slip behind the US and other leading trading partners in terms of competitiveness. In addition, unemployment rates are generally significantly higher in rural than in urban regions. More in general, just over one quarter (28.0 %) of the EU-28 population lived in a rural area in 2015, with a somewhat larger share living in towns and suburbs (31.6 %), while the biggest share of the EU-28 population lived in cities (40.4 %)[7].

The opportunities stemming from the transition to a biobased economy are immense: strong and sustainable bioeconomy sectors, enabled by more responsible use of biological resources, are a central element for the development of Europe and can help in addressing environmental, social and economic challenges. **Concrete potential benefits of bioeconomy** include the following: :

- **Reduction of greenhouse gas emissions and decrease in dependence on fossil resources**: from a climate change perspective, the key importance of the use of biomass resources in economic sectors beyond food and feed production is to reduce carbon emissions caused by the use of fossil resources.

- **Wiser management of natural resources.**

- **Opportunities for adding value to by-products, waste and residues from food and feed production processes**, which become feedstocks for biobased processes to obtain a wide range of food and non-food products and to generate energy.

- **Opportunities for employment creation** in the different stages of food and non-food biobased value chains and in support activities (logistics, research and development, etc.). As explained in more detail at § 2.1.2, agriculture accounts for 51% of total employment in the EU bioeconomy (9.2 million workers), whereas manufacture of food, beverage and tobacco accounts for 25% (4.5 million workers). The contribution of non-food value chains to total employment in the bioeconomy is bound to increase in the future.

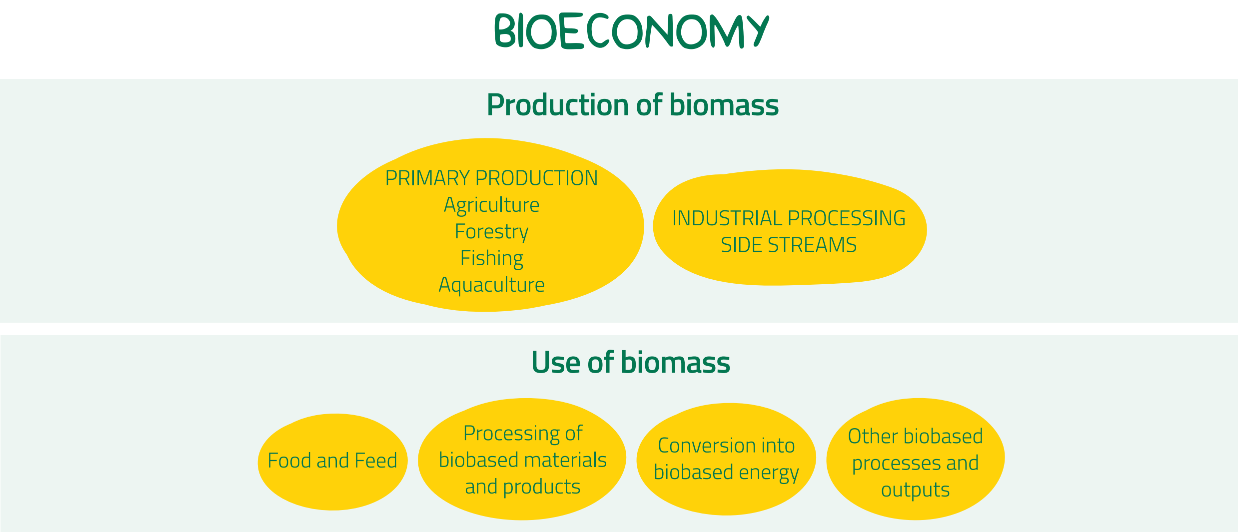
[5] United Nations (2018), *UN Climate Change Annual Report 2017*, United Nations Framework Convention on Climate Change (UNFCCC). https://unfccc.int/resource/annualreport/
[6] European Investment Bank (2016), *Restoring EU competitiveness* (updated version).
[7] Eurostat (2017), *Statistics on rural areas in the EU*, https://ec.europa.eu/eurostat/statistics-explained/index.php/Statistics_on_rural_areas_in_the_EU

1.4 Biomass and types of biomass conversion (yellow, green, blue, red, white, brown and purple)

Biomass is any renewable raw material - residues, side streams or biological feedstocks - which can be converted into several biobased value added products and into bioenergy.

Figure 1.1 shows a very simplified overview of the **key sources of biomass** and of the **main uses of biomass**. The concept of biorefineries, where the conversion from biomass to bioproducts and bioenergy takes place, is illustrated at § 1.5.

Figure 1.1 – Key sources and main uses of biomass in the bioeconomy
Source: Areté elaboration on Spatial Foresight, SWECO, ÖIR, t33, Nordregio, Berman Group, Infyde (2017), Bioeconomy development in EU regions. Mapping of EU Member States'/regions' Research and Innovation plans & Strategies for Smart Specialisation (RIS3) on Bioeconomy for 2014-2020



A large variety of feedstocks can be processed into biobased products and bioenergy. Some, like food products, are already important factors in the economy. Others, like crop residues, industrial side-streams and bio-waste, already exist but have so far had little economic value. The agriculture, forestry, fishing, aquaculture and waste (industrial and domestic) sectors can provide potential feedstock for the production of biobased products.

Biomass can either be a residue from agricultural, forestry or industrial activities or **can be specifically produced**. Currently the main feedstock used for producing agricultural biomass are dedicated crops, which should increasingly be substituted by waste and residues such as wheat straw, corn stover, bagasse from sugar cane processing, oil seed press pulps, forestry residues and manure. According to Cherubini[8], biomass feedstocks can be subdivided into primary, secondary or tertiary ones:

- **Primary feedstocks**: residues from forestry or agriculture and fishery.
- **Secondary feedstocks**: biomass from processing side-streams, such as sawmill residues or black liquor generated by the forest products industry, by-products of milk processing,

[8] Cherubini, F. (2010). "The biorefinery concept: using biomass instead of oil for producing energy and chemicals". *Energy conversion and management*, 51(7), 1412-1421.

slaughterhouse waste, fish processing waste.

- **Tertiary feedstocks**: biowaste such as waste water, municipal solid waste (MSW), spent greases, sludge etc.

Another classification foresees the **use of colours to link the biomass resources with their origins**[9]. Table 1.1 below illustrates the different types of biomass as well as some uses which can be linked with each feedstock. The color-coding and grouping of feedstocks also reflect recalcitrance to processing, pre-treatment needs, and upgrading potentials of the biomass. For instance, yellow is the most recalcitrant biomass, with the strongest need for pre-treatment; the red animal-derived biomass does not need such harsh decomposing pre-treatment, as animal cells do not have cell walls. Sludge is wet and dirty and can therefore not be used for upgrading to food or feed; however, it can be used as nutrient for growing bacteria, which again can produce building blocks for e.g. bioplastic or chemicals.

Table 1.1 – Classification of biomass for the purpose of valorisation in biobased processes

Name	Biomass origin	Example
The **Yellow** biomass	Straw, corn stover and wood chips	Sustainable building begins with bio-based bricks in a child's bedroom. The eco-friendly blocks consist mainly of a mixture of wood fibres and a carbohydrate-rich raw material such as potato starch. Large quantities of the fibres accrue as a by-product of the wood industry – up to 40% of the raw material. The majority is processed into paper, while some is used to produce thermoplastic composites, a new product from which the bricks are manufactured. The bricks have a wood-like appearance, are highly sturdy and can be dyed pastel shades using food colouring (example from "*BioSTEP – Bioeconomy in everyday life*").
The **Green** biomass	Green leaves of grass, clover, etc	Production of protein rich and prebiotic animal feed products from grass and clover leaves (Green Biorefinery, Denmark)
The **Blue** biomass	Fish, seaweed, clams, etc.	BioMega (Norway), produces food ingredients (oil and protein powder) from heads, tails and bones from salmons. Codland (Iceland) uses now >90% of all parts of fish for upgraded fish products. Ocean Rain Forest (Faroe Islands) cultivates seaweeds for production of a spectrum of higher value products, including healthy food and feed ingredients.
The **Red** biomass	Residues from animal meat production (slaughterhouse waste)	Danish Crown Ingredients (Denmark) produces higher value products from close to all parts of the pig Saria (Germany) converts slaughterhouse processing side streams into value added products
The **Grey** biomass	Residues from industrial processing of feed and food	According to the European Coffee Federation, Europeans consume 2.5 million tonnes of coffee per year in around 725 million cups of coffee. Coffee is a luxury product and has a high value, but in the end only little of it is used. Nearly 80% of the coffee bean is left behind as residue. Making use of these residues is one of the goals of Re-Worked company. The Greencup company provides office buildings with Fairtrade coffee, collects the residues afterwards and then supplies Re-Worked with the spent coffee grounds. Re-Worked uses these grounds, designing furniture created with a hybrid material that is made up of 60% used coffee. The primary goal of the innovative venture is to promote the idea of a circular economy (example from "*BioSTEP – Bioeconomy in everyday life*"). Beyond Coffee company grows mushroom sold as delicacy products in super markets (or directly to the providers of the coffee grounds), directly on the coffee grounds. Next development: making higher value products by converting also the double spent coffee grounds (left over from mushroom production) into protein-rich and tasty food ingredients.

[9] United Federation of Danish Workers 3F (2016), *The fundamentals of bioecomomy. The biobased society.*

Name	Biomass origin	Example
The **Brown** biomass	Organic content of sewage sludge and household waste	ReneScience (Ørsted Group, Denmark; commercial plant under construction in the United Kingdom) converts municipal solid waste (MSW) into value added products after enzymatic treatment, enabling separation of organic content from inorganic MSW.
The **Purple** approach: **carbon capture and use (CCU)**	Conversion of greenhouse gases (GHG) into higher vale products	UniBio (Denmark) converts methane into EU-approved animal feed by growing single cell bacterial protein on the gaseous side streams of producing methane from biogas.

In general, the use of biomass is subject to intense discussion, in particular when it is used for energy production. It should be noted that the so-called "first-generation" biofuels were produced from food crops such as maize, sugarcane and palm oil. The production of biofuels from these sources, but more in general the use of these resources for feeding biorefineries, is in competition with the production of food: the carrying out of the related activities has several ethical implications, in particular in the current scenario of increasing global population. The **competition between food use and other uses** is a major problem when biomasses are imported from developing countries, in which food production is strategic for ensuring the livelihood of population.

From the two classifications presented above it emerges that there are a number of **opportunities stemming from the use of biomass from different origins**:

- Biomass includes material currently seen as waste (household waste; industrial and municipal wastes).
- In the future, biomass could be mainly composed by non-edible parts of the crops/plants or other products not used as food. An example already in use is lignocellulose obtained from wood or grass.
- The use of by-products, side streams and residues of food production as feedstock for biorefineries can contribute to the reduction of competition between food and other uses of biomass. The edible portion of biomass can be removed and used in food production processes, and the remainder can be further refined and processed into both food and non-food products[10].

1.5 What is a biorefinery?

The principal products of the bioeconomy are bio-based products and bioenergy, while the fundamental technology is known as biorefineries. Biorefineries can be compared to conventional petro-chemical clusters, where crude oil is converted into a wide range of different products, ranging from fuels (diesel, gasoline, kerosene, etc.) to chemicals and plastics.

The important difference is that feedstock for biorefineries can be used also for production of food, feed, and fibre products, while carbon compounds in crude oil are broken down during refining (cracking), hereby destroying their potential for production of food and feed.

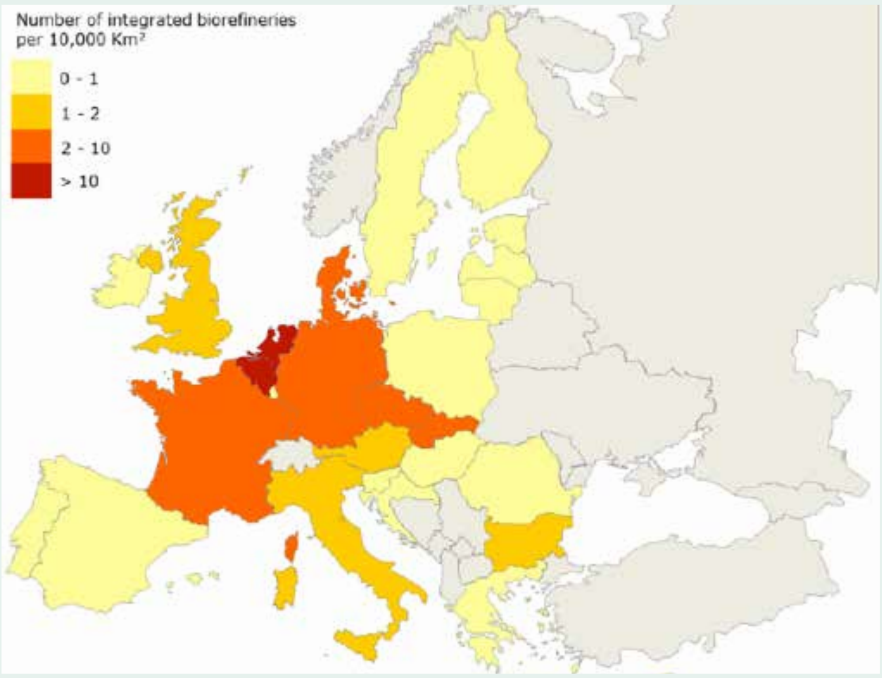
[10] Asveld L., van Est R., Stemerding D. (Eds) (2011), *Getting to the core of the bio-economy: A perspective on the sustainable promise of biomass.* The Hague: Rathenau Instituut.

A **biorefinery is an integrated processing plant using biomass as raw material**; biomass is converted into a wide spectrum of products such as food and feed, biomaterials, biochemicals, biofuels and bioenergy. The IEA Bioenergy[11] defines the biorefinery concept as "sustainable processing of biomass into a portfolio of marketable biobased products (food and feed ingredients, chemicals, materials, fuels, energy, minerals, CO2) and bioenergy (fuels, power, heat)". According to JRC[12], this definition is only related to the concept of integrated biorefineries, where both energy and biobased products are produced.

The **803 operational biorefineries in the EU in 2018** include 507 biorefineries producing bio-based chemicals, 363 biorefineries producing liquid biofuels and 141 biorefineries producing bio-based composites and fibres. It should be noted that multi-product facilities are counted more than once. Of those 803 facilities, 177 are reported as integrated biorefineries that combine the production of bio-based products and energy. An important and rapidly growing type of biorefinery is the one where existing industrial plants start upgrading their own side streams to higher value products, strengthening their competitiveness and their environmental performance; hereby providing the basis for significant job growth (examples include processing plants in the dairy sector, breweries, slaughterhouses, plants producing food ingredients, forestry processing plants, etc.).

Figure 1.2 shows the map of the density of integrated biorefineries in the EU.

Figure 1.2 - Density of integrated biorefineries in the EU, 2018
Source: Parisi, C. (2018). Research Brief: Biorefineries distribution in the EU. European Commission - Joint Research Centre



It is worth noting that:

- The location of most biorefineries shows correspondence with petro-chemical clusters and ports.
- The highest density of biorefineries is in the central part of the EU, particularly in Belgium and the Netherlands and in some regions of Germany, France and Italy.

[11] *De Jong, E., Higson, A., Walsh, P., Wellisch, M., (2012),* Bio-based Chemicals. Value Added Products from Biorefineries - Task 42 Biorefinery. http://www.ieabioenergy.com/publications/bio-based-chemicals-value-added-products-from-biorefineries .
[12] Parisi, C. (2018). *Research Brief: Biorefineries distribution in the EU.* European Commission - Joint Research Centre.

- Agricultural resources are the feedstock source used by most biorefineries in all EU Member States, followed by forestry, waste, marine and other (e.g. insects-derived feedstock).

The most advanced types of integrated biorefineries apply the so-called "cascading approach" to unlock the full potential of biomass (see § 1.5). According to the cascading approach, only residues which are unsuitable for obtaining food and non-food products are converted into bioenergy.

1.6 The cascading approach and the value pyramid

Biorefineries allow for optimal utilisation of biomass: in fact, a biorefinery is a facility that integrates biomass conversion processes to produce food ingredients, feed additives and value-added chemicals and materials, as well as equipment to produce fuels and to generate electricity and heat by combustion. Biorefineries which primarily produce biobased products use the residues of each stage of the process for further processing or for producing energy for internal use or for sale. By producing several products, a biorefinery takes advantage of the various components in biomass and of their intermediates, therefore maximising the value derived from the biomass feedstock. It should be noted that this type of integrated biorefineries is still in its early stages of development in most areas. The key constraints to a wider diffusion of integrated biorefineries on a commercial scale derive from the need to standardise available raw materials, from challenges in establishing supply chains for all the products obtained, and from limitations concerning the scalability of the model.

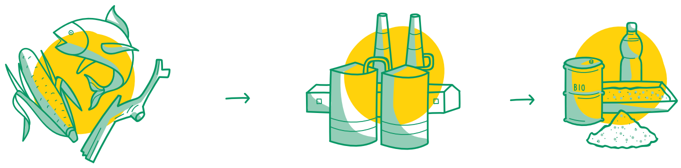
The **biorefinery** and the **principle of cascading use of biomass** are **complementary concepts**: cascading is an essential element of the biorefinery concept. Cascading involves obtaining the most valuable products in the first stages of biomass processing, and lower-value products only in successive stages; only the residues from biomass processing into biobased products are finally used to generate energy. In general, biorefineries can only be profitable if a variety of different products can be produced simultaneously. Biomaterials and bioenergy share the potential to reduce greenhouse gas emissions: competition for biomass resources is hence undesirable for the development of both biomaterials production and bioenergy generation. In theory, a wider application of the cascading use principle would allow material and energy uses of biomass to be implemented in a complementary way, thus achieving the benefits of both biomaterials and bioenergy[13].

A key factor in the realisation of a successful bio-based economy is the production of a wide range of biobased products in combination with bioenergy, with a view to substituting fossil-derived equivalent products by processing a wide variety of biological feedstocks. With respect to the agro-food system, materials that were previously considered as waste can now be used as feedstocks for production of new added-value products, hence adding value to side streams from agro-industrial production processes. New industrial sectors are being developed around processing of waste streams, production of new biobased products in biorefineries or use of raw materials from farming, food processing and forestry in new value chains. In addition, bioeconomy can reduce dependence on fossil feedstock in the chemical industry, thanks to the emergence of biobased alternative products and materials, such as biobased plastic packaging.

[13] Keegan D. et al. (2013), "Cascading use: A systematic approach to biomass beyond the energy sector", in *Biofuels Bioproducts and Biorefining*, March 2013.

Examples of new value chains

Biological resources as the basis for new biobased products



> primary production (biological resources and residues from agriculture, forestry and oceans)

> conversion in bio-refineries

> new biobased materials (e.g. biomaterials, food ingredients, etc.)

Upgrading side streams and waste streams in food processing

> primary production (biological resources from agriculture and oceans)

> food processing

> processing side streams and waste streams

> high value compounds, new biobased materials, bioenergy.

Upgrading side streams and waste streams in agribusiness processing

> primary production (biological resources from agriculture and forestry)

> agribusiness processing

> processing side streams and waste streams

> conversion in bio-refineries

> food ingredients, bioenergy, new biobased materials (e.g. bioplastic, bio-based chemicals), and fibres.

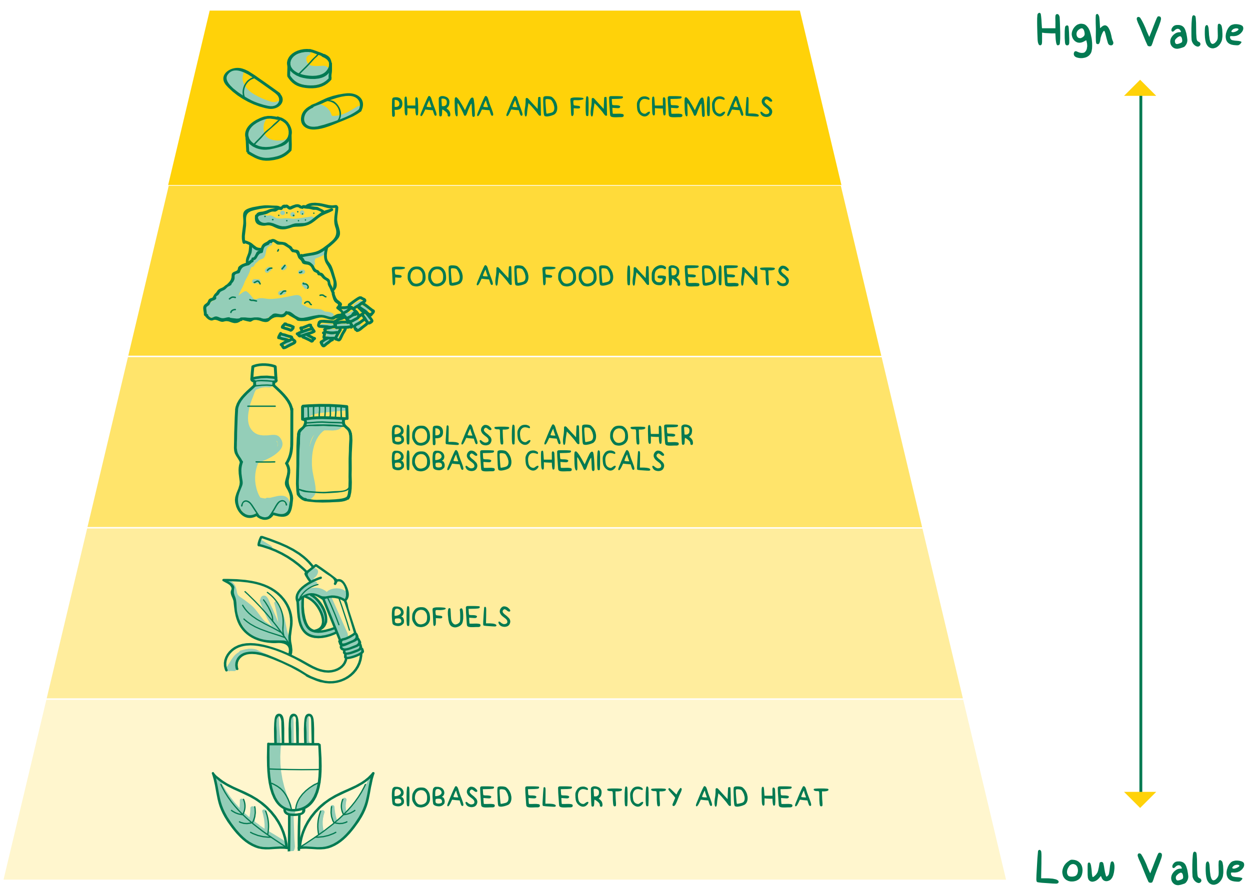
Bioeconomy differs from traditional approaches to the use of natural resources. The traditional approach generally uses natural resources for one purpose only (e.g. crops for food/feed or wood for energy). By contrast, the **bioeconomy uses natural resources for several purposes, and also minimises waste**. In addition, new and complex value cycles emerge due to new research findings and technological opportunities to work with the molecular building blocks of biological resources[14].

