

# Biorefineries distribution in the EU

## Research Brief

### HIGHLIGHTS

- 803 biorefineries have been identified in the EU, of which 507 produce bio-based chemicals, 363 liquid biofuels and 141 bio-based composites and fibres (multi-product facilities are counted more than once).
- Of those facilities, 177 are reported as *integrated biorefineries* that combine the production of bio-based products and energy.
- The location of most biorefineries shows correspondence with chemical clusters and ports.
- Generally, the highest concentration of biorefineries is located in the central part of the EU, particularly in Belgium and the Netherlands.
- Agricultural resources are the feedstock source used by most biorefineries in all EU countries with the exception of Finland, Sweden and Portugal.
- Marine and waste resources are relevant in some countries but not yet highly exploited in biorefineries.

### BIOREFINERY DEFINITION

Several definitions of biorefinery have been elaborated in the last decades. According to the US DOE<sup>1</sup>, a biorefinery is intended as "an overall concept of a processing plant where biomass feedstocks are converted and extracted into a spectrum of valuable products". This is the definition employed in this research brief.

Other sources define a biorefinery as a more specific concept, more closely derived from the concept of oil refinery of the petrochemical industry. For instance, a biorefinery is defined by de Jong et al. (2012)<sup>2</sup> as the sustainable processing of biomass into a spectrum of marketable products (food, feed, materials, chemicals) and energy (fuels, power, heat), using a wide variety of conversion technologies in an integrated manner. This definition is also employed by the Bio-based Industry Consortium<sup>3</sup>. Therefore, this research brief dedicates a section also on the concept of "integrated biorefinery", which follows this last definition.

### OBJECTIVES AND SCOPE

The general objective of this research brief is to illustrate the level of development of the bio-based industry in the EU in terms of number and location of biorefineries.

With this purpose, the JRC developed a database of facilities producing the following:

- **Bio-based chemicals:** including platform chemicals, solvents, polymers, paints, coatings, inks, surfactants, cosmetics, adhesives, lubricants, plasticisers, stabilisers, enzymes and agrochemicals, among others;
- **Liquid biofuels:** including bioethanol, biodiesel and bio-based jet fuel among others;
- **Bio-based composites and fibres:** including wood-plastic composites, natural fibres composites and different types of fabrics, among others;

<sup>1</sup> US DOE, 1997, Energy, Environmental and Economics (e3) Handbook, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Washington D.C.

<sup>2</sup> 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>. IEA Bioenergy - Task 42 Biorefinery

<sup>3</sup> <https://biconsortium.eu/news/mapping-european-biorefineries>

- **Other type of energy from biomass** (this part of the database is not comprehensive, see below): including electricity, heat and gas, among others.

The final database includes biorefineries at different Technology Readiness Level (TRL), i.e. commercial, demo, pilot and R&D biorefineries are all counted. Specific data are not shown since the distinction between the four levels was not always feasible based on the available information.

Finished goods/products derived from bio-based products (i.e. plastic bottles derived from bio-based polymers or car parts derived from bio-based composites) are not included in the scope of this study.

It is to be noted that the dataset on facilities producing other types of energy from biomass (257 in total) is not comprehensive as many plants producing only bioenergy (not biofuels and not bio-based products) have not been identified. Therefore, these 257 plants are not included in the maps to avoid confusion, but are taken into consideration in the case of integrated production (bio-based products and energy).

## METHODOLOGY