[14] Spatial Foresight, SWECO, ÖIR, t33, Nordregio, Berman Group, Infyde (2017), *Bioeconomy development in EU regions. Mapping of EU Member States'/regions' Research and Innovation plans & Strategies for Smart Specialisation (RIS3) on Bioeconomy for 2014-2020*, Study commissioned by DG Research & Innovation, European Commission.

The **economic value of biomass** is determined by the value added it can generate, i.e. by the difference between the revenue from the various products marketed and the production costs (capital costs and operational costs) of those products. Biomaterials (e.g. polymers) are in general the biobased products with the highest value added, followed by bioechemicals (e.g. flavours, proteins, fine chemicals), biofuels (e.g. bioethanol, biodiesel, biogas) and bioenergy (e.g. wood pellets for direct combustion   combined heat and power generation).

In most of the cases, products with a relatively high market value are associated with high production costs, and vice versa. In addition, also the size of the market is relevant for the economic feasibility of biorefining. In most of the cases, products with a high market value have a relatively small market (e.g. specialty chemicals) and vice versa (e.g. biofuels). Figure 1.3 below shows the growing added value of products originating from biomass, i.e. the so called "value pyramid".

Figure 1.3 - Added value of biobased products
Source: United Federation of Danish Workers 3F (2016), The fundamentals of bioecomomy. The biobased society.



The term value chain (or value added chain) reflects the fact that the processing of biomass implies an increase in the value obtained in each step. It should be noted that the development of new biobased value chains requires cooperation between previously unconnected sectors.

2 The state of the art of bioeconomy in Europe

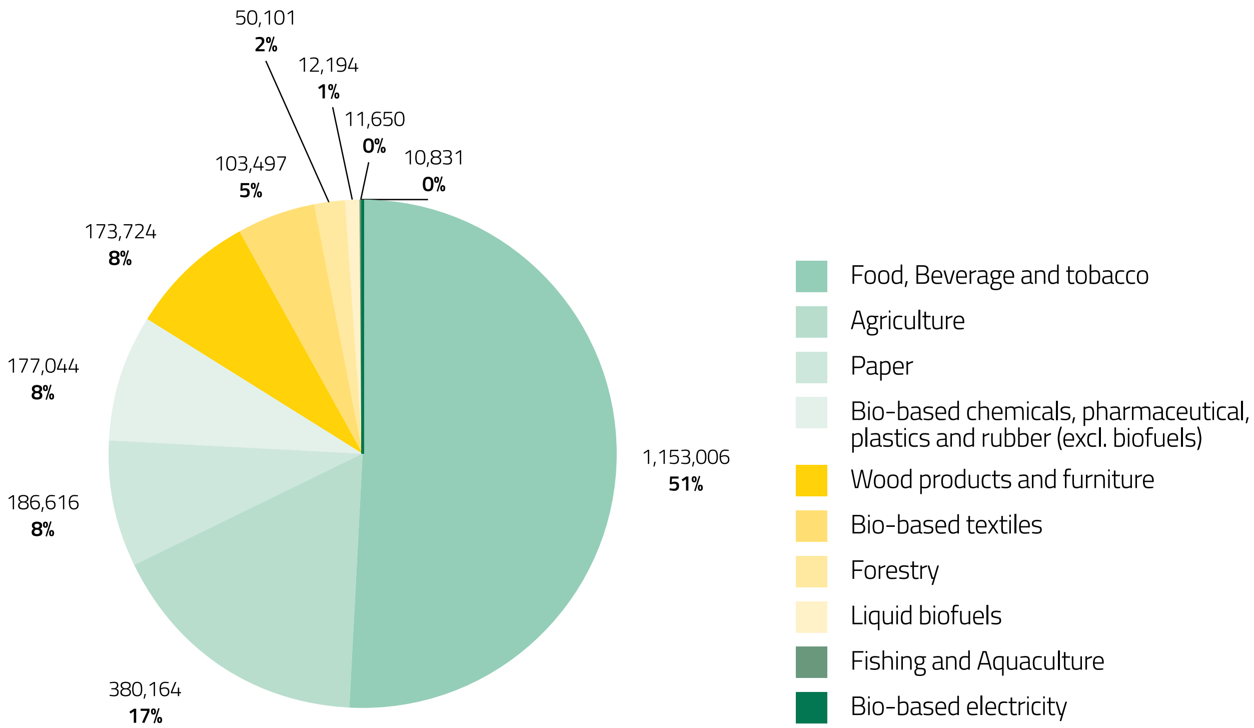
2.1 The state of the art in bioeconomy sectors

2.1.1 TURNOVER OF EU BIOECONOMY

Bioeconomy is a key contributor to economic growth across the EU: in 2015, the total turnover of bioeconomy sectors in the EU was estimated at 2,259 billion Euros.

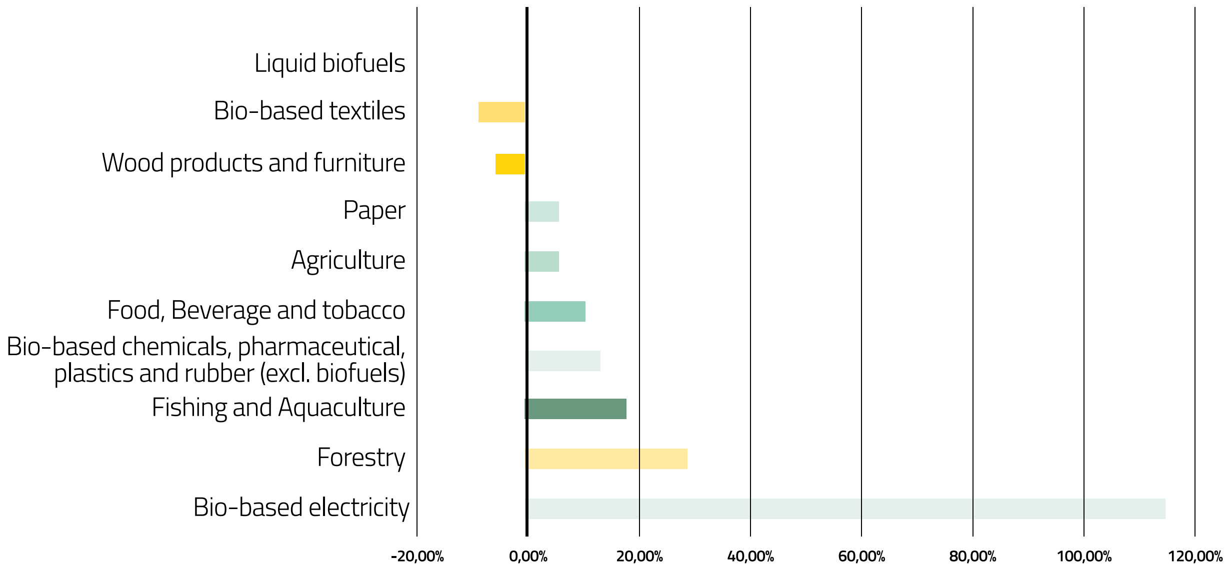
Figure 2.1 illustrates the turnover of each bioeconomy sector in the EU. Manufacture of food and beverages and the agricultural sector were by far the largest contributors to the EU bioeconomy turnover. Food and beverage (and tobacco) accounted for 51% of the overall turnover, while agriculture accounted for 17%.

Figure 2.1- EU turnover of bioeconomy sectors in 2015 (million Euros)
Source: JRC data portal (https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html)



Between 2008 and 2015, the turnover of the EU bioeconomy (Figure 2.2) grew by approximately 169 billion Euros (an 8.1% increase). In absolute terms, the growth is mainly driven by the development of bioeconomy in the manufacture of food, beverages and tobacco products (+114 billion), and to a lesser extent by the development of bioeconomy in agriculture (+23 billion) and in the production of biochemicals, biopharmaceuticals, bioplastics and biorubber (+21 billion). In relative terms, the most impressive growth has been recorded by generation of biobased electricity (+115.6% from 2008 to 2015), forestry (+29.5%) and fishing and aquaculture (+18.3%).

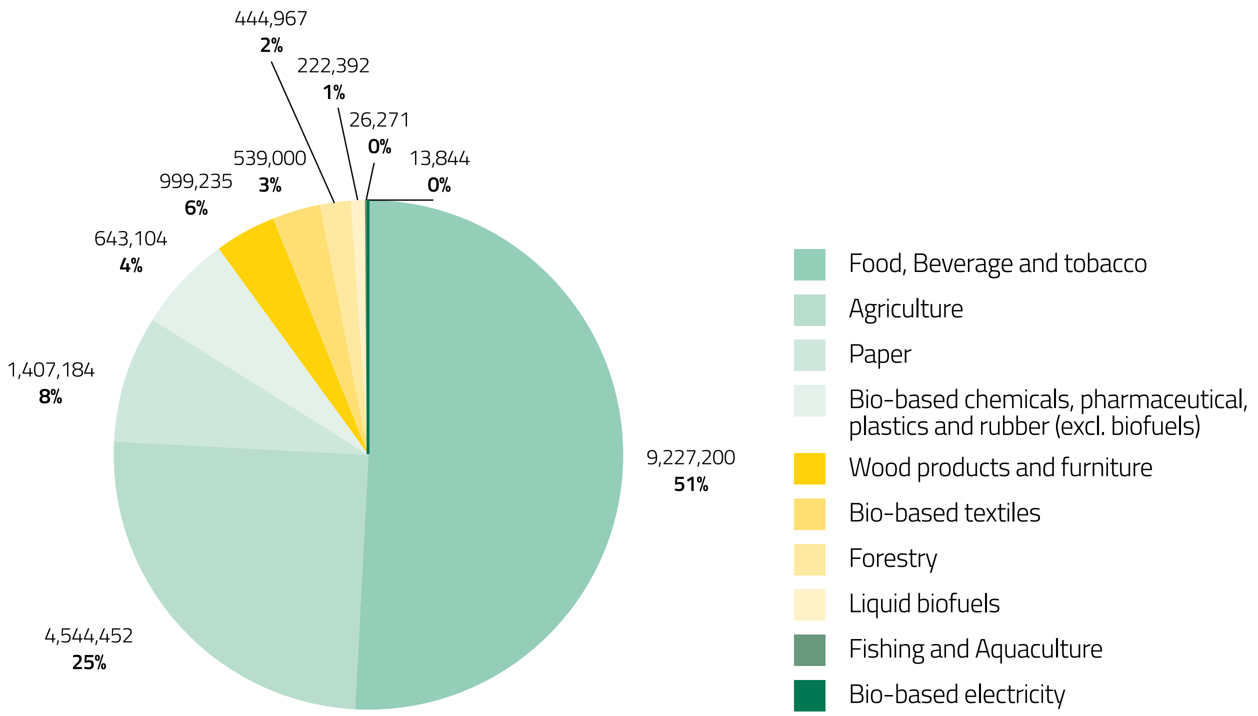
Figure 2.2 - Turnover growth by sector between 2008 and 2015 in EU28
Source: JRC data portal (https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html)



2.1.2 EMPLOYMENT

According to the European Commission (JRC data portal), bioeconomy in the EU28 employed around 18 million workers in 2015. In terms of number of employees, the key sectors are agriculture and the manufacture of food, beverages and tobacco. Nevertheless, it should be noted that the contribution of the primary sector to the bioeconomy is significantly lower in terms of turnover than in terms of the number of persons employed. Agriculture accounts for 51% of total employment in the EU bioeconomy (9.2 million workers); manufacture of food, beverage and tobacco accounts for 25% (4.5 million workers). Figure 2.3 illustrates the employment in each bioeconomy sector in the EU in 2015.

Figure 2.3- EU employment of bioeconomy sectors in 2015
Source: JRC data portal (https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html)



The number of workers in the EU bioeconomy decreased by 12% from 2008 to 2015 (i.e. by approximately 2.5 million units). According to JRC "*this declining trend is mainly driven by the ongoing restructuration of the European agricultural sector, still the main employment sector of the bioeconomy*"[15]. Employment in agriculture experienced a reduction of 1.5 million units (-14.4%). The manufacture of food, beverage and tobacco also saw a reduction of its workforce of 189,000 units, which however amounts to a -4% reduction only in relative terms.

Estimates and projections from authoritative sources suggest that **bioeconomy as a whole has a remarkable potential in terms of prospective employment creation**. According to industry estimates cited in the European Commission *Bioeconomy Action Plan 2018*[16], the EU bioeconomy can create up to one million new green jobs by 2030, in particular in rural and coastal areas. A study focusing on the development of bioeconomy in Denmark[17] comes to a similar conclusion: most of the new jobs are likely to be concentrated in rural areas. The results of a study cited by the United States Department of Energy[18] provide comparable estimates for the United States (1.1 million new jobs), and suggest that production of traditional and advanced biofuels, generation of bioenergy (heat and

[15] JRC (2017), *Bioeconomy report 2016*, Publications Office of the European Union.
[16] European Commission (2018), *Bioeconomy: the European way to use our natural resources – Action plan 2018*, Directorate-General for Research and Innovation - Unit F – Bioeconomy
[17] Copenhagen Economics (2015), *Geographical employment potentials from bioeconomy*, study prepared for the United Federation of Danish Workers.
[18] Rogers J. N., Stokes B., Dunn J., Cai H., Wu M., Haq Z. and Baumes H. (2017), "An Assessment of the Potential Products and Economic and Environmental Impacts Resulting from a Billion Ton Bioeconomy", *Biofuels, Bioproducts, and Biorefining*, 11, No. 1 (2017), pp. 110–128.

electricity) and manufacturing of advanced bioproducts are likely to account for most of the future employment creation potential. Finally, the results of another recent simulation study[19] suggest that a substantial share of the new jobs created by the development of bioeconomy in the EU will be in supporting services (transportation, storage, contract machinery services, production of equipment and inputs, etc.).

The historical and prospective trends in the development of the bioeconomy illustrated above suggest that **the importance of the contribution of agriculture and of the food industry to total employment in the bioeconomy may decrease in the future, even though this general trend may be offset, at least in part, by increases in employment in the forestry and "blue bioeconomy"**. It is likely that **most of the growth in employment will take place in non-food sectors** (including liquid biofuels and bioenergy), as well as in support services (logistics, equipment and input production, etc.).

This implies that **trade unions representing agriculture and food industry workers** should **pay attention to the development of biobased value chains in non-food industries**, should not overlook the **expansion of support services**, and should **enhance their cooperation with the relevant trade unions**. The issue is investigated in more detail at § 3 and 4; recommendations aimed at addressing the issue are provided at § 6.

2.2 EU policy framework

The most significant milestone in the evolution of EU policy framework for the bioeconomy is the **Bioeconomy Strategy**, elaborated in 2012.

The EU strategy puts the bioeconomy in a broader context: bioeconomy is described as an opportunity to address several challenges, such as food security, natural resource scarcity, fossil resource dependence and climate change, with emphasis on the sustainable use of natural resources, competitiveness, socioeconomic and environmental issues[20]. Launched and adopted on February 13, 2012, in the framework of the "Innovation Union" and "Resource-efficient Europe" 9 flagship initiatives of the EU 2020 strategy, the **Strategy and Action Plan "Innovating for Sustainable Growth: A Bioeconomy for Europe"** is structured around three pillars: 1) investments in research, innovation and skills; 2) reinforced policy interaction and stakeholder engagement; 3) enhancement of market set and competitiveness. The strategy aims at paving the way "to a more innovative, resource efficient and competitive society that reconciles food security with the sustainable use of renewable resources for industrial purposes".

The strategy proposes a comprehensive approach to address five societal challenges through the introduction of bioeconomy: 1) ensuring food security; 2) managing natural resources sustainably; 3) reducing dependence on non-renewable resources; 4) mitigating and adapting to climate change; 5) creating jobs and maintaining EU competitiveness.

The strategy was updated in 2018. The updated strategy aims at accelerating the deployment of a sustainable European bioeconomy, in order to maximise its contribution towards the 2030 Agenda and its Sustainable Development Goals (SDGs), as well as the Paris Agreement on climate change. The updated strategy includes an action plan with 14 measures, which are focused on three priorities:

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

[19] Fuentes-Saguar P.D., Mainar-Causapé A.J., Ferrari E. (2017), "The Role of Bioeconomy Sectors and Natural Resources in EU Economies: A Social Accounting Matrix-Based Analysis Approach", *Sustainability*, 9, 2383, MDPI, Basel, Switzerland.
[20] Scarlat, N., Dallemand, J. F., Monforti-Ferrario, F., & Nita, V. (2015), "The role of biomass and bioenergy in a future bioeconomy: Policies and facts", *Environmental Development*, 15, 3-34.

2. Deploy local bioeconomies rapidly across the whole of Europe.
3. Understand the ecological boundaries of the bioeconomy.

Following the publication of the 2012 strategy, many important activities have been developed in the bioeconomy field at EU level, including:

- The European Commission and the private sector joined their forces to set up a long-term public-private partnership for fostering the development of bioeconomy across the EU. In 2014, the **Bio-based Industries Joint Undertaking** (BBI JU) was established through a Public Private Partnership between the EU and the Bio-based Industries Consortium. The BBI JU operates under Horizon 2020; it aims at enhancing the collaboration among all levels of the biobased value chains by implementing the Strategic Innovation and Research Agenda (SIRA), a programme of research and innovation activities in Europe that will assess the availability of renewable biological resources and the development of new bio-refining technologies to sustainably transform these resources into biobased products, materials and fuels.

- A **European Stakeholders Bioeconomy Panel** has been set up to support interaction, synergies and coherence between different policy areas, and to provide a discussion platform and a framework to support the implementation of EU bioeconomy strategy. The Panel has 29 members, carefully selected after an open call for applications. They represent different groups of stakeholders: business operators, trade unions (including EFFAT), policymakers and public administrations, scientists and researchers and civil society organisations.

- The **Knowledge Centre for Bioeconomy** was launched by the European Commission to support national policymakers and stakeholders with science-based evidence in this field. The Knowledge Centre is being developed by the Joint Research Centre in cooperation with the Directorate-General for Research and Innovation.

2.2.1 KEY SECTORAL BIOECONOMY STRATEGIES AT EU LEVEL

The 2012 bioeconomy strategy officially introduced the bioeconomy concept in the EU policy. However, **bioeconomy encompasses several sectors and is a cross-sectoral concept**. In this light, several sectoral policies introduced before and after the development of the 2012 strategy contributed to shape the EU policy framework which is relevant for the bioeconomy.

It should be noted that while no specific EU bioeconomy legislation exists, **sectoral legislation can have a strong impact in the field of bioeconomy**[21] .

Table 2.1 in the next pages summarises the key EU sectoral policies and legislation relevant for the bioeconomy.

[21] Except where otherwise noted, this section is based on information contained on the website of the Knowledge Centre for Bioeconomy of the European Commission: https://ec.europa.eu/knowledge4policy/bioeconomy/topic/policy_en

Table 2.1- Key EU sectoral policies and legislation
Sources: European Commission's Knowledge Centre for Bioeconomy (https://biobs.jrc.ec.europa.eu); JRC (2017), Bioeconomy report 2016; Scarlat, N., Dallemand, J. F., Monforti-Ferrario, F., & Nita, V. (2015), "The role of biomass and bioenergy in a future bioeconomy: Policies and facts", Environmental Development, 15, 3-34.

Sectors	Related policies and legislation
Agriculture	The Common Agricultural Policy (CAP) is among the oldest EU policies. The current CAP applies for the programming period 2014-2020. The CAP includes several measures linked with environment conservation and bioeconomy, including: • Linking direct payments (a form of support to farmers' income) to compliance with a number of environmental standards and good practices. • Market measures to stabilise biomass prices. • Funding agri-environmental measures and measures aimed at addressing climate change through the European Agricultural Fund for Rural Development (EAFRD).
Forestry	In the absence of a common forestry policy, the EU forest strategy (Commission communication "A new EU forest strategy: for forests and the forest-based sector") provides a policy framework for the forest sector and includes among its priority areas the goal of "fostering the competitiveness and sustainability of the forest-based industries, bio-energy and the wider green economy".
Fisheries, aquaculture and algae	The Common Fisheries Policy (CFP), first introduced in the 1970s, is a set of rules for managing EU fishing fleets and for conserving fish stocks. The new CFP applies for the programming period 2014-2020. The measures contained in the CFP have, among others, an important impact on the availability and prices of fish as a feedstock for the bioeconomy.
Circular economy and waste	Waste is a further source of biomass with increasing importance. Waste from the agricultural, forestry and fishery sectors, but also from other sources such as households or manufacturing, is increasingly used as feedstock in biobased processes. Bioeconomy promotes the use of waste in existing value chains as well as the creation of innovative value chains using organic waste. The EU approved several legal acts regulating waste management. In addition, the overall approach of the Commission is to move towards the new circular economy approach, aimed at maintaining the value of products and materials for as long as possible whilst minimising resource use and generation of waste. The "circular economy package" was adopted in 2015: it includes an action plan for the circular economy and a revised legislative proposal on waste.

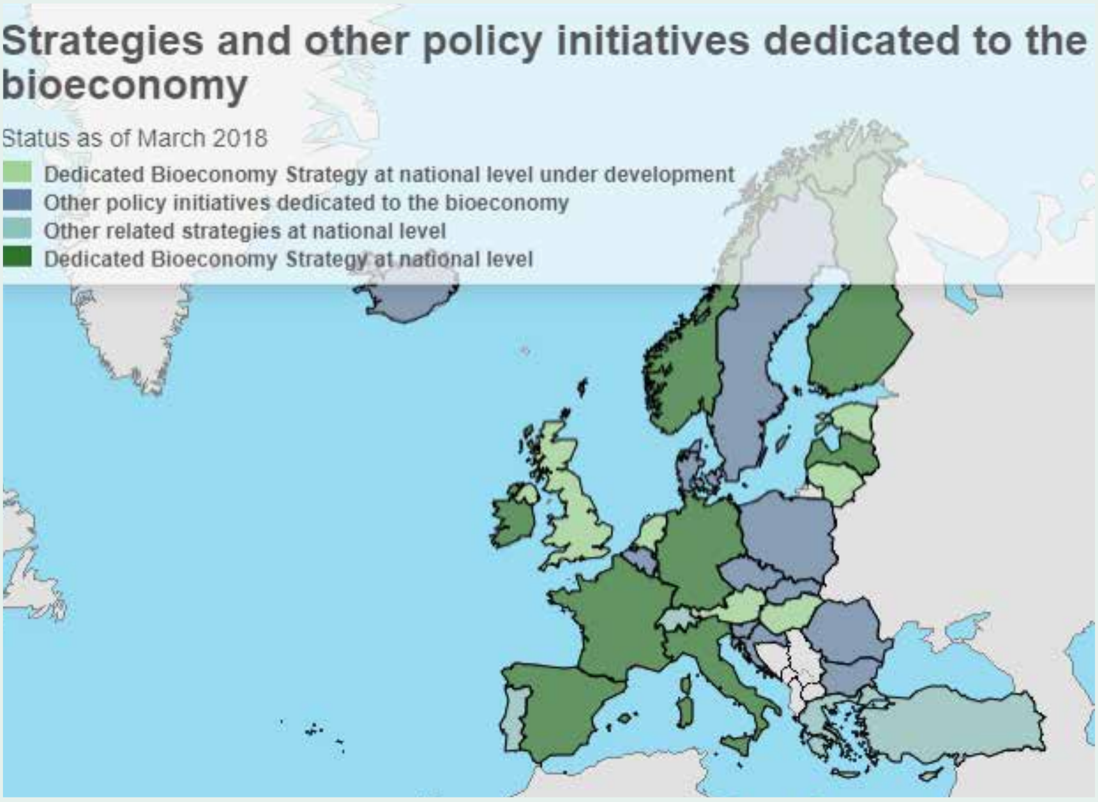
[22] Europe 2020 strategy aims at achieving the following priority themes: a smart growth (based on innovation and knowledge); a sustainable growth (resource efficient and low-carbon economy) and an inclusive growth (promoting social and territorial cohesion and improving the labour market). The five headline targets set for the EU 2020 strategy are: employment (employment rate of the population aged 20-64 should increase to 75%); research and development (3% of EU GDP in R&D); climate and energy (reducing greenhouse gas emissions by 20%, increasing the share of renewables energy to 20%, and increasing energy production by 20%); education; social inclusion and poverty reduction. In order to achieve such goals, seven flagship initiatives have been developed, aimed at addressing Europe 2020 priority themes:
- Smart growth => a digital agenda for Europe; Innovation Union; youth on the move.
- Sustainable growth=> Resource Efficient Europe; an industrial policy for the globalisation era.
- Inclusive growth=> an agenda for new skills and jobs; European platform against poverty.

Sectors	Related policies and legislation
Biobased industries	• There is no EU policy strategy or legislation specifically dedicated to biobased industries. Nevertheless, a number of initiatives targeting biobased products and industrial biotechnology have been identified, including: • Commission communication "A lead market initiative for Europe". • Commission communication "Preparing for our future: developing a common strategy for key enabling technologies in the EU". • Commission communication: "A stronger European industry for growth and economic recovery". • Commission communication "For a European industrial renaissance".
Climate change and energy	Since 2007, a number of strategic policy documents were issued to promote the use of renewable energy (which includes bioenergy) and combat climate change. The policy framework for climate and energy for the period from 2020 to 2030 identifies a number of targets for 2030: 40% reduction of greenhouse gases (GHG) emissions compared to 1990 levels; at least a 27% share of renewable energy; 27% improvement in energy efficiency. More in general, the EU has set a long-term goal of reducing GHG emissions by 80-95% by 2050 compared to 1990 levels.
Food	Food 2030 was launched after the 2015 Milan World Expo. It is a EU research and innovation policy response to the recent international policy developments including the Sustainable Development Goals and COP21 (Paris agreement on climate change) commitments. Food 2030 is based on the core idea that the transformation of the food system should make it more sustainable, resilient, responsible, diverse, competitive and inclusive. • Food 2030 is built on the following key Food and Nutrition Security priorities: • Nutrition for sustainable and healthy diets. • Climate smart and environmentally sustainable food systems. • Circularity and resource efficiency of food systems. • Innovation and empowerment of communities.
Research and innovation	Research and Development (R&D) is one of the European Union's priorities and a core part of the Lisbon strategy to boost employment and growth. Innovation Union is a key element for meeting the target of a smart growth addressing the challenges of climate change, energy and resource efficiency, health and demographic change. Innovation Union is one of the seven flagship initiatives developed in the framework of Europe 2020[22] the 10-year strategy set after the Lisbon strategy. Funding for research is provided at EU, national and regional levels. Financial instruments for the implementation of Europe 2020 strategy and of the Juncker presidency's priorities are Horizon 2020 and the European Fund for Strategic Investment (EFSI).

2.2.2 NATIONAL POLICIES AND STRATEGIES

Bioeconomy (or bioeconomy-related) strategies or policies also exist or are being developed in **many of the EU Member States,** as well as in other countries, and in some of their regions. Figure 2.4 below shows the diffusion of bioeconomy-related strategies and other political initiatives in most of the European countries.

Figure 2.4 - Strategies and policies on bioeconomy in Europe
Source: European Commission's Knowledge Centre for Bioeconomy; https://biobs.jrc.ec.europa.eu



In 2017, the Joint Research Centre (JRC) - as coordinator of the European Commission's Knowledge Centre for Bioeconomy (BKC) - undertook a survey research in order to collect information on bioeconomy strategies or policies in the EU Member States and in other countries. Survey results showed that[23]:

- Most of the surveyed countries reported the existence of networks, platforms, associations and clusters supporting the biobased industrial sector.
- Most of the surveyed countries reported about funding programmes available at national level.
- About half of the surveyed countries stressed the opportunities offered by mechanisms aimed at boosting the economic growth of regions (e.g. European Structural and Investment Funds - ESIFs - and other instruments). These mechanisms, based on the use of local biomass and the involvement of local actors across the biobased value chains, have the potential to support the deployment of biobased industries on the territory.

[23] This section is based on information available in the website of the BKC (https://biobs.jrc.ec.europa.eu) and in the BBI JU report on the outcomes of the survey: BBI JU (2018), *Example of good practices reported by the BBI JU States representatives group. Outcomes of the JRC – BBI JU – IEA survey on strategies and policies for the EU bioeconomy in 2017.*

- Mechanisms for enabling feasible synergies and combination of different sources of funding (e.g. funding programmes established by different EU Policies such as CAP, Cohesion Funds, Research and Innovation Frame Work Programmes) are relevant for supporting the growth of the biobased industrial sector and the deployment of the related technology sectors at national and regional level.

An interesting initiative putting together a number of EU Member States[24] is the **Central-Eastern European Initiative for Knowledge-based Agriculture, Aquaculture and Forestry in the Bioeconomy – BIOEAST**. Among the aims of BIOEAST there is also the creation of "a cross-sectorial approach for the development of a national circular and bioeconomy strategy". The BIOEAST initiative assists the involved Member States in:

- operationalising their bioeconomy visions for 2030 by drawing on their biomass potential to develop a sustainable increase in biomass production and circular processing of the available biomass in viable rural areas;
- developing an innovative, climate-ready and inclusive model of growth.

[24] Czechia, Hungary, Poland, Slovakia, Bulgaria, Croatia, Estonia, Latvia, Lithuania, Romania, and Slovenia.

3 National focuses

The selection of case studies analysed in the following sections covers a **wide range of food and non-food biobased value chains**.

The selection is **representative of the diversity of the bioeconomy** in terms of: types of biomass which can be exploited; approaches, organisational solutions and technologies for implementing biobased value chains, including the "cascading approach" explained at § 1.6; external factors which have an influence on the development of biobased value chains.

The variety of situations investigated in the case studies allows a **comprehensive analysis** of the **challenges and opportunities of the bioeconomy** in the EU agribusiness system, on the **application of skills for working in the bioeconomy** and on **how those skills can be obtained**, and on **future prospects of working in the bioeconomy**.

3.1 Belgium

3.1.1 NATIONAL STRATEGIES ON BIOECONOMY

The case study focuses on **Flanders**, the region in Belgium with the strongest and most dedicated approach to bioeconomy. The case study explains the role of Ghent Biobased cluster in the development of biobased value chains and in employment creation.

Flanders has opted to develop a sustainable bioeconomy as a transition strategy to respond to the threats presented by the use of fossil raw materials, whose sources face the risk of exhaustion. In addition, Flanders wants to be ready to cope with major societal challenges such as population growth, climate change, the increasing scarcity of other raw materials, pressure on ecosystems and economic development. In 2012 the Interdepartmental Working Group for Bioeconomy (IWG BE) was set up, and its first result was "**The Flemish vision and strategy for a Flemish bioeconomy"**, which was approved by the Government of Flanders in 2013[25].

This strategy is currently under revision in order to link it to the strategy for a transition to a circular economy as defined in "Circular Flanders", which was approved by the Ministers of Environment and of Employment, Economy, Innovation and Sports in 2017[26]. Its overall goal is the development of a competitive bioeconomy to produce biomass in a sustainable way and to (re)use side and end streams for producing food and feed, materials, and other biobased products; the generation of bioenergy is also explicitly included.

5 strategic goals for bioeconomy have been defined:

- Policy coherence.
- Strength in research, innovation and education.
- Sustainable production and use of biomass.
- Competitive bio-economy sectors and markets.
- European and international cooperation.

3.1.2 CASE(S) UNDER STUDY

There are two strategic sectors for the biobased industries in the Flanders region: i) chemistry, plastics and life sciences and ii) agro-food industry. The chemistry, plastics and life sciences sector directly accounted for 59,500 jobs (plus 100,000 indirect jobs) in 2015, whereas the agro-food industry accounted for 145,500 jobs in 2014. Others sectors include pharma, energy, harbours (Antwerp petro-chemical cluster) and Ghent Biobased cluster, which is the focus of the present case study[27].

In general, the impact of the Flemish biobased economy is significant. While the Flemish biobased economy is growing, the importance of the general manufacturing industry in the Flemish economy as a whole is losing ground. Biobased products (e.g. paper, wood, bioplastics and biochemicals) already create five times as much added value and ten times more employment than bioenergy. Almost half of the total gross margin from the Flemish biobased economy is generated by fine chemicals, biopolymers and bioplastics[28].

[25] Departement Omgeving (2014), *Bioeconomy in Flanders*, https://www.vlaanderen.be/en/publications/detail/bioeconomy-in-flanders
[26] ERRIN Bioeconomy WG (2017), *Bioeconomy in Flanders - Policy aspects*, https://errin.eu/sites/default/files/05.19_ERRIN%20BioWG_BioEconomy%20in%20Flanders.pdf
[27] ERRIN Bioeconomy WG (2017), cited.
[28] Departement Omgeving (2014), cited.

3.1.2.1 Description of the companies/industrial plants/chains under study

Flanders Bio-based Valley was founded upon initiative of professor Wim Soetaert in July 2005 as a Public Private Partnership among Ghent University, the City of Ghent, the Port of Ghent, and the Development Agency East-Flanders. A number of industrial companies related to the Ghent region, active in the fields of generation, distribution, storage and use of bioenergy (then known as Ghent Bio-Energy Valley) also joined the partnership.

Professor Wim Soetaert promoted the initiative because he saw a need for a networking organisation that would bring people together and promote cooperation. In 2005, most of the research and development (R&D) in bioenergy and bioproducts development was taking place in isolation, without cooperation and knowledge sharing. Substantial activity was happening, but companies and researchers were not exchanging knowledge: this led to this initiative aimed at identifying common interests, at improving cooperation, and at knowledge sharing.

An opportunity arose since the European Union was committed to reducing EU greenhouse gas emissions. The EU therefore issued a renewable energy directive that set a binding target for its member countries to get 20% of their final energy consumption from renewable sources by 2020. In response, Belgium established a national quota system and set up a competitive bidding system to allocate government biofuel investment. To obtain and take advantage of a substantial portion of the quota, Professor Soetaert persuaded Ghent University, the City of Ghent, the Port of Ghent, the Development Agency East-Flanders and a number of industrial companies active in bioenergy to form Ghent Bio-Energy Valley. On aggregate, the parties from Ghent got 80% of the Belgian national quota. Formally, Ghent Bio-Energy Valley became a non-profit organization in 2008 and later changed its name to Flanders Bio-based Valley (FBBV).

Today, Ghent produces up to 90% of all Flemish biofuels. Government regulations mandate the blending of biofuels with conventional fuels in specific proportions to qualify for lower taxes: these policies have promoted increased demand for biofuels.

While the partners and members of FBBV initially cooperated to achieve specific goals, the cluster also has an overall vision, which is to **promote the development of the biobased economy of the future**. This goal is pursued by FBBV in four ways:

1. Supporting technological innovation through joint research programmes, thus building research and development expertise in the field of biobased products and bioenergy.

2. Fostering clusters and integration by assisting its industrial partners in finding synergies, new ways of cooperating with each other or building a new cluster, all leading towards industrial integration.

3. Setting up various types of communication activities and participating in others in order to inform the public on bioenergy and the new biobased products.

4. Providing technological assistance concerning all aspects of the biobased economy, ranging from feedstocks to products and from technology to partner companies.

Today, the cluster (Figure 3.1) counts 16 members (companies) in addition to four partners (Ghent University, the City of Ghent, the Port of Ghent, and the Development Agency East-Flanders).

*Figure 3.1 – Aerial view of the Port of Ghent and of the Syngas Biorefinery Cluster**
Photo from Huffington Post, retrieved from https://www.sustaineurope.com/growing-the-bioeconomy-in-flanders--12042017.htm

** the view shows the fermentation plants where the gas is made and then transferred by pipelines from storage facilities to distribution centres and to power plants, where it is burned to generate electricity*

So far, FBBV has attracted over 420 million Euros in investments and created more than 500 jobs. Rodenhuizedok biorefinery cluster in Ghent Port is an example of industry partnership supported by FBBV. It is the largest integrated production site for bioenergy in Europe[29] At Rodenhuizedok, Bioro produces 350,000 tonnes of biodiesel and Alco Biofuel produces 170,000 tonnes of bioethanol from wheat, maize, and barley. That makes Bioro and Alco Biofuel the two most important biofuel producers in the port.

Another tangible outcome from this cooperation is the independent **Bio Base Europe Pilot Plant**. This pilot plant is a joint project between FBBV and its sister organisation, BioPark Terneuzen. Their collaboration led to funding for the plant and the creation of Bio Base Europe, an international organisation. The Bio Base Europe Pilot Plant is a service facility designed to speed up the innovation and commercialisation of biobased products. It provides flexible equipment and infrastructure that can be used by for-profit companies for process development, custom manufacturing, or industrial scale-up. For instance, the plant can take a customer's biobased laboratory protocol and bring it to industrial scale. So far, the Bio Base Europe Pilot Plant has successfully carried out 225 projects for more than 120 companies[30] .

Currently, FBBV is working closely together with the Port of Ghent to find interested companies willing to be located in a new biobased cluster: an 80 hectare area has been set aside by the port exclusively for biobased companies.

If FBBV's longer-term vision is fulfilled, the Ghent Canal Zone would become a sort of "European Silicon Valley" for companies pioneering the development and commercialisation of second- and third-generation biobased products. Whereas first-generation biobased products are produced directly from plant sugars and starches, second-generation bioproducts are made from cellulosic biomass and other materials. Third-generation bioproducts are obtained from algae.

[29] Berger, John J. (2017), "Growing A Bioeconomy — Flanders To Produce Fossil-Free Fuels, Chemicals, And Products", *Huffington Post*
[30] Bio Base Europe Pilot Plant (2019), http://www.bbeu.org/pilotplant/wp-content/uploads/2019/03/Algemene-folder_voor-web_LR.pdf

3.1.2.2 Challenges and opportunities of bioeconomy for the chains

The main **challenges** for the development of Ghent Biobased Valley were (and still are) related to:

- Promoting cooperation and knowledge sharing among the involved partners: cooperation and knowledge sharing are the cornerstones for developing new biobased value chains.

- Providing targeted education, in order to motivate young generations to take interest in the bioeconomy for a future career.

The most significant **opportunities** offered by the development of Ghent Biobased Valley can be identified in:

- Improvement of biomass exploitation and development of new biobased value chains and products through the establishment of systems for coordinating availability of biomass.

- Improvement in the skills of prospective employees in the cluster through cooperation between educational facilities and processing plants. Such initiatives also function as cantilevers for upskilling the existing workforce.

3.1.3 CHANGES IN THE PRODUCTION PROCESS STEMMING FROM THE BIOECONOMY

The development of Ghent Biobased Valley has had relatively **limited impacts in terms of changes in existing production processes**. The **new biobased processes are actually carried out in dedicated plants**. These plants use the existing logistical infrastructure (Port of Ghent and the related transportation hubs) and/or dedicated infrastructure (e.g. pipelines for gaseous biofuels) for the distribution of biobased products to final customers.

The **involvement of several diverse stakeholders** (companies, Ghent University, the City of Ghent, the Port of Ghent, and the Development Agency East-Flanders) has been of paramount importance for the development of Ghent Biobased Valley.

3.1.4 EFFECT ON THE USE OF LABOUR AND NEW REQUIRED SKILLS

A central entity in the Ghent Biobased Valley is the Biobase Europe Pilot Plant (Figure 3.2). This entity serves more purposes:

- Pilot plant for development of new technologies and products.
- Demonstration plant with options for contract production.
- Training of workers.
- Internships for students

Figure 3.2 - Arial view of the Bio Base Europe Plant
Source: http://www.bbeu.org/

In total, the Biobase Europe Pilot Plant employs 75 persons: of these, 60 persons work in production and process optimisation. As of May 2019, the plant had vacant positions as listed below[31]:

- Process Technician.
- Process Operator.
- Pilot plant Operator.
- (Bio) process Technician.
- Bioprocess Engineer.
- Worker for logistics.
- Student assistant.

As indicated by the list, the **positions are quite similar to positions available in the food industry**, hence implying a **high degree of transferability of skills** between the two.

An emerging trend is young people working in the pilot plant for around 5 years, and then moving to other jobs. While working at the facility, employees learn about biobased production, diverse technologies and processes, and gain experience from working with different types of equipment. It emerged from interviews made for the case study that the facility is among the best places to learn about biobased manufacturing. To further stimulate learning, workers and students during their internships are enrolled in a rotation scheme. This system provides the opportunity for learning from work carried out in diverse departments of the facility, contributes to a more holistic understanding of biobased manufacturing, strengthens the employee's overview of a process and builds responsibility[32]. Figure 3.3 provides illustrations of the technologies and processing equipment in the Bio Base Europe Pilot Plant.

Ghent Technical College (HOGENT) offers a **bachelor level course to become Bioprocess Technician**. The course is especially designed for the needs of the biobased industries (Figure 3.4). It is claimed that an increasing number of young people are attending the course: this indicates a growing interest to work, and build a career rooted in, the bio-economy[33].

[31] Source: http://www.bbeu.org/
[32] Interview with BioBase Europe Pilot Plant (2019).
[33] Interview with BioBase Europe Pilot Plant (2019).

Figure 3.3 - Technologies and processing equipment at the Bio Base Europe Pilot plant
Source: http://www.bbeu.org/

The three-year course combines lectures with internships at the Biobase Europe Pilot plant; internships account for 6 months in total. When graduating from the bachelor course, students have obtained basic knowledge about how to work with fermentation processes, cascade processing, downstream processing, and circular systems. In addition, skills within LEAN manufacturing[34] and operation of processing equipment are also developed. The bachelor course can be followed by a one-year course at Master's level; also the Master course includes 3-4 months of internship at the Biobase Europe Pilot plant.

Figure 3.4 - Outline of course at HOGENT targeted at Bioprocess Technicians
Source: https://www.hogent.be/

BACHELOR
Bioprocess Technician

3 years education, Ghent Technical Collage

Chemistry Acting safely and sustainably ITC and sttistical methods	Research and communication skills Microbiology Project: Bio-organic search	Analysis techniques Quality management Communication
Biochemistry Chemistry Environmental techn.	Biochemistry Chemistry Environmental techn.	Workplacement and bachelor paper linked to main subject

[34] LEAN manufacturing is a methodology that focuses on minimising waste within manufacturing systems while simultaneously maximising productivity.

3.2 Croatia

3.2.1 NATIONAL STRATEGIES ON BIOECONOMY

The framework for the development of bioeconomy in Croatia is defined by three strategic documents: the Rural Development Programme 2014/2020; the National Forestry Policy and Strategy; the Smart Specialisation Strategy and the related Action Plan 2016/2020.

The **Rural Development Programme (RDP) of the Republic of Croatia** for the period 2014/2020 aims at facilitating the supply and use of renewable sources of energy, of by-products, waste, residues and other non-food raw materials for the purposes of the development of bioeconomy. The RDP focuses – among others – on: development and increased application of new technologies; increased cooperation between research, institutions and the private sector; improved management of forests; increased production and use of energy form renewable sources.

The **National Forestry Policy and Strategy** underlines that the Croatian forestry sector currently relies on traditional techniques and machinery. The Strategy aims at optimising forestry management through cooperation among stakeholders and a combination of strategic actions, including:

1. Implementation of ecological, ergonomic, economic and energy favourable technologies in forestry (the so called "4E technologies")..
   - Establishment of appropriate evaluation of the implementation of 4E technologies in forestry.
   - Support measures to provide the required training for the implementation of 4E technologies.
   - Development of financial incentives to support the implementation of environmentally friendly technologies (e.g. cable railways).
   - Development of work techniques and safety at work via capacity building, evaluation and verification of the initiatives taken.

2. Utilisation of biomass for energy production.
   - Undertaking an inventory of unused biomass as potential energy source.
   - Identification of unused land, selection of the most favourable species and identification of the most suitable technologies for the establishment of dedicated plantations.

3. Defining and providing incentives for biomass production based on the implementation of the Kyoto protocol, in cooperation with other sectors.

4. Utilisation of biomass as main energy source in forested areas.

On March 30, 2016, the Croatian Government adopted the **Smart Specialisation Strategy for Croatia 2016/2020** and the related **Action Plan for the Implementation of the Smart Specialisation Strategy 2016/2017**. The Strategy aims at guiding capacities in the knowledge and innovation fields towards the areas showing the highest potential, to promote the development and transformation of the Croatian economy. "Food and bioeconomy" is one of the five thematic priority areas of the Strategy: the area covers sustainable production and processing of food and wood. Development of smart skills is one the instruments for the implementation of the Strategy: the main driving force of the Smart Specialisation Strategy will be the skilled workforce and the ability to understand future needs in terms of skills, to timely translate them into relevant training programmes and to deliver training to relevant groups of the Croatian population.

3.2.2 CASE(S) UNDER STUDY

The case under study concerns an example of forest biomass value adding through heat and power cogeneration. In Croatia, forest biomass for bioenergy production comes from: primary forest production like round wood and harvest residues; secondary products like forest industry residues (pulp residues) and waste wood (sawdust, bark and chips); biomass from "trees outside forests" (road sides, trees in border zones surrounding agricultural land).

3.2.2.1 Description of the companies/industrial plants/chains under study

The company **Sherif Export-Import Ltd**. is a leading one in the Croatian wood industry. At the end of 2009, the company set up a subsidiary, **BE-TO Glina Ltd**., whose main goal was to build a biomass cogeneration power plant.

In 2017, the company built a **biomass cogeneration power plant** (see Figure 3.5) which uses both wood waste and wood chips as feedstock. The plant has a total installed power generation capacity of 5 MW and a thermal capacity of 12 MW. Thermal energy is used for the company's own purposes, as well as for heating a number of nearby buildings owned by public institutions (Glina penitentiary, primary and high schools, nursery school, Community Health Centre etc.).

The **main achievements of the Glina project** are sustainable heat and power generation at affordable prices, value adding to wood processing residues, collection of forest biomass in the framework of integrated forest management, new job opportunities (mainly in forest biomass preparation and transport), and application of innovative technologies.

Figure 3.5 – Aerial view of the Glina cogeneration plant
Source: adapted from http://sherif.hr/

3.2.2.2 Challenges and opportunities of bioeconomy for the chains

The context where the Croatian forestry sector is operating is becoming increasingly complex. There is **increased demand for wood feedstock**, as well as strong national priorities - such as **reducing greenhouse gas emissions and mitigation of the adverse effects of climate change** – which need to be met. Risk management, project management and environmental management techniques need to be adopted, and innovative technologies need to be implemented in order to meet sectoral challenges.

The most critical challenge for companies operating in the Croatian forestry sector is ensuring that their **workforce achieves an adequate balance between technical skills and ecological management skills.** The diversity of businesses in the Croatian forestry sector results in a number of specific challenges, in particular related to the future availability of skilled staff. Many businesses within the sector experience difficulties in recruiting young people, due to poor reputation and image of the sector, which is perceived as a low-wage one with poor working conditions and limited career opportunities. Operators need adequate supply of appropriately skilled and qualified workers at level of pre-tertiary education. Training of workers in the sector is often undertaken outside of formal national qualification frameworks (e.g. thanks to projects financed by the European Union); the Croatian Strategy of Education, Science and Technology – New Colors of Knowledge (2014), covering pre-tertiary education and promoting the enhancement of educational institutions and the implementation of a comprehensive curricular reform, should also play a role in that respect.

The forestry sector in Croatia is also challenged by **migrations from rural to urban areas**, and **ageing of its workforce**. This highlights the importance of succession planning (see § 3.2.4). Furthermore, senior skilled workers need to be able to transfer their skills to the younger workers.

3.2.3 CHANGES IN THE PRODUCTION PROCESS STEMMING FROM THE BIOECONOMY

The main changes in the production process stemming from the development of bioeconomy in the forestry sector concern the production of wood feedstock, its transportation and its processing into bioenergy.

The main **sources for wood biomass** in Croatia have traditionally been wood cutting residues, sawmill residues, small diameter trees, as well as trees damaged by or at risk of wildfire, insects and disease. In the last few years, however, increased demand for wood biomass – mainly fuelled by the development of bioenergy production – has resulted in **expanded cultivation of fast growing, short rotation forestry**. Poplars, willows and other species are specifically grown to provide feedstock for heat and power generation. These species often grow from a cut stump; if properly managed, they can grow rapidly and be ready for harvest in four to eight years. After harvest, the site can be replanted, or the stumps can be left to regrow, in order to re-start the production cycle. Growing short rotation wood crops can also be combined with wastewater disposal, as sewage and wastewater from food processing factories and farms can contain nutrients capable of accelerating tree growth. Short rotation wood crops have proved to be an economically viable strategy for ensuring environmentally sustainable supply of wood biomass. Fast growing species can be planted at relatively low costs and harvested in less time than traditional species, and improvement in their yields are expected in the near future.

Forest cutting residues used as feedstock source may be **transported** as unconsolidated material and comminuted material. **Unconsolidated material** is what remains after the trees have been cut: it includes stumps, bark, leaves, needles, branches, and even trunks. Such material was traditionally considered unsellable, and was usually left on the logging site. Recent progress in wood biomass utilisation as feedstock for bioenergy generation provides new opportunities for adding value to unconsolidated wood material, which is increasingly used as fuel at wood processing facilities. **Comminution** makes woody material smaller, and is often performed at logging sites. Chipping (more than grinding and shredding) is the most common type of comminution: chippers are well integrated into conventional wood harvesting systems. Equipped with high-speed cutting knives, chippers are high output machinery, and in most cases are equipped to throw chipped material into trucks for transportation.

Wood biomass can be **converted into bioenergy and bioproducts** through three main types of processes: biochemical, chemical and thermochemical. In Croatia, heat and power are generated from wood biomass through thermochemical conversion: combustion is used in most plants. Wood is burned to generate steam in a boiler; steam activates turbines, which generate electricity. In industrial sawmills, steam can be used in wood processing and/or to generate electricity. When electricity and heat are produced and used simultaneously, the process is referred to as **cogeneration or combined heat and power (CHP)**. Cogeneration accounts for the largest share of bioenergy generated from forest biomass in wood processing plants in Croatia. Sawmills use their waste wood or by-products in cogeneration systems to substitute fossil fuels such as natural gas.

3.2.4 EFFECT ON THE USE OF LABOUR AND NEW REQUIRED SKILLS

Increased attention for environmental sustainability in forestry, as well as technological innovation, have had the most **implications on traditional jobs** in the sector in Croatia, and are defining the needs in terms of **new required skills from workers** in the sector.

Professionalization in the sector is important to attract new workers with better skills.

Succession planning skills are needed to address the issues of migrations from rural to urban areas and ageing workforce.

Increased use of **advanced machinery in forestry** in Croatia has resulted in increased specialization among workers: operators are moving away from old techniques, manual labour and basic machinery maintenance. Advanced machinery is gradually substituting manual work in a number of operations in the forestry sector. While the use of advanced machinery in the forestry sector offers great opportunities for boosting resource efficiency, workers in the sector increasingly need to **update their operations and maintenance skills**, in order to use such advanced machinery effectively, and to maximise its productivity and future lifespan.

Climate change and environmental degradation increase forestry workers' responsibilities in environment conservation and management. Forestry workers must safeguard ecological sustainability also against extreme weather events, potential water shortages, etc. As forestry practices play a critical role in promoting environmental sustainability, there is a growing need for skilled forestry workers to understand how environmental sustainability (reducing carbon dioxide emissions, using renewable energy, etc.) is integral and applicable to their everyday practice. Planning skills are also required to account for likely climate changes, alongside knowledge of new species, as well as pest and disease identification. Increased demand for wood feedstock has resulted in increased needs for knowledge in coppicing and other sustainable forestry management practices.

Negotiation and influencing skills will become more and more important for operators. The increasing use of contractors in the forestry sector implies the need to develop stronger negotiation skills to ensure securing of contracts.

Finally, **scientific knowledge and technology transfer** are increasingly needed to support the application of innovative technology in the Croatian forestry sector. Improved linkages between research centres and operators in the sector would facilitate knowledge and technology transfer and would ensure the availability of professional development programmes. The Croatian forestry sector will likely need to operate and implement production technology within the context of increasing use of Information and Communication Technology (ICT). Higher level **ICT skills** - including the use of smartphones and handheld devices, GIS/GPS applications, and internet - will increasingly be required in the sector. An issue for the Croatian forestry sector is the availability and speed of broadband services in rural areas, which are a critical aspect for the delivery of better ICT skills.

3.3 Denmark

3.3.1 NATIONAL STRATEGIES ON BIOECONOMY

At present, Denmark is among the few EU Member States without a national strategy for bioeconomy. For Denmark to keep its frontrunner position in biobased economy, professionals and researchers are advocating that the Danish government adopts a national strategy on bioeconomy. In order to meet this demand, the Danish government has set up the **National Bioeconomy Panel**[35] as a first step. The Panel is composed of leading firms and researchers, as well as NGOs, key organisations and authorities; its first meeting was held in December 2013. The Panel's central task is to draw attention to opportunities for specific measures aimed at promoting the development of the bioeconomy in Denmark. Those measures – targeting a wide range of sectors, from agriculture and fisheries to processing and distribution – should foster a sustainable bioeconomy in which resources and products are, to a much greater extent than today, used for the benefit of the environment, climate, growth and employment.

One of the issues addressed by the Panel is how Denmark can obtain more economical and sustainable biomass, since this is perceived as all-important for advancing the bio economy. The National Bioeconomy Panel published a number of **recommendations to the Danish government** in 2018[36]. The recommendations rely on three cornerstones: partnerships with the participation of all relevant players throughout the bioeconomy value chain; access to financing; good coordination of research and development activities.

According to the Panel, one of the fields in which Denmark has the opportunity to create a competitive lead within bioeconomy is the development of new protein value chains, established from processing new types of protein-rich biomasses. In Denmark, annual imports of feed protein amount to around 1 million tonnes; soy protein accounts for a 64% share of total protein imports, while extracted sunflower seeds/cakes, extracted rape seeds/cakes, and fish meal account for most of the remaining portion. Total use of protein for feed production in Denmark amounted to around 3 million tonnes of protein-rich products. The above figures illustrate the potential for developing new protein value chains that can substitute a large share of imported soy protein. In order to exploit that potential, a search for new

[35] Danish Ministry of Food, Agriculture and Fisheries (2013), *Fact sheet Bioeconomy* (http://naturerhverv.dk/fileadmin/user_upload/NaturErhverv/Filer/Indsatsomraader/Biooekonomi/Fact_sheet_the_National_Bioeconomy_Panel.pdf)
[36] Danish Ministry of Food and Environment (2018), *Proteins for the future, Recommendations from the National Bioeconomy Panel* (https://mfvm.dk/fileadmin/user_upload/MFVM/Miljoe/Biooekonomi/Recommendations_from_the_National_Bioeconomy_Panel_Proteins_for_the_future__PDF_.pdf)

types of protein-rich biomass suitable for industrial-scale processing was started.

A specific target recommended by the Panel is that within five years from 2018 a commercial production of sustainable protein-rich raw materials from land-based production, aquatic sources, and from industrial residual and secondary flows has been established for both feed and food purposes, also characterised by a better environmental and climate footprint than existing products.

3.3.2 CASE(S) UNDER STUDY

The cases under study for Denmark focus on two examples of biobased value chains, based on:

- value adding to organic clover grass;
- value adding to starfish.

3.3.2.1 Description of the companies/industrial plants/chains under study

Value adding to organic clover grass

Green leaves can be processed into a variety of products, spanning from biogas to high-value compounds. "Green leaves as biomass" in principle include all kinds of green leaves that can be processed, such as sugar beet tops, lettuce, green parts of crops and grass, just to mention some examples. Grass is a crop that grows well in Northern European countries (Figure 3.6) and farmers are used to produce and manage this crop. This implies that farmers have the skills and farm machinery needed to produce, harvest and store grass in different formats such as hay or silage.

Figure 3.6 – Map of grass growing areas in the EU
Source: European Environment Agency, https://www.eea.europa.eu/data-and-maps/figures/area-under-permanent-grassland-in-utilised-agricultural-area-uaa-in-eu15-in-1995/fig_15_3_grass.eps/fig_15_3_grass.eps.75dpi.gif

In Denmark, annual imports of protein-rich products amounts to around 1 million tonnes: these products are used to produce feed for pigs, poultry and cattle[37] . Pig farming is a key sub-sector in the Danish organic animal farming sector; organic pig farmers have agreed on use of 100% organic feed protein only. This is in contrast to the present EU legislation which allows for using only 95% organic protein (the remaining share would come from conventional farming). Under the likely hypothesis of a shift to mandatory 100% organic protein in the EU by 2021, there is an urgent need to find alternative protein sources. Today, most of the organic protein needed for organic farming in Denmark is imported from China, Ukraine and Italy[38]. One of the fundamental principles in organic agriculture is local production, and therefore the idea of developing a **Danish system for producing organic feed protein** took off. **Organic clover grass** was chosen as the optimal raw material for building this new value chain.

A survey carried out among Danish organic farmers in 2018 showed that they were willing to include more grass into the crop rotation as long as the income per hectare could be sustained or, if possible, increased[39]. In this perspective, using organic clover grass for biorefining could become a new business option for farmers and replace the existing ways of using grass (for pasture land or for production of silage for cattle). There are two main issues for establishing this new biobased value chain:

1. How to make farming of organic clover grass attractive to the farmers to secure the supply of biomass.
2. How to link up with the market for the new type of organic feed protein obtained from organic clover grass.

The production of organic pigs in Denmark amounted to 180,000 heads in 2017, and is forecasted to grow to 200,000 heads by 2019[40]. The increased production and the EU rules about the use of organic feed protein together spur demand for a local and sustainable source of organic feed protein. Danish organic agriculture is supplied with feed from agribusiness companies, which were seen as the obvious market entry point for the new feed protein. To ensure that the organic feed pellets made with grass protein were safe and nutritious for the organic pigs, research and trials have been carried out by **Aarhus University**. The results showed **promising prospects for practical use of the organic grass protein**[41].

The combination of favourable production conditions, a genuine market need, and collaboration across diverse stakeholder groups have formed the basis for turning organic clover grass into a new type of green biomass.

Value adding to starfish

Starfish is a species naturally occurring in Danish waters, including inland fjords. Since starfish have no natural enemies in the fjords, the abundance and density of starfish population has increased substantially in the last years, leading to a reduced population of mussels and oysters. Starfish contribute to increasing the emissions of nitrogen and phosphorous in the waters: a reduced population of this species could hence help improving water quality.

Starfish are caught in a local fjord, Limfjorden, where they are feeding voraciously on mussels and oysters and are of great nuisance to both the fishermen and the bio-balance in the fjord. Mussel relay activities are heavily disturbed by starfish predation. It was calculated by DTU Aqua that it would be environmentally safe to catch 10,000 tons of starfish annually for processing, generating a business worth around 600,000 Euros. This demonstrates that there could be a potential business case, with related employment opportunities, from establishing starfish processing activities. Figure 3.7 shows the aspect of starfish and starfish meal.

[37] Danish Ministry of Food and Environment (2018), cited.
[38] Gylling M. and Hermansen J (2018), *Quantification of the future protein markets and mapping of the potential derived from various protein sources*, IFRO report no. 2018/08, University of Copenhagen (in Danish).
[39] Hamann K. (2018), *Opportunities and barriers for producing and using organic clover grass as feed protein.*
[40] Hamann K. (2018), cited (based on data from Organic Denmark).
[41] Data retrieved in the Supergrass pork project (ongoing), *Organic pig production based on green protein*, (http://icrofs.dk/en/research/danish-research/organic-rdd-3/supergrasspork/)

Figure 3.7 – Starfish and starfish meal
Source: Niels Joergen Madsen, Danish Marine Protein

In 2013 the Danish Ministry of Food and Environment allocated 870,000 Euros from the Green Development and Demonstrations Projects Funding to the **"STARPRO" project** (acronym for STARfish PROtein), in order to finance research needed to establish a **sustainable production of fish meal obtained from starfish**, as well as to develop the methods for **processing starfish into feed**[42]. Current production of protein powder from starfish is the result of six years of cooperation between researchers, fishermen and business owners, who have joined the project STARPRO[43]. As environment conservation is a priority in Denmark, it was necessary to develop a special tool for catching the starfish without harming the seabed[44].

Regulatory issues can be an important challenge for processing of new types of biomass. Starfish were not included on the EU catalogue of approved feed materials and were therefore — by definition — not permitted. However, effective collaboration between the Danish Ministry of Environment and Food, the STARPRO project, and Danish EU parliamentarians paved the way for starfish to be included in the EU catalogue of feed materials in June 2017. This was possible because the European Commission passed an amendment to the relevant EU legislation in December 2016[45]. Permission was hence granted to "the using of products made by heating, pressing and drying whole *Asteroidea* or parts of *Asteroidea*"[46], a fundamental prerequisite for establishing a new biobased value chain.

In March 2019, the **Danish Marine Protein factory** opened (Figure 3.8). The factory represents an example of establishment of a completely new bio-based value chain, and it is the first and only "starfish processing plant" worldwide. The starfish are grinded and dried to produce starfish meal, containing 70 % protein. This makes the feed highly relevant for farms with organic pigs and poultry. Besides using starfish, the factory is designed also to process fish trimmings, seaweed and shrimp and crab shells for making protein powders for feed use. The factory is running 24 hours a day and can produce 500 kilos of protein powder per hour[47].

Figure 3.8 - Danish Marine Protein's factory in Skive, Denmark
Source: Niels Joergen Madsen, Danish Marine Protein

[42] Danish Ministry of Food and Environment (2016), https://mfvm.dk/nyheder/nyhed/nyhed/danske-svin-og-kyllinger-skal-spise-soestjerner/
[43] STARPRO-GUDP Project, Danish Shellfish Center, DTU-Aqua (2016), http://www.skaldyrcenter.aqua.dtu.dk/forskning/starpro-gudp-projekt
[44] Danish Technical University (2019), From menace to resource – Starfish become animal feed https://www.dtu.dk/english/news/2019/03/from-menace-to-resource-starfish-become-animal-feed?id=d9943bfa-8ebc-4e58-976a-9b0176b14002
[45] Danish Ministry of Food and Environment (2016), cited.
[46] Commission Regulation (EU) 2017/1017 of 15 June 2017 amending Regulation (EU) No 68/2013 on the Catalogue of feed materials, https://eur-lex.europa.eu/eli/reg/2017/1017/oj
[47] Andersen, H. K. (2019), The first starfish factory in the world has started, LandbrugNord, https://landbrugnord.landbrugnet.dk/artikler/foder/nu-aabner-verdens-foerste-soestjernefabrik.aspx

3.3.2.2 Challenges and opportunities of bioeconomy for the chains

The two case studies about Denmark highlighted a number of challenges and opportunities. These are summarised for each case study in the sections below.

Value adding to organic clover grass

The main **opportunities** identified were the following:

- The skills required for undertaking a job in biobased processing are quite similar to the skills required in the food industry. This means that biobased value chains offer significant employment opportunities to workers in the food industry.
- Technological skills and innovative thinking can create new job opportunities in adjoining sectors, such as those related to the development of new types of machinery, or to logistics.

The main **challenges** are related to meeting the following essential conditions for the development of a biobased chain for valorisation of clover grass, and of new biobased value chains in general:

- Establishing intense and long-term collaboration involving a diverse range of stakeholders.
- Before a new biobased product can be marketed, market acceptance needs to be investigated (e.g. by running trials with potential end-users).
- Biorefining is an industry heavily dependent on scalability and economies of scale; this implies that processing of several hundred thousand tonnes of biomass often requires a relatively limited number of jobs in production departments.

Value adding to starfish

Scalability of biobased production processes offers significant **opportunities** in terms of employment creation. The recently opened starfish processing plant in Denmark is a small-scale one, and provides rather few jobs in processing: however, the key aspect is that once the right set-up is discovered, the production concept and organisation can be scaled up and established in other locations. Discussions have already begun with businesses located in the Faroe Islands for using the starfish concept for processing of fish trimmings[48]. Therefore, the potential implications for employment creation can be extremely promising.

Two main **challenges** had to be overcome for establishing the first starfish processing plant in the world:

- Regulatory issues. A very important learning of the case study is the fundamental requirement of having addressed the regulatory issues early in the process of establishing a new biobased value chain. Without legal permission to market the new biobased product, there would not be a business case, and no employment in biomass processing activities would be created.
- Securing adequate funding and establishing cooperation among diverse stakeholders. A key factor in developing the use of a yet unexploited biomass type is close cooperation among invididual

[48] Kristensen, J. (2019), "Starfish become feed for pigs", *Skive Folkeblad*, https://www.skivefolkeblad.dk/artikel/sostjerner-bliver-til-grisefoder-fuld-gang-i-greenlabs-forste-fabrik

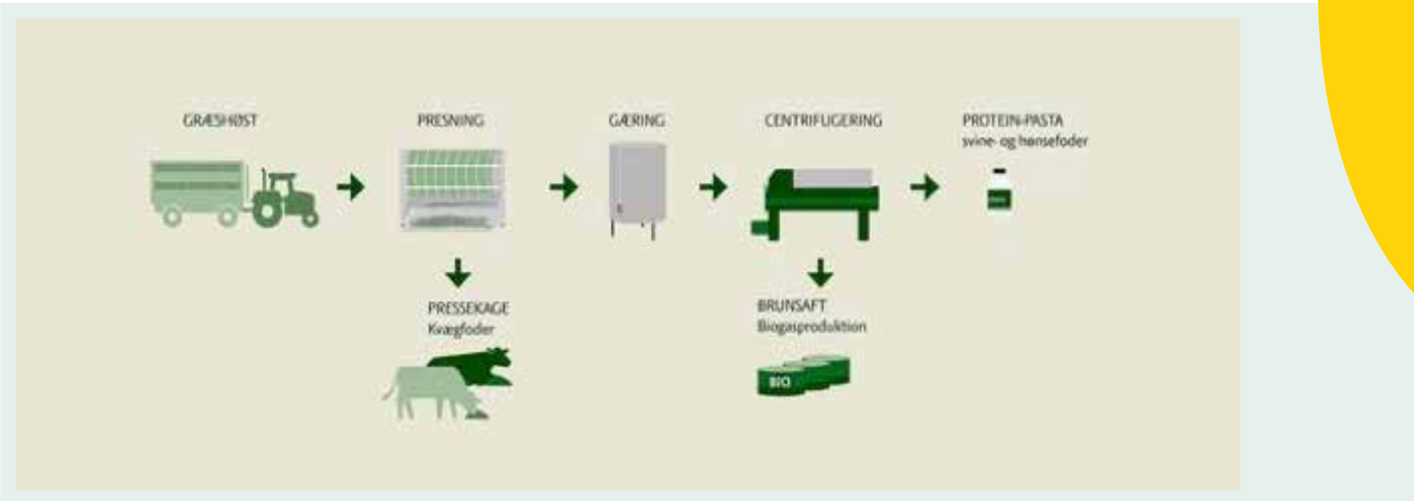
businesses and their associations, researchers and authorities. Funding for the initial research activities was provided by the Danish authorities, upon demand from the businesses which fostered the idea of beginning to exploit starfish as a raw material for extracting proteins for feed use.

3.3.3 ORGANISING EMERGING BIOBASED VALUE CHAINS

Value adding organic clover grass

Organisation of production and logistics is all-important for establishing a new biobased value chain. In the case of clover grass, the production process is foreseen to include several steps (Figure 3.9). Initially, the grass is cultivated and harvested at the farms. Then, the fresh grass would be transported to a biorefinery plant for processing into a powdered feed protein which can be marketed to the feed industry[49]. Value would also be added to side streams from the biorefining process, potentially as cattle feed and biogas. A piloting value chain has been tested in 2016-2018 and it has been demonstrated that the biorefining process and logistics do function from farm-to-feed protein.

Figure 3.9 - Lay-out of the value chain for biorefining of clover grass
Source: https://www.seges.dk/



In 2019, the regional government of Central Denmark provided financial support to build a demonstration plant to scale up the production volume to 100,000 tons of green biomass per year (corresponding to 20,000 tons of dry matter per year). The demonstration plant will be inaugurated in June 2019; this year will be its first year of commercial production[50].

Value adding to starfish

The Danish Marine Protein factory is located in Green Lab Skive, an industrial area in the outskirts of the small Danish town of Skive (20,000 inhabitants). Green Lab Skive is a business park that offers an integrated, internal energy grid - called SymbioseNet - which balances supply and demand of energy among participants. The SymbioseNet uses renewable energy and makes it possible for the businesses to exchange their surpluses of energy and resources[51]. Danish Marine Protein uses surplus energy from the SymbioseNet grid. The Skive starfish processing plant is designed to meet the vision of Danish food producers to be climate neutral by 2050[52].

[49] SEGES Landbrug & Fødevarer F.m.b.A (2018), *White paper on Future Farming – Biorefining.* Elaborated by L. V. Toft and Erik Fog.
[50] Interview with Aarhus University (2019).
[51] Green Lab Skive: http://www.greenlabskive.dk/
[52] Danish Agriculture and Food Council (2019), *The starfish factory producing high quality protein*, https://lf.dk/for-medlemmer/virksomhedsmedlem-hos-os/ingredients-biotech-bulletin/2019/maj-2019/danish-marine-protein

The Skive factory case illustrates how **industrial symbiosis can contribute to the sharing of resources among companies**. In the case of starfish processing, the access to surplus energy is an important part of achieving the goal of climate neutral impact. There is a strong interest in Denmark to develop and use technologies that contribute to mitigating climate change, and particularly renewable energy sources are high on the agenda. Thinking about renewable energy sources is also relevant for the lay-out of a factory for processing of biobased materials, and workers' skills in identifying and implementing energy- or resource-saving measures are valued by companies.

3.3.4 EFFECT ON THE USE OF LABOUR AND NEW REQUIRED SKILLS

There is great uncertainty about the overall potential for employment creation from introducing the bioeconomy in Denmark. In 2013, it was estimated that 24,000 jobs and a sector turnover of 3.5 billion Euros could be the outcome of introducing bioeconomy in Denmark[53]. Further, it was calculated that 80 % of these jobs would be created in rural areas, mainly as the result of agricultural production and, additionally, in logistics related to transportation of biomass and as the result of biobased manufacturing. This indicates that the overall employment effects resulting from bioeconomy are perceived to mainly benefit rural areas, but with implications for several groups of workers and job functions. Further evidence and insights from the two case studies are presented in the following sections.

Value adding to organic clover grass

The demonstration plant is anticipated to employ: two workers in each of the three shifts (six workers in total for running the production process); two drivers for transporting biomass to the plant; and around ten persons working in development, coordination, marketing and management[54]. Processing of green biomass into a marketable product requires many different kinds of skills (Table 3.1). The essential condition for developing a new value chain is the ability to coordinate the entire value adding process, which involves dealing with diverse stakeholders and, at the same time, ensuring motivation to collaborate to reach the common goal: the realisation of new opportunities for income generation and employment.

Table 3.1 - Skills required for making feed protein from green biomass

Process	Skills required	Skills owners
Production of biomass		
Cultivation and harvesting of grass	Experience in crop production and operation of farm machinery	Farmers
Optimisation of crop for biomass production	Insights into cultivation, varieties, crop production	Farmers, researchers, agricultural advisors
Equipment for grass harvesting	Technical expertise	Builders of farm machinery

[53] Naess-Schmidt, H. S. et al. (2015), Geographical job potential of Bio Economy, Copenhagen Economics, https://www.groennejob.dk/nyheder-fra-groenne-job/biooekonomi-kan-skabe-tusindvis-af-job
[54] Interview with Aarhus University (2019).

Process	Skills required	Skills owners
Green biorefining process		
Identifying the biorefining process	Insights into fermentation technology and biochemistry	Researchers
Establishing the production set-up, adapting and running the machinery	Engineering skills, process knowledge	Engineers, process technologists, mechanics, innovators
Organising the value chain		
Identifying the market and linking up with market actors	Market insights and network	Researchers, advisors, innovators
Designing and developing the value chain	Insights into logistics, overview of technologies, bottlenecks, seeing opportunities and having a network	A diverse group of stakeholders => collaboration is the key issue here

A new biobased value chain builds on ideas and innovation. It is essential to understand that being innovative and able to apply already acquired skills in this new context are the key fundamental skills to possess – no matter what job or step of the biobased value chain is concerned. The skills needed to operate the processing equipment in the pilot plant and the demonstration plant can be identified in the following:

- Technological skills.
- Insights into the "processing" concept.
- Understanding the principles of biomass processing.
- Initiative, innovative approach and ability to think and act.

The skills needed by those who will work in the demonstration plant could be found among machine operators, smiths, agricultural technicians, dairy technologists, or process technologists[55]. This indicates that the core skills for working with processing technologies and development in a biorefinery are present among workers representing many different backgrounds and skills.

Value adding to starfish

The Skive starfish processing plant is fully automatic and has three employees working in production. The three employees have very different educational backgrounds: a blacksmith, a farmer and a cook. A common feature is that the workers have continuously participated in re-skilling and up-skilling activities such as using ICT and interpreting data, basic economics, or acquisition of truck driver license. The cook is currently training to become a process technologist. According to the plant manager, the workers share the skill of being innovative and focused on the development of new products, which is the reason why they were hired at the factory. Production processes should be optimised on a continuous basis, and new products should be in the pipeline[56]. In addition to the jobs created in the starfish processing plant, a number of related jobs in the local area are foreseen to follow.

[55] Interview with Aarhus University (2019).
[56] Interview with Danish Marine Protein (2019).

3.4 France

3.4.1 NATIONAL STRATEGIES ON BIOECONOMY

Since the 2000s, France has issued legislation aimed at increasing production and use of renewable energy and at addressing climate change.

The **Investment Programme for the Future** (*Programme d'Investissements d'Avenir*) allocated more than 250 million Euros to support bioeconomy-related projects from 2010 to 2015.

The **National Low-Carbon Strategy** (*Stratégie Bas-Carbone*), elaborated in 2015 in the framework of the Energy Transition Law for Green Growth (*Loi relative à la transition énergétique pour la croissance verte*), defined the main goals towards a low-carbon and sustainable economy. The strategy aimed at **developing bioeconomy** and at increasing the use of **biomass** in the energy, materials and chemical sectors. It also emphasised that the development of bioeconomy **should not come at the expense of food production**.

The **National Strategy for Bioeconomy**, elaborated by four French Ministries (including the Ministry of Food and Agriculture) and launched in 2016, defined the bioeconomy as "***the photosynthesis economy, and more generally the living world economy***". The strategy is consistent with the one addressing climate change, and covers a wide range of sectors: agriculture, forestry, food and wood industries, biomass energy, biomaterials, biochemistry, etc. . It is centred around 6 main goals:

1. Ensuring that the products of bioeconomy become a reality on the markets.
2. Supporting a transition to bioindustry that is effective, innovative and sustainable.
3. Promoting sustainable production of the biological resources needed to meet the requirements of value chains and of society as a whole..
4. Ensuring the sustainability of bioeconomy.
5. Building dialogue with society for a genuinely shared bioeconomy.
6. Promoting innovation for a high performance bioeconomy.

Actions at regional level are important to achieve the goals of the national strategy. In April 2018, the first regional meeting for bioeconomy took place in the Region Hauts-de-France, which hosts the administrative headquarters of the competitiveness cluster IAR[57], focusing on bioeconomy. A similar meeting was held in June 2018 in the Region Grand Est, where the biorefinery at Bazancourt-Pomacle is located. These regional meetings aim at gathering the different stakeholders and at defining the foundations for a regional plan in line with the national strategy. Local job and value creation is a priority for the regions.

[57] Industries & Agro-Ressources (IAR).

3.4.2 CASE(S) UNDER STUDY

3.4.2.1 Description of the companies/industrial plants/chains under study

The cases under study for France concern the **development of biobased value chains starting from traditional processing of sugar beet into sugar, ethanol, yeast and by-products** (molasses, beet pulps).

Key statistics for sugar beet processing in France are presented in Table 3.2.

Table 3.2 - Sugar beet processing in France: key statistics
Source: CEDUS https://www.lesucre.com/

Sugar beet farmers (N°)	**26,000**
Operational sugar factories in the 2018/19 campaign (N°)	**25**
Ethanol production from sugar beets: operational distilleries in the 2018/19 campaign (N°)	**15**
Personnel directly employed in the supply chain (sugar beet farming + sugar beet processing) (N°)	**46.000**

The new bio-based value chains process sugar, ethanol and by-products into a wide range of **biorefinery products and biopolymers** through many different types of processes.

The case studies presented here focus on:

1. Production of betaine, a substance used to produce feed, cosmetics and pharmaceuticals, from beet vinasse (a by-product of sugar beet processing into ethanol).
2. Development of a biorefinery cluster around a traditional sugar factory.

Production of betaine in Origny-Sainte-Benoîte

In 2012, French agro-industrial group Tereos and worldwide chemical group Dupont co-invested in a betaine extraction unit located at Tereos sugar and ethanol production plant in Origny-Sainte-Benoîte (Region Picardie). Dupont owns the patent for the betaine extraction process, and Tereos operates the betaine extraction unit linked to its ethanol distillery. Dupont integrates betaine produced at Origny in the final products in its Finnish unit. The extraction plant has a production capacity of 8,000 tonnes of betaine per year. This new activity led to the creation of 20 full-time jobs at Origny-Sainte-Benoîte. The new jobs required skills in process managing, which are the same needed in distilleries and starch plants. The distillation process was not impacted, and R&D skills required for betaine extraction were provided by the partnership with Dupont. The betaine extraction unit was fully integrated in the ethanol plant, with employment synergies between the two units.

Development of a biorefinery cluster around a traditional sugar factory in Bazancourt-Pomacle

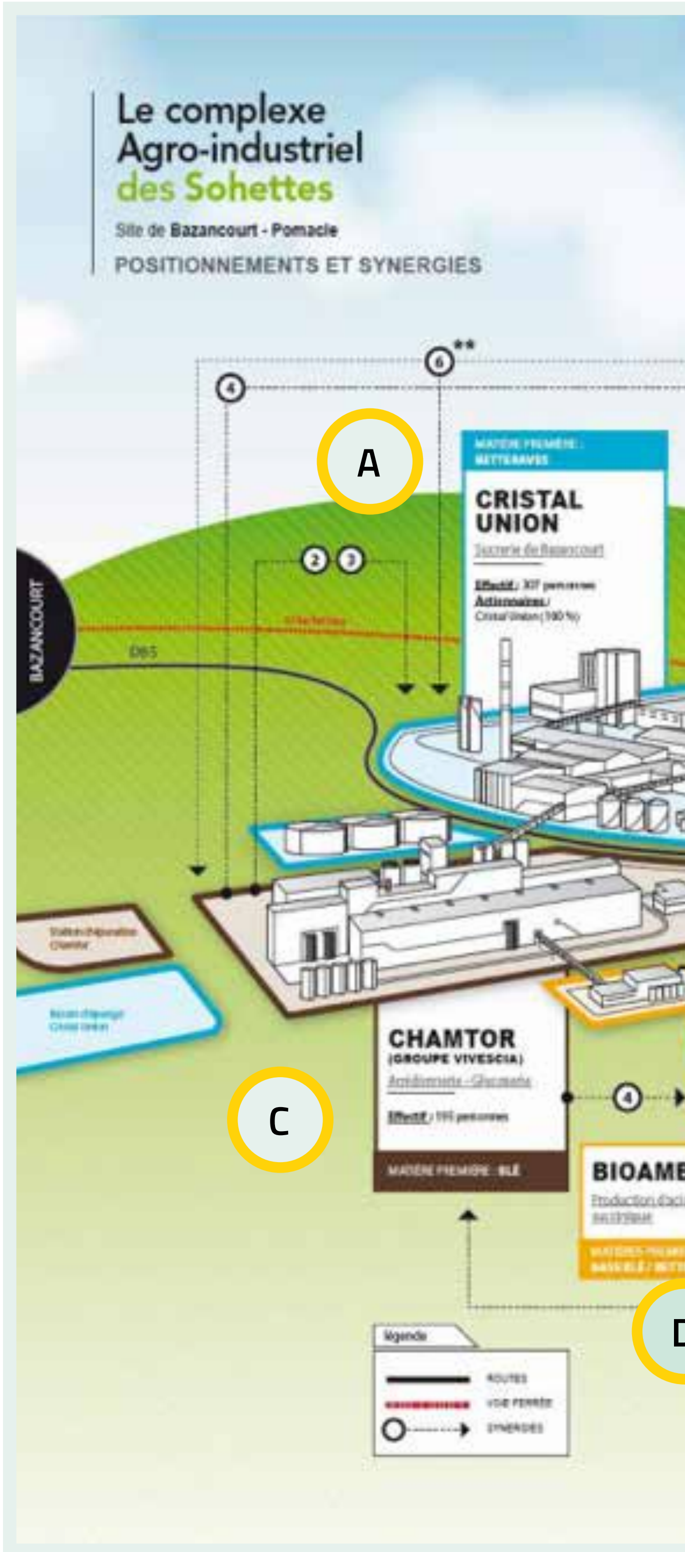
The development of the cluster started around the sugar and ethanol production unit of French agro-industrial group Cristal Union and a wheat starch plant of Chamtor (a subsidiary of agribusiness cooperative Vivescia), both located in Bazancourt-Pomacle (Region Grand Est).

The development of the biorefinery cluster was based on the exploitation of products and by-products of the two plants, as well as of synergies:

- in the use of water, steam, energy;
- in the organisation of production processes and logistics;
- in research and development activities

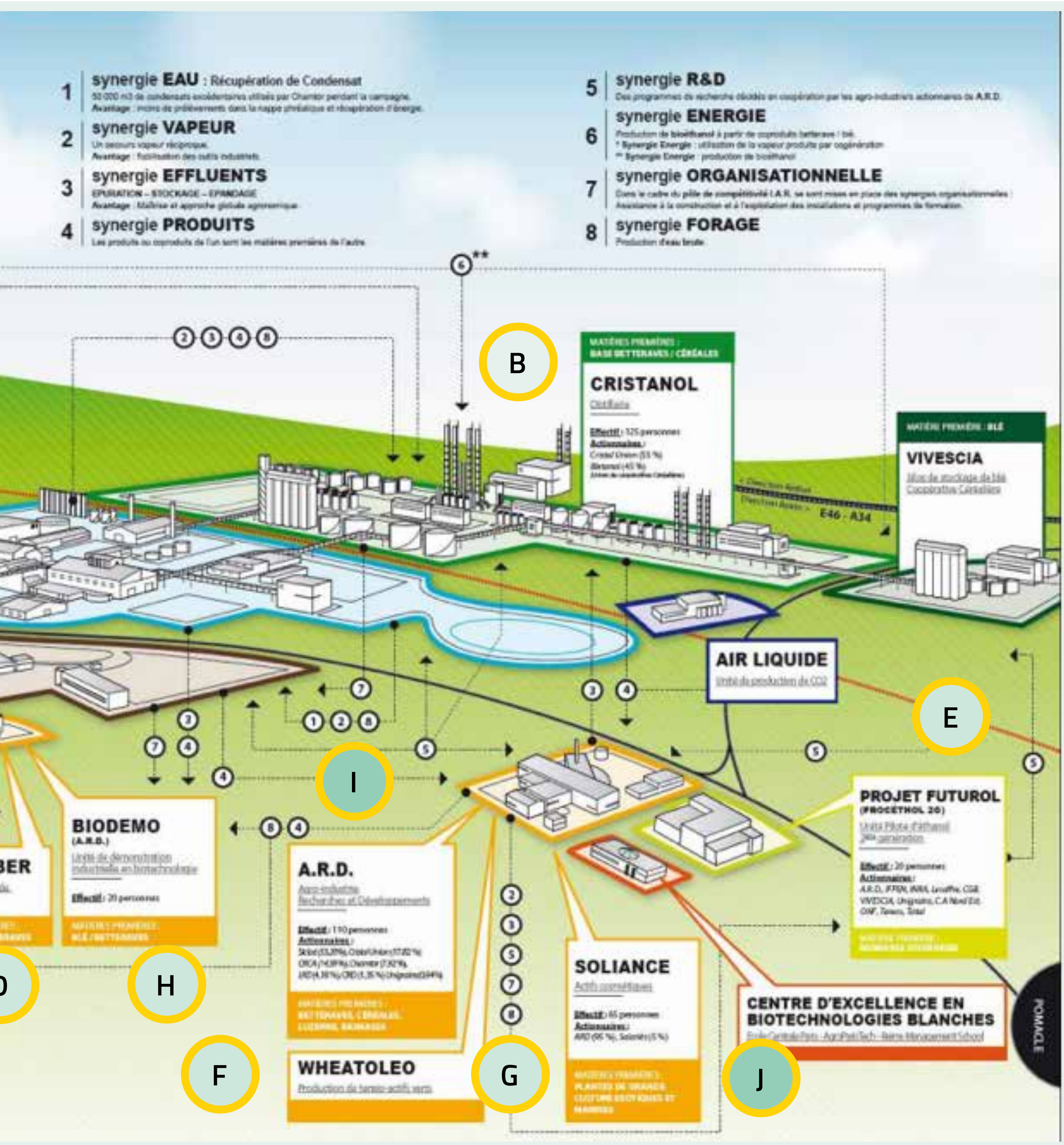
The cluster now includes (Figure 3.10):

A. A sugar production plant.
B. A distillery producing ethanol from sugar beet.
C. A wheat starch plant.
D. A plant producing biobased succinic acid from glucose (which can be obtained from starch or sugar).
E. A plant producing second-generation ethanol from biomass.
F. A plant producing biobased surfactants.
G. A plant producing cosmetics.
H. A demonstration plant for an innovative process for producing biobased succinic acid.
I. A research and development centre.
J. An excellence centre for white biotechnology, also providing education and training.



The entire cluster at Bazancourt-Pomacle concentrates approximately 1,200 jobs and generates an annual turnover of around 800 million Euro. In addition, the R&D centre has generated around 300 local jobs related to bioeconomy. The "turnover per full-time worker equivalent" ratio is quite high compared to the global agro-food sector (666,000 Euros versus 440,000 Euros), which means that the employment in the cluster is relatively limited compared to other agro-food industries. While the biorefinery in itself has led to relatively few "new" jobs, it has brought new skills and a cross-sector approach. On a larger scale, it should be noted that the biorefinery cluster is a major source of employment with a high impact on the surrounding territory. Biorefineries are a good example of the impact of bieconomy on employment location : while industries using fossil-based products (e.g. petro-chemical plants) are usually located in harbours or at railroad hubs, the switch to biomass as raw material may affect their location, and bring them closer to agricultural and forestry areas of production (which are usually low employment density ones)..

Figure 3.10 – The Bazancourt-Pomacle biorefinery cluster
Source: Pôle IAR

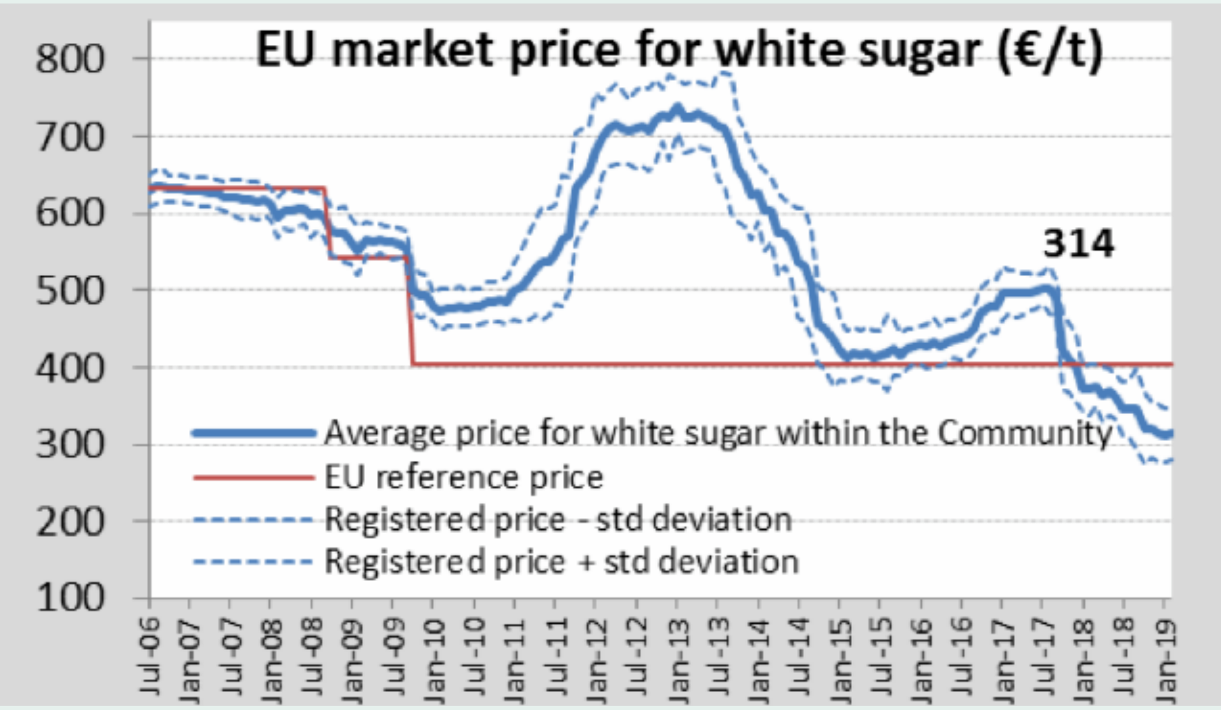


3.4.2.2 Challenges and opportunities of bioeconomy for the chains

France is the leading producer of sugar in the European Union, and is also the leading producer of sugar from beet in the world (sugar can also be produced from cane).

After the termination of production quotas in October 2017, sugar production in the EU (and also in France) increased. However, unfavourable conditions in the world sugar market have led to a decrease of sugar prices on the EU market (Figure 3.11). In addition, the ethanol market is unpredictable, as it depends from public policies promoting its use as fuel, and from the evolution of oil prices.

Figure 3.11 – Evolution of sugar price on the EU market
Source: European Commission – DG Agriculture – Sugar dashboard / April 2019



The pressure from **low sugar prices** may threaten the economic viability of the less competitive sugar production plants in France and in other Member States, with **risk of plant closures** which would have **serious implications for workers**, also because workers in the sugar sector tend to stay longer in the same plant than in other agro-food sectors. Sugar production plants in France are now relatively distant from one another: even in the fortunate case that a worker from a closed plant can find a job in another sugar plant, he/she might have to cover a significant distance to get there, or to relocate closer to the plant.

New opportunities for value creation offered by **biobased technologies may help French sugar and ethanol plants to stay in operation** also when the situation on the sugar and ethanol markets is difficult, with positive effects for the safeguard of sectoral workforce, and may result in the **creation of new jobs either on site or in the surrounding area**. Indeed, the sugar sector in France and abroad has been developing biobased value chains (biofuels, bioenergy, biochemicals, bioplastics etc.) since long, and the two case studies presented at § 3.4.2.1 show that the opportunities for value creation offered by biobased technologies do exist, and can successfully be exploited in practice.

However, the development of new biobased value chains from sugar, ethanol, their derivatives and their by-products, in France and in the EU in general, also faces a number of **challenges and potential limitations, which should not be overlooked**. These challenges and limitations may derive from, among others:

- the availability of cheaper alternative biomass sources for the new biobased processes;
- the instability of oil prices, which can have an influence on the profitability of some biobased value chains;
- the limited size of the (potential) market for certain biobased products;
- the substantial investments which the development of certain biobased value chain require;
- with special respect to job creation, the fact that some biobased processes require substantial capital investments, but relatively limited workforce;
- the strong debate on the ethical, social, environmental implications of food versus non-food uses of biomass;;
- the allocation of value among the various actors along the chain.

3.4.3 CHANGES IN THE PRODUCTION PROCESS STEMMING FROM THE BIOECONOMY

The development of biobased value chains stemming from sugar beet processing into sugar and ethanol has **limited impacts on the related processes**.

Indeed, as the case studies clearly show, the **new biobased processes are carried out in dedicated units**. As the biobased processes use sugar, ethanol or the related by-products as feedstock, those dedicated units are usually **located on the same sites of sugar factories and ethanol distilleries**, so that feedstock can be transported via short pipelines or conveyor belts.

The nature of the biobased technologies involved in the new value chains often implies the **involvement of stakeholders from outside the sugar sector** (e.g. chemical companies). The involvement of external stakeholders may have **implications for the allocation of the value created by the new biobased processes among the various actors involved**.

3.4.4 EFFECT ON THE USE OF LABOUR AND NEW REQUIRED SKILLS

Sugar beet processing into sugar and ethanol is a capital-intensive activity: it is based on **high-capacity production plants with heavy capital investments and relatively limited workforce**. Also several of the **new biobased processes** stemming from sugar, ethanol and the related by-products have **similar nature**.

If it is true that the potential of those biobased processes in terms of **creation of new jobs** within the sugar sector or in technologically linked food and non-food sectors is **relatively limited**, it is also true that new biobased value chains, by improving the profitability of sugar companies, may help to **maintain the current occupational levels in the sugar sector**, which is facing severe pressure from low sugar prices.

The development of new biobased processes from sugar beet processing **does not seem to have substantial implications in the required skills and jobs**. Indeed, most of those processes are continuous flow ones, just like the processes used in sugar and ethanol production. The French competitiveness cluster IAR, specialised in bioeconomy, conducted a study[58] of the impacts of bioeconomy on jobs. The study concluded that bioeconomy would **not generate many new typologies of jobs**, but that **many current typologies of jobs** (in production, marketing, business development, etc.) **would be affected**. Moreover, the development of new biobased value chains requires a cross-sectoral approach (as the two cases illustrated here clearly show) and an adaptation of the industries to new clients and needs. This may affect the level of qualification of workers and their recruitment process, and raises the critical issue of training opportunities that could be offered to current workers in the sugar beet processing sector to take advantage of the development of new biobased value chains**.**

3.5 Italy

3.5.1 NATIONAL STRATEGIES ON BIOECONOMY

Italy launched its **National Bioeconomy Strategy** in 2017. The Strategy aims at providing a **shared vision of the economic, social and environmental opportunities and challenges** associated with the development of an **Italian Bioeconomy**. The strategy has the main goal of integrating sustainable production of renewable biological resources and their processing (along with organic wastes and by-products), in order to develop a range of value-added products. Among the objectives of the strategy there is also the promotion of bioeconomy and of its sustainable growth in the EU and in the Mediterranean area.

The National Bioeconomy Strategy is part of the wider National Strategy for Smart Specialisation[59] and is especially linked with its "health, food and quality of life" and "smart and sustainable industry, energy and environment" areas. The National Bioeconomy Strategy aims at reaching by 2030 a 20% increase in the value of economic activities related to bioeconomy (50 billion Euros) and in the related employment (350.000 new jobs)[60]; to do so, two main actions are foreseen:

1. Enhancing the sustainable production of quality products in each of the above sectors, by exploiting more efficiently the interconnections existing among them. Adding value to terrestrial and marine biodiversity through the development of services and circular economies and the creation of new value chains.

2. Promoting more investments in research and innovation, start-ups and spin-offs, education and communication. Enhancing the coordination of actors in charge of policy measures at local, national and EU level and improving the participation of the general public to develop the market.

The strategy also encompasses the participation to international initiatives such as BLUEMED and PRIMA, with the objective of incentivising the role of the Mediterranean area within the wider EU bioeconomy.

Italian legislation in the field of bioeconomy is mainly represented by the **Environmental Annex** to the **2014 Stability Law**[61] *(Collegato Ambientale alla Legge di Stabilità 2014) – Rules in the environmental field to promote green economy measures and to limit the excessive use of natural resources.* The document sets out

[58] APEC, IAR et UIC (2014), *Chimie du végétal et biotechnologies industrielles : quels métiers stratégiques ?, "Les études de l'emploi"* cdre n° 2014-55
[59] S3 Nazionale – *Strategia nazionale di specializzazione intelligente.*
[60] Presidenza del Consiglio dei Ministri et al. (2016), BIT – *La Bioeconomia in Italia.*
[61] Presidenza del Consiglio dei Ministri et al. (2016), cited.

the objectives and the future environmental strategies for the country. The document addresses green economy and circular economy through the Green Public Procurement (GPP) which defines the minimum environmental criteria for Public Administration procurement policies (the so called "green purchases"), including a number of certifications (EMAS, Ecolabel, Environmental Footprints, Made Green in Italy). The document also sets out incentives for the use of recycled materials, the management of specific categories of waste (including composting) and for the increase of certain categories of collected wastes. The document also establishes a National Committee for Natural Capital which is in charge of collecting data on the use of natural biomasses and to monitor the impact of policies on the preservation of natural resources.

National Technological Clusters as defined by the Ministry for Education, University and Research in the National Research Plan (NRP) 2015-2020 also play a significant role in the development of bioeconomy in Italy. Clusters directly linked to bioeconomy (Agrifood, Green Chemistry, Smart Factory, Blue Growth and Energy) are priority areas of intervention in the framework of the NRP.

3.5.2 CASE(S) UNDER STUDY

The cases under study for Italy focus on:

- **Novamont,** a company which developed a wide range of biobased value chains, also in partnership with other stakeholders.
- **Pilot initiatives** aimed at developing biobased value chains in the **tomato processing sector**.

3.5.2.1 Description of the companies/industrial plants/chains under study

***The Novamont case*[62]**

Founded in 1989 as Fertec, Novamont has its roots in a strategic research centre responsible for integrating chemistry and agriculture. Through internal growth, acquisitions and partnerships the company has reached a leading position in the development of biobased value chains in Italy.

The company started producing Mater-Bi, a starch-based bioplastic, in its Terni plant (Umbria region), located within a former chemical industry complex.

Novamont has solid linkages with the Italian starch sector (Figure 3.12). In Italy, starch is mainly produced from maize in two plants located in the Piedmont region (Cassano Spinola (AL), operated by Roquette) and Veneto region (Castelmassa (RO), operated by Cargill). The leading maize-growing regions in Italy are Veneto, Lombardy, Piedmont, Emilia Romagna and Friuli Venezia Giulia. Table 3.3 reports key statistics for the starch sector in Italy.

[62] Except where otherwise noted, the information about Novamont case was sourced from the company website (https://www.novamont.com/eng/) and from an interview with the management of the Strategic Planning and Corporate Communication department of the company.

Table 3.3 – Starch sector in Italy: key statistics
Source: AISPEC (Italian starch sector association) (https://aispec.federchimica.it/amidi_derivati/ChiSiamoAmidieDerivati.aspx); ISTAT (Italian Institute of Statistics: https://www.istat.it/).

Maize farmers supplying starch production plants (N°)	**4,000**
Operational starch production plants (excluding downstream processing plants) (N°)	**2**
Employees in starch production plants (including downstream processing plants) (N°)	**1,400**

In 2006, Novamont and Italian farmer union Coldiretti formed Sincro, a 50:50 joint-venture to develop the production of chemical intermediates and biolubricants from renewable resources. In cooperation with local farmers, Sincro developed experimental fields and agronomic protocols in support of the integrated biorefinery, also located in Terni.

In 2011, Novamont contributed to starting production of biopolyesters in a plant in Patrica (FR) (Lazio region), which it now manages through its Mater-Biopolymer subsidiary (founded in 2014 and fully owned since 2017). In the same year it also created Matrìca, a 50:50 joint-venture with chemical company Versalis, to reconvert a pre-existing petrochemical site in Porto Torres (Sardinia region) into a biorefinery integrated in the local area for the production of biochemicals, building blocks for bioplastics, bases for lubricants, bioadditives for rubbers and plasticizers for polymers. After some initial difficulties for sourcing the main agricultural feedstock needed (thistles) from local farmers, which were reluctant to cultivate the crop, an agreement with Italian farmer union Coldiretti greatly contributed to improve the situation.

In 2012, Novamont purchased from Bioitalia/Ajinomoto a non-operational lysine plant located in Adria (RO) (Veneto region). In 2016, Novamont completed – through its fully-owned subsidiary Mater-Biotech – the reconversion of the plant, which produces butanediol (1,4 BDO) directly from sugars through fermentation processes. Butanediol is a renewable building block for producing an advanced version of Novamont's Mater-Bi bioplastic with increased renewable content (from about 35% to more than 60%) and decreased greenhouse gas emissions (10-15% reduction of carbon).

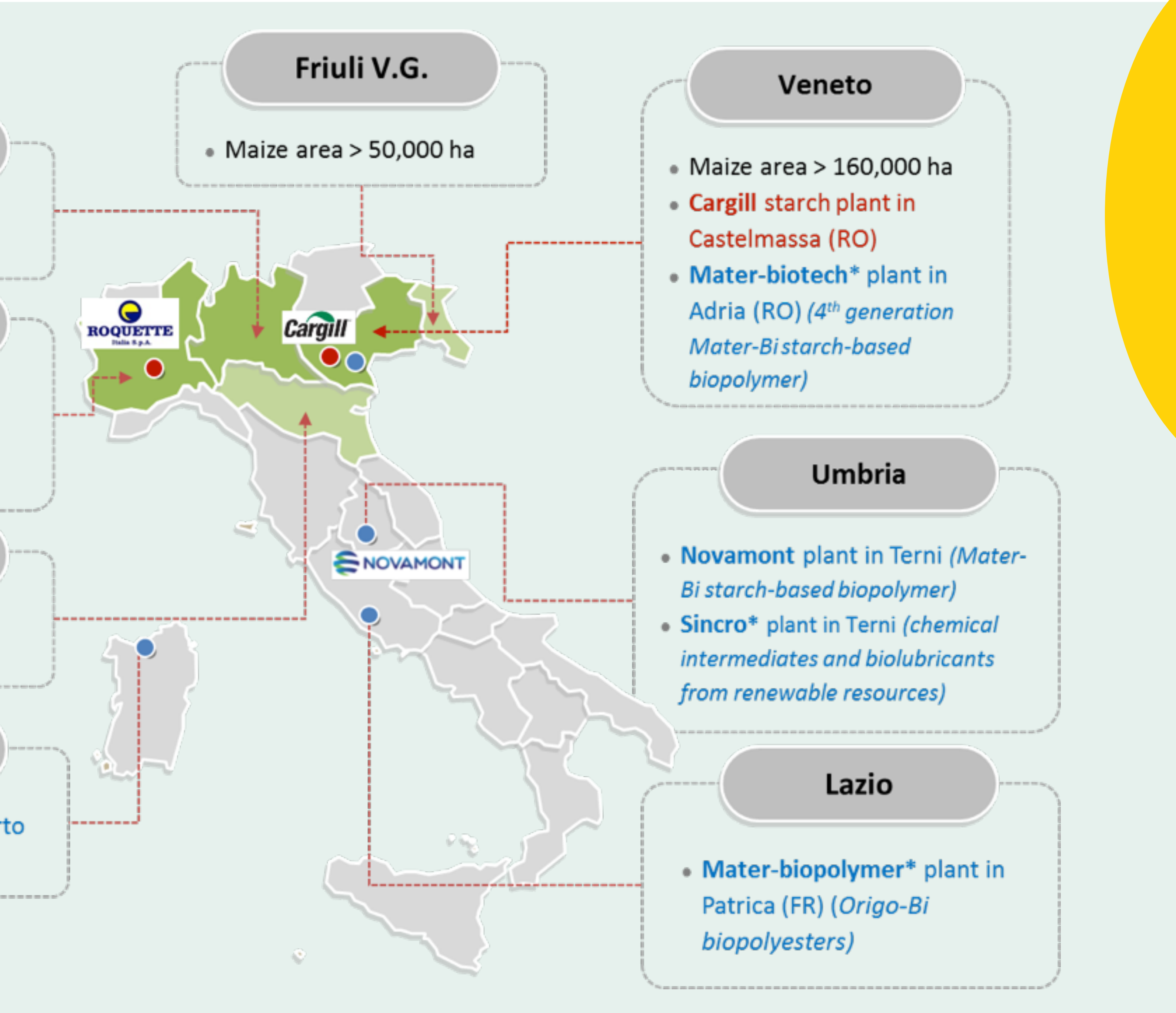
The most noteworthy element in the expansion of Novamont is what the company calls the "**Novamont model**", an approach to the development of biobased value chains based on the efficient use of renewable resources and on the regeneration of local areas. The "Novamont model" is based on three key concepts:

1. Re-conversion of non-operational plants into biorefineries integrated in the local economy, to revitalise deindustrialised areas and to promote new job opportunities.

2. Promotion of a circular economy: renewable raw materials are processed into renewable products, which can be again recycled into renewable raw materials at the end of their life.

3. Promotion of inter-sectoral linkages between farming and processing, and between food and non-food value chains.

Figure 3.12 - Novamont in Italy: plants, activities and linkages with the starch value chain
Source: elaboration by Areté



Pilot initiatives for the development of biobased value chains in the tomato processing sector[63]

Italian tomato processing company **Mutti** explored the possibility of developing – internally or in partnership with other actors - a number of biobased value chains from residues of tomato processing:

- lycopene extraction from tomato skins;
- biogas production from tomato skins and tomatoes which do not meet the quality parameters for processing (around 3-4% of inbound tomatoes);
- production of bioresin (cutin) from tomato skins, to be used to produce lacquers for the inner lining of tomato cans.

The lycopene extraction project never went beyond the study stage, as it emerged that the cost disadvantage versus other lycopene production processes was substantial.

Also biogas production in an onsite digestor was not implemented: due to seasonality of tomato processing, the digestor would have remained idle for several months every year.

On the contrary, pilot production of bioresins from tomato skins was started through a partnership with other actors, including a research centre on processed vegetables located in Parma (Emilia Romagna region).

TomaPaint is a startup company whose objective is the construction of an industrial plant for the extraction of bioresins from tomato skins, which will be the main component of a biolacquer to use in the food packaging sector.

The project started in 2012; after laboratory tests, the company started pilot production in a small test plant located at an agricultural holding in Canneto sull'Oglio (MN) (Lombardy region). The farm already processed tomato skins (in combination with other types of biomass) into biogas in an onsite digestor; the residues from bioresin extraction in the test plant are used as feedstock in the digestor, thus implementing a cascading biobased value chain. Tomapaint is currently working on a biorefinery project: the plan is to implement a cascading biobased value chain using tomato skins as feedstock for producing cutin, lycopene and bioenergy.

3.5.2.2 Challenges and opportunities of bioeconomy for the chains

The two case studies presented here provide a good example of both the opportunities and the challenges related to the development of biobased chains in Italy.

The Novamont case is a clear success story. Even if the company mainly focuses on non-food bioproducts, it has activated strong linkages with both food processing (especially in the starch and sugar sectors) and agriculture. The "Novamont model" has proved to be a winning one to exploit the **opportunities** offered by advanced biotechnology, by the wide variety of biomasses and by the substantial volume of food industry residues available in Italy. It has also proved the potential of biobased value chains in terms of job creation, and revitalisation of idling production units in both urban and rural areas, with positive social implications. However, the replication of the "Novamont model" poses a number of challenges, and the model may be unsuitable to small-scale initiatives.

[63] The information on the case was sourced from interviews with representatives of the companies involved in the initiatives.

Interviews with Italian researchers and consultants have highlighted a number of **challenges and limitations** for the development of biobased value chains in the Italian agro-food system, which are mainly related to:

- Risk propensity/aversion by entrepreneurs, which may be inversely proportional to the availability of financial resources. Pilot initiatives for the development of biobased value chains are often implemented by small-scale companies; larger companies may support those initiatives, but usually "sit and wait" for a proof of the economic viability of the new biobased processes, and are reluctant to start pilot initiatives "in house".
- The sectoral focus of many initiatives, which prevents them from exploiting the inter-sectoral synergies which have contributed to Novamont's success. The biggest potential for job creation, or at least for safeguard of current occupation levels, is offered by an inter-sectoral approach.
- The substantial investments often required to start commercial production, which are clearly unaffordable for small-scale start-ups in the lack of external support.
- Inadequate legislative framework. Indeed many limitations to the development of biobased value chains in Italy derive from the prohibition to use specific typologies of biomass - which are categorised as "waste" by legislation - for the production of food or feed.
- Scarce synergies between research clusters focusing on biobased technologies and the food industry. There are many promising innovations, but very few of them see commercial exploitation.

3.5.3 CHANGES IN THE PRODUCTION PROCESS STEMMING FROM THE BIOECONOMY

Similarly to what observed for France (see § 3.4), the changes in the production processes of the food industry highlighted by the two cases presented here absent or limited, as the **new biobased processes are carried out in dedicated units**.

Differently from the cases observed in France, the Novamont case shows successful examples of biobased processes carried out in dedicated **plants located rather far (or very far) from the plants which supply the needed feedstocks**.

Similarly to the French case, the Italian cases highlight the importance of **involving actors in different sectors** (food and non-food processing, farming), as well as **scientific and technological research centres**, in the development of new biobased supply chains.

3.5.4 EFFECT ON THE USE OF LABOUR AND NEW REQUIRED SKILLS

Even in the absence of quantitative data[64], the Novamont case shows that the development of biobased value chains has **significant potential in terms of job creation**. If it is true that Novamont focuses on non-food bioproducts, and that its production processes are capital-intensive rather than labour-intensive, it is also true that companies like Novamont offer significant opportunities for value creation to both the food industry and agriculture. As already observed for the French case study, adding value to products and by-products of the food industry in non-food biobased processes can contribute to improve the profitability of the food industry, and to safeguard its occupation levels.

[64] According to Novamont CSR Report for 2014, the Terni plant had 80 workers employed in production, but no analogous data are available for the plants operated by its subsidiaries or joint ventures.

On the other hand, it is evident that small-scale plants like those which will (hopefully) follow the pilot initiatives in the tomato sector can have a significant impact on job creation only if they are built in great numbers.

As for the new required skills in the biobased value chains studied for Italy, it emerged from interviews with representatives of the concerned companies that the related processes mostly need **skilled workers with medium-to-high-level technical education**.

4 Conclusions from case studies

4.1 Opportunities and challenges stemming from the introduction of bioeconomy for workers in the agricultural and food sectors

The case studies suggested that **bioeconomy in the EU is developing rapidly**, and this opens up **opportunities for creating new jobs** and **offering workers new possibilities**.

The case studies also revealed that in many ways **the bioeconomy resembles food processing and the chemical industry,** since these industries make use of highly automated processing equipment, the production is process-oriented, and the industries process biomass into products and materials.

Many workers who consider themselves as employed in the food industry – and especially those employed in the food ingredients sector – could already be deemed to work in the bioeconomy. The food ingredients sector makes use of biomaterials for the manufacturing of food ingredients such as colorants, texturisers, starches or proteins, just to mention a few products[65]. Research on the Danish food ingredients sector showed that many of the companies operating in the sector had based their business on processing of side-streams from the food industry (see Table 4.1).

Table 4.1 - Using biomass from side-streams to produce food ingredients: examples from Denmark
Source: Hamann K. (2015), The Food Ingredients Industry – Implications for resource efficient and sustainable food production.

Company	Biomass or side stream for processing	Finished products / ingredients
Chr. Hansen	Grape waste	Natural colorants
Arla Food Ingredients	Whey	Whey proteins and lactose
CP Kelco	Citrus peels	Pectin
Lactosan	Cheese cuttings	Cheese powder
Essentia Protein Solutions	Trimmings, bones and rinds	Functional proteins

The production chain for processing biomass into food ingredients includes raw material handling, processing, packing and logistics; similar processes are carried out in food manufacturing. Food ingredient production plants make use of modern and automated processing equipment, often pursue scale economies (high-capacity plants), and digitalised systems are implemented to ensure quality, food safety and traceability of ingredients, just like in the food processing industry. The food ingredients sector makes use of internationally recognised certification schemes for quality and food safety assurance: schemes like HACCP, IFS and BRC are implemented across the sector.

The above examples demonstrate that **the principles, processes and skills used in the food industry and for processing of biomass are quite transversal**. This is an important aspect to keep in mind when looking at the opportunities or challenges for work in the bioeconomy. The bioeconomy is dependent on supplies of biomass of a certain volume and quality. This is equally valid for wood for bioenergy as well as grape waste for making food colorants. The principle of ensuring a supply of biomass and its quality is fundamental to companies operating in the bioeconomy. Today, the European bioeconomy is emphasising the use of renewable materials as a core principle for sector development: resource management is hence an important issue that is foreseen to attract more attention in the future. This could also provide a new dimension to the skills base of workers in the biobased industries.

Technologies for harvesting or cleaning new types of biomass may have a strong impact on the quality of the biomass itself. For example, if biomass such as green leaves is contaminated with large volumes of sand, the volume and quality of the output from green leaves processing can be significantly reduced. It is therefore essential that, in this case, the green leaves are harvested with adequate machinery, operated by a driver who is knowledgeable about the parameters needed for producing high quality biomass.

Processing of biomass can lead to products such as chips or straw pellets for biofuel, or starches and sugars processed into bio-chemicals. In the Flanders case (see § 3.1) it emerged that knowledge about biomass processing can support the development of a biobased industry producing a diverse range of products, including biochemicals and nutraceuticals[66].

[65] The information source for the examples in the food ingredients sector is Hamann K. (2015), *The Food Ingredients Industry – Implications for resource efficient and sustainable food production.*
[66] Interview, 2019 (Bio Base Europe Pilot Plant).

The case study on Croatia (see § 3.2) showed that the country is building bioeconomy on its forestry sector, and that there is a close focus on ensuring a sustainable development of bioeconomy. In this context, woodland protection and management become important aspects for ensuring a sustainable resource base. The case study on Croatia has demonstrated how sustainable forestry management may impact the future skills requirements for jobs across the forestry sector.

The French and Italian cases (see § 3.4 and 3.5, respectively) showed that **besides positive effects in terms of employment creation** (which may be significant, as also demonstrated by the Flanders case: see § 3.1), the development of biobased value chains (including non-food ones) can improve the profitability of food companies, and hence **contribute positively to the safeguard of employment levels in the food industry**.

The Italian case (see § 3.5) also showed an interesting approach to the development of biobased value chains, based on:

1. Re-conversion of non-operational plants into biorefineries integrated in the local economy, to revitalise deindustrialised areas and to promote new job opportunities.

2. Promotion of a circular economy: renewable raw materials are processed into renewable products, which can be again recycled into renewable raw materials at the end of their life.

3. Promotion of inter-sectoral linkages between farming and processing, and between food and non-food value chains.

The **importance of establishing inter-sectoral linkages** and of **promoting cooperation among diverse groups of stakeholders** as conditions for the development of biobased value chains clearly emerged from all case studies. These conditions are especially important for developing **large-scale biobased industrial clusters** (like the ones described in the case studies on Belgium and France: see § 3.1 and 3.4, respectively), which have **significant potential in terms of employment creation**.

Opportunities from processing of new types of biomass such as green leaves or marine materials can also result in **significant opportunities for employment creation**. Those are emerging segments in the bioeconomy, yet they are already providing employment. Interviews revealed that the newly opened facility in Denmark for processing starfish estimates to employ three persons in production and to process around 10,000 tons of biomass annually[67]. For processing of green biomass into proteins, the Danish demonstration plant estimates an employment of around six persons in the high-season for grass processing (around 100,000 tons of biomass)[68]. The opportunities for employment creation can be further increased by the scalability of many biobased processes: a process implemented in a small-scale plant with relatively few workers can be successfully applied also in larger plants, with more significant opportunities for employment creation.

However, case studies (especially the ones carried out in Denmark, France and Italy) also revealed that **the development of biobased value chains in the agro-food system** faces a number of **challenges and constraints**. These can be classified as follows (indications on possible approaches to address those challenges are also provided).

CHALLENGES FOR WORKERS: THESE HAVE DIRECT IMPLICATIONS FOR TRADE UNIONS

- With special respect to **job creation**, the fact that some biobased processes require substantial capital investments, but relatively limited workforce (capital-intensive processes rather than labour-intensive processes).

[67] Interview, 2019 (Danish Marine Protein)
[68] Interview, 2019 (Aarhus University)

- The **sectoral focus of many initiatives for the development of biobased value chains**, which prevents them from exploiting inter-sectoral synergies. The biggest potential for job creation, or at least for safeguard of current occupation levels, is offered by an inter-sectoral approach in the development of biobased value chains.

- The issue of the **allocation of value among the various actors** involved in biobased chains, with a special attention for the **share allocated to workers**.

Challenges for **workers** can be addressed by trade unions alone, or through their cooperation/dialogue with other stakeholders (business operators, policymakers, civil society, etc.).

CHALLENGES FOR BUSINESS OPERATORS WISHING TO DEVELOP BIOBASED VALUE CHAINS

- Availability of cheaper alternative biomass sources for the new biobased processes.

- Limited size of the (potential) market for certain biobased products.

- The substantial investments which the development of certain biobased value chains require. Those investments are clearly unaffordable for small-scale start-ups in the lack of external support (see below "challenges from context factors").

- Scarce synergies between research clusters focusing on biobased technologies and the food industry. There are many promising innovations, but very few of them see commercial exploitation.

Challenges for business operators wishing to develop biobased value chains may have **direct or indirect implications for workers**: trade unions can usually address those implications through cooperation/dialogue with business operators and/or other stakeholders (including policymakers).

CHALLENGES FROM CONTEXT FACTORS (BUSINESS CULTURE, INSTITUTIONAL SETTINGS, POLICY FRAMEWORK, ETC.)

- Risk propensity/aversion by entrepreneurs, which may be inversely proportional to the availability of financial resources.

- Promoting cooperation among diverse stakeholders (which may have partly conflicting goals): businesses, trade unions, institutions, research centres, civil society organisations, etc.

- The strong debate on the ethical, social, environmental implications of food versus non-food uses of biomass.

- Inadequate legislative framework. Significant limitations to the development of biobased value chains may derive from the prohibition to use specific typologies of biomass – e.g. because they are categorised as "waste" by legislation - for the production of food or feed.

Challenges from context factors are usually addressed through policy measures and/or dialogue among stakeholders. Those challenges **may also have indirect implications for workers**, which can usually be addressed by trade unions through cooperation/dialogue with policymakers and/or other stakeholders.

CHALLENGES FROM EXTERNAL FACTORS

- Instability of fossil fuel prices, which can have an influence on the profitability of some biobased value chains.

Challenges from external factors are usually addressed through policy measures. Those challenges **may also have indirect implications for workers**, which can usually be addressed by trade unions through cooperation/dialogue with policymakers.

4.2 Application of skills for working in the bioeconomy

Companies operating in the bioeconomy depend on **many of the same skills** as companies operating in the **food and food ingredients industry, the chemical industry and materials processing industry**. Interviews with companies in a number of EU Member States[69] have provided findings about the most important skills needed for working in the bioeconomy (Table 4.2). Overall, among the most important skills needed are the ability to think and take an initiative; identify and implement solutions; and to monitor and steer a technical process. Those findings emerged from several interviews with companies across a wide range of subsectors in the bioeconomy.

Table 4.2 - Required skills for working in the bioeconomy
Source: interviews, workshops and case studies

Stage of the biobased value chain	Function of the worker	Skills required
Biomass production	Harvesting / collecting biomass	Skills for handling harvesting equipment Insights to the parameters determining quality of the biomass
Biomass handling and processing	Operating processing equipment and process monitoring	Skills for operating processing equipment including automated production systems Understanding of batch production and continuous production Insights into ICT and digitalised systems for production control, quality and traceability including interpretation of data Experience in quality assurance work Experience in cleaning of processing equipment and maintenance
Biomass packing and storing	Operation of equipment for filling and packing of products	Skills for operating processing equipment including automated production systems Insights into ICT and digitalised systems for production control, quality and traceability, and interpretation of data Experience in quality assurance work Experience in cleaning of processing equipment and maintenance
Biomass and logistics	Transport of biomass and finished products	Insights into ICT and digitalised systems for production control, quality and traceability Truck certificate Driver's license

[69] Case studies carried out in Denmark, Belgium, Italy, Croatia, France and interviews from workshops carried out for the study.

For industrial-scale production, the bioeconomy makes use of technologies and systems that integrate digital interfaces for monitoring and control as well as automated technologies for processing of the biomass. This is a very similar set-up to the system used in the food industry. **Workers holding experience from the food industry could have the opportunity of finding a job in biobased manufacturing**. Bioeconomy could also be an option for older workers, as the production in the biobased economy is often not dependent on hard physical work.

4.3 Obtaining skills for working in the bioeconomy

The case studies have demonstrated that the **transferability of skills between the food industry and biobased manufacturing**, as well as **across the sub-sectors of biobased manufacturing**, is **very high**. These industries need skills such as technological insights, skills for using ICT, and understanding of the materials processed and the production processes. Therefore, **skills for working in the bioeconomy** could in principle be **obtained within the present system of education targeted at different job profiles in the food industry**.

In addition to well-known skills from the food industry, the **understanding of the idea of "biobased manufacturing"** is considered as very valuable by companies operating in the biobased industries[70]. This is due to the fact that this understanding frames such worker competencies as:

- Ability to understand the biomass processed.
- Understanding of the product.
- A general understanding of biobased manufacturing.

There is a **growing interest among farmers** to apply a **circular approach to production**[71], and this is **reflected in agricultural colleges**. More students are interested in learning about circular production systems and opportunities for growing new crops and adding value to them. An example is the cultivation of industrial crops such as elephant grass, which is used for making building and insulation materials. Developing the biobased economy builds on ingenuity and technical competences, and "farmers-to-be" could represent an important segment to target by including technology development into curricula. Further down this line, it is obvious that **agricultural and technical colleges** could play a **key role for providing education of employees for the biobased industries**.

4.4 Prospects of working in the bioeconomy

Biobased manufacturing is a highly diverse industry, since many different types of biomass are processed into a wide variety of products, materials and substances.

It could be argued that the bioeconomy builds on **three transversal dimensions** that can be **applied across the many sub-sectors and value chains of the bio-based manufacturing**, and which are **relevant for work and skills**. This is because skills for working in the bioeconomy are centred around experience in processing of biomaterials (with adjoining functions that are adapted to the specific context of the company), the type of biomass and the status of the bioeconomy. The three dimensions are discussed in the following sections.

[70] Interview, 2019 (Aarhus University)
[71] The circular approach is based on reuse of / value-adding to residues of agricultural production, which are used as production inputs (e.g. as feed, as fertilisers etc.) and/or as feedstock for new processes (e.g. production of biomaterials, generation of bioenergy, etc.).

THE COMPANY AND BUSINESS IDEA

The bioeconomy spans from start-up companies to large-scale industrial manufacturing. TomaPaint from Italy is a good example of small-scale entrepreneurial start-up company, whereas the Bazancourt-Pomacle biobased cluster is an example of large industrial site involving multiple companies and plants. The production technology and organisation of production will relate to the company and factory lay-out, but experience in operating processing equipment is fundamental. Such skills are valued in industry in general, as demonstrated by the case of the sugar industry from France. Here, it was evident that workers who were formerly employed in the sugar industry could transfer their skills to hold a job in a large-scale biorefining plant.

THE TYPE OF BIOMASS

The types of biomass processed in biobased value chains can be sourced from many different environments: agriculture and forestry, marine environment, side streams from industries, and more. Some types of biomass have been used for many years (e.g. straw and wood) and others are new (e.g. starfish). The bioeconomy provides a frame for using known types of biomass in a new context, as demonstrated by the Italian example of using tomato skins for making bio-based lacquer. The **type of biomass to process defines the technology to be used and points to the end-products for the market and re-circulation**. For example, skills related to monitoring and adjusting automated processing equipment is equally relevant for any processing industry, irrespective of the type of biomass it is processing. Ability to combine insights about technological opportunities with coordination of activities and human resources are valued skills and are needed across many functions - no matter what company size or production process is in focus.

THE BIOECONOMY AND ITS POTENTIAL SPIN-OFF EFFECTS

Bioeconomy is in principle already integrated in the use of resources today, as many resources are **re-circulated to improve the overall exploitation** of natural resources. Wood is a good example in that respect. As more attention is devoted to ensuring sustainable sourcing of raw materials and to paying attention to possibilities for re-use of waste and side streams, new perspectives open up. In Croatia, for example, the forestry sector has emphasised its role as contributor to sustainable resource management and nature conservation programs. This approach is an add-on to a biobased value chain and could motivate to obtaining new skills within, for instance, sustainable resource management or sustainable processing technologies.

As demonstrated by the example of using clover grass in Denmark, **biobased value chains can spur the development of new job functions**. The quality of the grass harvested is essential for obtaining a sufficient yield from the biorefing process, and therefore the development of new and improved technologies for grass harvesting has led to creation of new job functions in Denmark.

It is important to underline that the development of new biobased value chains may create jobs **not only in the processing stage**, but also (and in some cases especially) **in the upstream stages** (biomass production; production of equipment, machinery, etc.) and **in support activities** (especially logistics, i.e. storage and transportation of both biomass and biobased products, but also in research and consulting).

5 The bioeconomy we want

The study showed that **bioeconomy is above all characterised by diversity**. A great variety of biomass types, biobased processes and related outputs, and approaches to the development of biobased value chains emerged from the analysis. Such diversity translates into a wide range of opportunities, but also in different challenges to address. The study highlighted that there is no "one fits all" approach to the development of biobased value chains. Successful, or at least promising examples of biobased value chains investigated in the study differ in many respects, including:

- the conditions to be ensured for a successful development of the initiatives;
- the needs in terms of workers' skills;
- the potential for employment creation.

To successfully develop new biobased value chains, such **diversity needs to be taken into account, to be properly understood, and to be adequately dealt with**: failure in doing that can lead to missed opportunities and/or to unaddressed challenges which can put the success of the related initiatives at risk.

The study highlighted a number of **critical conditions to be met** to ensure that the potential of bioeconomy in terms of employment creation (or, at least, of safeguard of current employment levels) is fully exploited. These conditions are of technical, economic, organisational and political nature, and include:

1. The application of the **cascading approach** to fully unlock the potential for adding value to biomass. Cascading involves obtaining the most valuable products in the first stages of biomass processing, and lower-value products only in successive stages; only the residues from biomass processing into biobased products are finally used to generate energy. The cascading approach also allows to minimise waste, with **positive implications for the development of an environmentally sustainable bioeconomy.**

2. Establishing **inter-sectoral linkages** (between farming and processing; between food and non-food value chains) and **cooperation among different groups of stakeholders** (business operators; research centres and education centres; institutions and policymakers; civil society; etc.) to fully exploit the aforementioned diversity and to implement the cascading approach.

3. Establishing an **adequate policy / regulatory framework**, in order to:
   a. **Minimise regulatory constraints** to full exploitation of biomass in value adding processes, **without prejudice to social standards and environment conservation.**
   b. **Provide financial support and incentives** to business operators, research centres and education centres.

Most importantly from EFFAT's standpoint, the study showed that the development of biobased value chains has **significant potential in term of job creation** as well as **safeguard of current employment levels**, and can have substantial direct **implications for workers** in terms of **required skills and career paths**. The study also showed that besides opportunities, the development of biobased value chains also presents challenges, which can turn into positive or negative implications for workers.

The study findings illustrated above clearly suggest that **trade unions** should not only **look at the development of the bioeconomy with great attention**, but should **also play a role in shaping that development**. In other words, trade unions should **define a "bioeconomy they want"**, and should **actively contribute to the realisation of a model of bioeconomy which is consistent with their values and goals**.

EFFAT deems that the **bioeconomy of the future** should be **socially, economically and environmentally sustainable**.

A SOCIALLY SUSTAINABLE BIOECONOMY

The development of bioeconomy should be an inclusive process. This means that:

- **Young people and unemployed people should be given a chance to find a job in the bioeconomy.** This implies **promoting an adequate educational offer,** including hands-on training in biobased production units.

- Innovation- and risk-oriented entrepreneurs lacking the needed resources and/or technological know-how to implement biobased productions processes should be supported through provision of incentives and/or counselling.

AN ECONOMICALLY SUSTAINABLE BIOECONOMY

Most of the successful examples of development of biobased value chains analysed in the report concern non-food biobased products and/or generation of bioenergy. However, the study revealed that **diversification into non-food biobased value chains** can improve the profitability of the involved food business operators, with **positive implications for the safeguard of current employment levels in the food industry**. These positive implications also derive from another finding of the study, which revealed that the skills needed for working in biobased production processes are often similar to the skills of food industry workers. This finding further reinforces the **importance of an inter-sectoral approach to bioeconomy**.

The study also showed that new biobased value chains can be successfully implemented at different scales: from small-scale pilot plants to large-scale industrial clusters. Even if the potential for employment creation in large-scale industrial clusters is generally much higher (even if several biobased processes are capital-intensive rather than labour-intensive), this development model may be unsuitable for some processes, or unfeasible in certain contexts. The **potential for employment creation of smaller biobased production units should not be overlooked**, especially where those units can be built in significant numbers.

AN ENVIRONMENTALLY SUSTAINABLE BIOECONOMY

Last but not least, the development of the bioeconomy should **contribute to enhanced environmental conservation and more effective action against climate change**. To these ends, the development of biobased value chains should:

1. be supported by a comprehensive analysis of their environmental/climate change implications; wherever these are negative, adequate **mitigating measures** should be taken;

2. **apply the cascading approach,** by virtue of its **waste-minimising effects.**

6 Recommendations

The recommendations in this section are aimed at promoting the development of the bioeconomy in the EU along the lines defined at § 5.

Recommendations are targeted at trade unions and workers' representatives, which can promote the "bioeconomy they want" in two ways:

1. Through direct initiatives.
2. Through dialogue/cooperation with, as well as sensitisation of, the other key stakeholders: business operators and their associations, national governments, EU institutions.

The recommendations propose **concrete actions to be implemented**, and move from the key findings of the study.

6.1 What should trade unions do...

6.1.1 ... TO PROMOTE THE DEVELOPMENT OF THE BIOECONOMY?

Trade unions and workers' representatives should:

1. Undertake initiatives aimed at **improving their knowledge of the bioeconomy**. This study represents a significant step forward in the right direction, but more can be done.

2. **Strengthen trade union solidarity and cooperation across sectors.** The study has clearly showed the importance of inter-sectoral dialogue and cooperation for the development of socially, economically and environmentally sustainable biobased value chains.

3. Consider the possibility to **invest part of the financial resources available to them** (e.g. those related to workers' retirement funds) **in projects for developing new biobased value chains** which meet the conditions set out at § 5, i.e. that are **socially, economically and environmentally sustainable**. Funds managed by trade unions could be invested in sustainable biomass production and processing, marketing of biobased products, logistical/support activities.

4. Contribute actively to the **adaptation of the existing EU-level and national-level instruments** to promote the development of the bioeconomy, as well as to **the elaboration of new ones**, to ensure that national, regional and **especially sectoral specificities are taken into account** wherever opportune. This can be done also in cooperation with business stakeholders (see § 6.2.1).

5. Contribute actively to the **elaboration of EU-level and national-level initiatives aimed at promoting the development of bioeconomy** (e.g. through research and education, granting of financial incentives, minimisation of regulatory constraints, etc.). This can be done also in cooperation with business stakeholders (see § 6.2.1).

6.1.2 ... TO PROMOTE EMPLOYMENT CREATION IN THE BIOECONOMY, AND TO ENSURE THAT WORKERS HAVE ADEQUATE SKILLS FOR WORKING IN THE BIOECONOMY?

Trade unions and workers' representatives should:

6. Undertake initiatives aimed at:

   a. **Improving their knowledge of the implications of the bioeconomy in terms of employment and required skills of workers.** As already underlined at point 1, this study represents a significant step forward in the right direction, but more can be done.

   b. **Improving awareness of, and general knowledge about bioeconomy,** within their membership base, i.e. **among workers** (e.g. through elaboration of informative material).

   c. **Helping unemployed workers to access technical education in the field of bioeconomy,** with a view to improving their chances of finding a job in the related sectors.

7. Consider the possibility to **invest part of the financial resources available to them** (e.g. those related to workers' retirement funds) **in initiatives aimed at providing workers with technical education in the field of bioeconomy**, always with a view to improving their chances of finding a job in the related sectors.

6.2 What should trade unions ask...

6.2.1 ... TO BUSINESS STAKEHOLDERS?

Trade unions and workers' representatives should:

8. **Discuss** with business stakeholders about the **fair allocation of value deriving from the development of new biobased value chains** among the involved stakeholders, focusing on the **share allocated to workers.**

9. **Discuss** with business stakeholders about the **working conditions in new biobased value chains,** with a special focus on the **safety and quality of jobs.**

10. **Sensitise business operators** which are about to develop biobased production processes on the critical importance of:

    a. **considering all the available options** in terms of: type(s) of biomass to be used as feedstock; type(s) of process to be activated; type(s) of biobased products to be obtained; technical and organisational solutions to implement the process(es), with special attention to the cascading approach; scale at which the process(es) should be activated; etc.;

    b. **establishing cooperation with other business operators** - including those from other sectors - and **with other relevant actors** (institutions; research centres; educational centres; etc.).

11. **Encourage business operators** which are about to develop biobased production processes to:

    a. **Secure the availability of skilled workers,** through cooperation with educational centres and/or in-house training.

    b. **Support public institutions and private entities** (technical colleges, universities, non-profit foundations, etc.) willing to offer **technical education in the field of bioeconomy,** especially by offering the opportunity for hands-on training in their biobased production units.

    c. **Explore, and take advantage of the available incentives and funding opportunities for the development of biobased production processes,** as well as non-monetary forms of support, with special attention to **technical counselling.**.

12. **Encourage sectoral and inter-sectoral business associations** willing to promote the development of bioeconomy to:

a. **Support public institutions and private entities** (technical colleges, universities, non-profit foundations, etc.) willing to offer **technical education in the field of bioeconomy.**

b. Contribute actively to the **adaptation of the existing EU-level and national-level instruments** to promote the development of bioeconomy, as well as to **the elaboration of new ones**, to ensure that national, regional and **especially sectoral specificities are taken into account** wherever opportune.

c. Contribute actively to the **elaboration of EU-level and national-level initiatives aimed at promoting the development of bioeconomy** (e.g. through research and education, granting of financial incentives, minimisation of regulatory constraints, etc.).

d. Undertake initiatives aimed at **sensitising business operators** which are about to develop biobased production processes on the **critical importance of the conditions at points 10 and 11 above** for a successful implementation of their projects.

e. Undertake initiatives aimed at:

- **improving their knowledge of the bioeconomy**;
- **improving awareness of, and general knowledge about bioeconomy,** within their membership base, i.e**. among entrepreneurs** (e.g. through elaboration of informative material, workshops and seminars, etc.).

6.2.2 ... TO LOCAL AND REGIONAL GOVERNMENTS?

Trade unions and workers' representatives should:

13. Encourage local and regional governments to **promote the development of local biobased industries** which can **create new jobs especially in rural areas**.

6.2.3 ... TO NATIONAL GOVERNMENTS?

Trade unions and workers' representatives should:

14. **Encourage** national governments to **involve trade unions, workers' representatives and social partners** in general in the **elaboration of national policies aimed at promoting the development of bioeconomy.**

15. **Encourage** national governments to:

a. **Include basic or advanced teaching in the fundamentals of bioeconomy in national**

educational programmes, tailoring the notions to be transmitted to the different educational profiles (primary, general secondary, specialist secondary, etc.).

b. **Support public institutions and private entities** (technical colleges, universities, non-profit foundations, etc.) willing to offer **technical education in the field of bioeconomy,** with special attention to **initiatives targeted at unemployed people.**

c. **Promote the offer of hands-on training in biobased production units to prospective workers,** through monetary and non-monetary incentives to the concerned businesses (e.g. tax benefits).

d. **Undertake initiatives to promote cooperation among different stakeholders interested in developing the bioeconomy,** including trade unions (e.g. through government-promoted inter-sectoral dialogue groups).

e. **Contribute actively to the adaptation of the existing EU-level instruments** to promote the development of bioeconomy, as well as to **the elaboration of new ones,** to ensure that **national/regional specificities are taken into account** wherever opportune.

f. **Ensure effective and efficient implementation of all the EU-level actions** (see § 6.2.4) **on their national territories,** taking into account national/regional specificities wherever this is allowed by the type of legislative instrument used (Directives).

g. **Elaborate and implement national initiatives aimed at promoting the development of bioeconomy** (e.g. through research and education, granting of financial incentives, minimisation of regulatory constraints, etc.), wherever this is not in conflict with EU legislation. National initiatives should be aimed at **completing EU-level ones and/or at seeking synergic effects** with them, and should instead **avoid any duplication** which can result in inefficient use of resources.

6.2.4 ... TO EU INSTITUTIONS?

Trade unions and workers' representatives should:

- **sensitise** the relevant EU institutions about the **importance of the conditions defined at points 16, 17, 18 and 19** for the **development of a socially, economically and environmentally sustainable bioeconomy**, consistently with the model defined at § 5;

- **encourage** the relevant EU institutions to **take action along the lines defined at points 16, 17, 18 and 19.**

16. **Scientific and techno-economic knowledge about bioeconomy must be improved** through both scientific and applied research. The diverse aspects of bioeconomy must be explored further, in order to promote full and sustainable exploitation of all the opportunities that bioeconomy offers, and to effectively address the challenges related to its development. There are already operational EU-level instruments whose contribution to improved knowledge about bioeconomy can be fostered (e.g. the Knowledge Centre for Bioeconomy, the Bio-based Industries Joint Undertaking, etc.). Additional ad hoc instruments can be devised and implemented upon initiative of the European Commission itself, or through EU-funded research

and technological development programs.

17. **Awareness of, and knowledge about bioeconomy among EU citizens must also be improved** through both general and specialist education, through existing instruments available to DG Education and Culture, and possibly through ad hoc initiatives. General education shapes the workers and consumers of tomorrow. Improved awareness of and knowledge about bioeconomy among EU citizens can:

    a. increase the attractiveness of biobased production units as workplaces;

    b. stimulate consumers' demand for biobased products and bioenergy;

    c. promote the positive image of bioeconomy as an environmentally conscious approach to efficient exploitation of natural resources.

18. The **availability of financial incentives to business operators** willing to contribute to the development of a biobased economy in the EU **must be increased**. Priority should be given to:

    a. entrepreneurs lacking the financial resources to implement techno-economically sound projects, irrespective of their scale;

    b. clusters of business operators and non-business actors (e.g. research centres) whose projects are characterised by an inter-sectoral approach based on the application of the cascading approach and on cooperation among stakeholders.

19. **Regulatory constraints to full exploitation of biomass along the "value pyramid"** (i.e. through both food and non-food biobased value chains, according to the cascading approach) **must be addressed** through opportune **amendments to the relevant EU legislation**, without putting at risk its coherence with the other political priorities of the European Union (safety of workers, consumer protection, environment conservation, etc.). In particular, the scope for promoting the production of safe food ingredients from side streams, wastes and residues of the food industry through adequate EU legislation should be explored.

7 References

Andersen, H. K. (2019), *The first starfish factory in the world has started,* LandbrugNord, https://landbrugnord.landbrugnet.dk/artikler/foder/nu-aabner-verdens-foerste-soestjernefabrik.aspx

APEC, IAR et UIC (2014), *Chimie du végétal et biotechnologies industrielles : quels métiers stratégiques ?,* "Les études de l'emploi" cdre n. 2014-55.

Asveld L., van Est R., Stemerding D. (Eds) (2011), *Getting to the core of the bio-economy: A perspective on the sustainable promise of biomass.* The Hague: Rathenau Instituut.

Berger, John J. (2017), "Growing A Bioeconomy — Flanders To Produce Fossil-Free Fuels, Chemicals, And Products", *Huffington Post.*

BBI JU (2018), *Example of good practices reported by the BBI JU States representatives group. Outcomes of the JRC – BBI JU – IEA survey on strategies and policies for the EU bioeconomy in 2017.*

Bio Base Europe Pilot Plant (2019), http://www.bbeu.org/pilotplant/wp-content/uploads/2019/03/Algemene-folder_voor-web_LR.pdf

Cherubini, F. (2010), "The biorefinery concept: using biomass instead of oil for producing energy and chemicals". *Energy conversion and management,* 51(7), 1412-1421.

Danish Agriculture and Food Council (2019), *The starfish factory producing high quality protein,* https://lf.dk/for-medlemmer/virksomhedsmedlem-hos-os/ingredients-biotech-bulletin/2019/maj-2019/danish-marine-protein

Danish Ministry of Food and Environment (2016), https://mfvm.dk/nyheder/nyhed/nyhed/danske-svin-og-kyllinger-skal-spise-soestjerner/

Danish Ministry of Food and Environment (2018), *Proteins for the future, Recommendations from the National Bioeconomy Panel* https://mfvm.dk/fileadmin/user_upload/MFVM/Miljoe/Biooekonomi/Recommendations_from_the_National_Bioeconomy_Panel_Proteins_for_the_future__PDF_.pdf

Danish Ministry of Food, Agriculture and Fisheries (2013), *Fact sheet Bioeconomy*: http://naturerhverv.dk/fileadmin/user_upload/NaturErhverv/Filer/Indsatsomraader/Biooekonomi/Fact_sheet_the_National_Bioeconomy_Panel.pdf

Danish Technical University (2019), *From menace to resource – Starfish become animal feed* https://www.dtu.dk/english/news/2019/03/from-menace-to-resource-starfish-become-animal-feed?id=d9943bfa-8ebc-4e58-976a-9b0176b14002

De Jong, E., Higson, A., Walsh, P., Wellisch, M., (2012), *Bio-based Chemicals. Value Added Products from Biorefineries - Task 42 Biorefinery.* http://www.ieabioenergy.com/publications/bio-based-chemicals-value-added-products-from-biorefineries

Departement Omgeving (2014), *Bioeconomy in Flanders,* https://www.vlaanderen.be/en/publications/detail/bioeconomy-in-flanders

ERRIN Bioeconomy WG (2017), *Bioeconomy in Flanders - Policy aspects,* https://errin.eu/sites/default/files/05.19_ERRIN%20BioWG_BioEconomy%20in%20Flanders.pdf

European Commission (2018), *Bioeconomy: the European way to use our natural resources – Action plan 2018,* Directorate-General for Research and Innovation - Unit F – Bioeconomy.

European Investment Bank (2016), *Restoring EU competitiveness* (updated version), European Investment Bank.

Eurostat (2017), Statistics on rural areas in the EU, https://ec.europa.eu/eurostat/statistics-explained/index.php/Statistics_on_rural_areas_in_the_EU

Gylling M. and Hermansen J. (2018), *Quantification of the future protein markets and mapping of the potential derived from various protein sources*, IFRO report no. 2018/08, University of Copenhagen (in Danish).

Hamann K. (2015), *The Food Ingredients Industry – Implications for resource efficient and sustainable food production.*

Hamann K. (2018), *Opportunities and barriers for producing and using organic clover grass as feed protein.*

JRC (2017), *Bioeconomy report 2016*, Publications Office of the European Union.

Keegan D. et al. (2013), "Cascading use: A systematic approach to biomass beyond the energy sector", in *Biofuels Bioproducts and Biorefining*, March 2013.

Kristensen, J. (2019), "Starfish become feed for pigs", *Skive Folkeblad*, https://www.skivefolkeblad.dk/artikel/sostjerner-bliver-til-grisefoder-fuld-gang-i-greenlabs-forste-fabrik

Mainar-Causapé, A.J., Philippidis, G. (Eds.) (2018), *BioSAMs for the EU Member States. Costructing social accounting matrices with detailed disaggregation of the bio-economy*, Euroepan Commission – Joint Research Centre.

McCormick, K., Kautto, N. (2013), "The Bioeconomy in Europe: An Overview", in *Sustainability* 2013, 5, 2589-2608.

Naess-Schmidt, H. S. et al. (2015), *Geographical job potential of Bio Economy*, Copenhagen Economics, https://www.groennejob.dk/nyheder-fra-groenne-job/biooekonomi-kan-skabe-tusindvis-af-job

Parisi, C. (2018). Research Brief: *Biorefineries distribution in the EU.* European Commission - Joint Research Centre.

Presidenza del Consiglio dei Ministri et al. (2016), BIT – *La Bioeconomia in Italia*.

Rogers J. N., Stokes B., Dunn J., Cai H., Wu M., Haq Z. and Baumes H. (2017), "An Assessment of the Potential Products and Economic and Environmental Impacts Resulting from a Billion Ton Bioeconomy", *Biofuels, Bioproducts, and Biorefining*, 11, No. 1 (2017), pp. 110–128.

Scarlat, N., Dallemand, J. F., Monforti-Ferrario, F., & Nita, V. (2015), "The role of biomass and bioenergy in a future bioeconomy: Policies and facts", *Environmental Development*, 15, 3-34.

SEGES Landbrug & Fødevarer F.m.b.A (2018), *White paper on Future Farming – Biorefining*. Elaborated by L. V. Toft and Erik Fog.

Spatial Foresight, SWECO, ÖIR, t33, Nordregio, Berman Group, Infyde (2017), *Bioeconomy development in EU regions. Mapping of EU Member States'/regions' Research and Innovation plans & Strategies for Smart Specialisation (RIS3) on Bioeconomy for 2014-2020*, Study commissioned by DG Research & Innovation, European Commission.

STARPRO-GUDP Project, Danish Shellfish Center, DTU-Aqua (2016), http://www.skaldyrcenter.aqua.dtu.dk/forskning/starpro-gudp-projekt

United Federation of Danish Workers 3F (2016), *The fundamentals of bioecomomy. The biobased society.*

United Nations (2018), *UN Climate Change Annual Report 2017*, United Nations Framework Convention on Climate Change (UNFCCC).

8 Websites and online resources

AISPEC:
https://aispec.federchimica.it/amidi_derivati/ChiSiamoAmidieDerivati.aspx

Bio Base Europe:
http://www.bbeu.org/

CEDUS:
https://www.lesucre.com/

European Commission – DG Agriculture – Sugar dashboard:
https://ec.europa.eu/agriculture/market-observatory/sugar/statistics_en

European Environment Agency:
https://www.eea.europa.eu/data-and-maps/figures/area-under-permanent-grassland-in-utilised-agricultural-area-uaa-in-eu15-in-1995/fig_15_3_grass.eps/fig_15_3_grass.eps.75dpi.gif

Ghent Technical College (HOGENT):
https://www.hogent.be/

Green Lab Skive:
http://www.greenlabskive.dk/

ISTAT:
https://www.istat.it/

JRC data portal:
https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html

Knowledge Centre for Bioeconomy of the European Commission:
https://ec.europa.eu/knowledge4policy/bioeconomy/topic/policy_en and https://biobs.jrc.ec.europa.eu

Novamont:
https://www.novamont.com/eng/

SEGES Landbrug & Fødevarer F.m.b.A.:
https://www.seges.dk/

Sherif Export-Import Ltd.:
http://sherif.hr/

Supergrass pork project (ongoing), *Organic pig production based on green protein*:
http://icrofs.dk/en/research/danish-research/organic-rdd-3/supergrasspork/

EFFAT is the European Federation of Food, Agriculture and Tourism Trade Unions, also representing domestic workers. As a European Trade Union Federation representing 120 national trade unions from 35 European countries, EFFAT defends the interests of more than 22 million workers towards the European Institutions, European employers' associations and transnational companies. EFFAT is a member of the ETUC and the European regional organisation of the IUF.

EFFAT
Avenue Louise 130 A, Box 3
BE-1050 Bruxelles
Tel: + 32 2 218 77 30
Fax: + 32 2 218 30 18
www.effat.org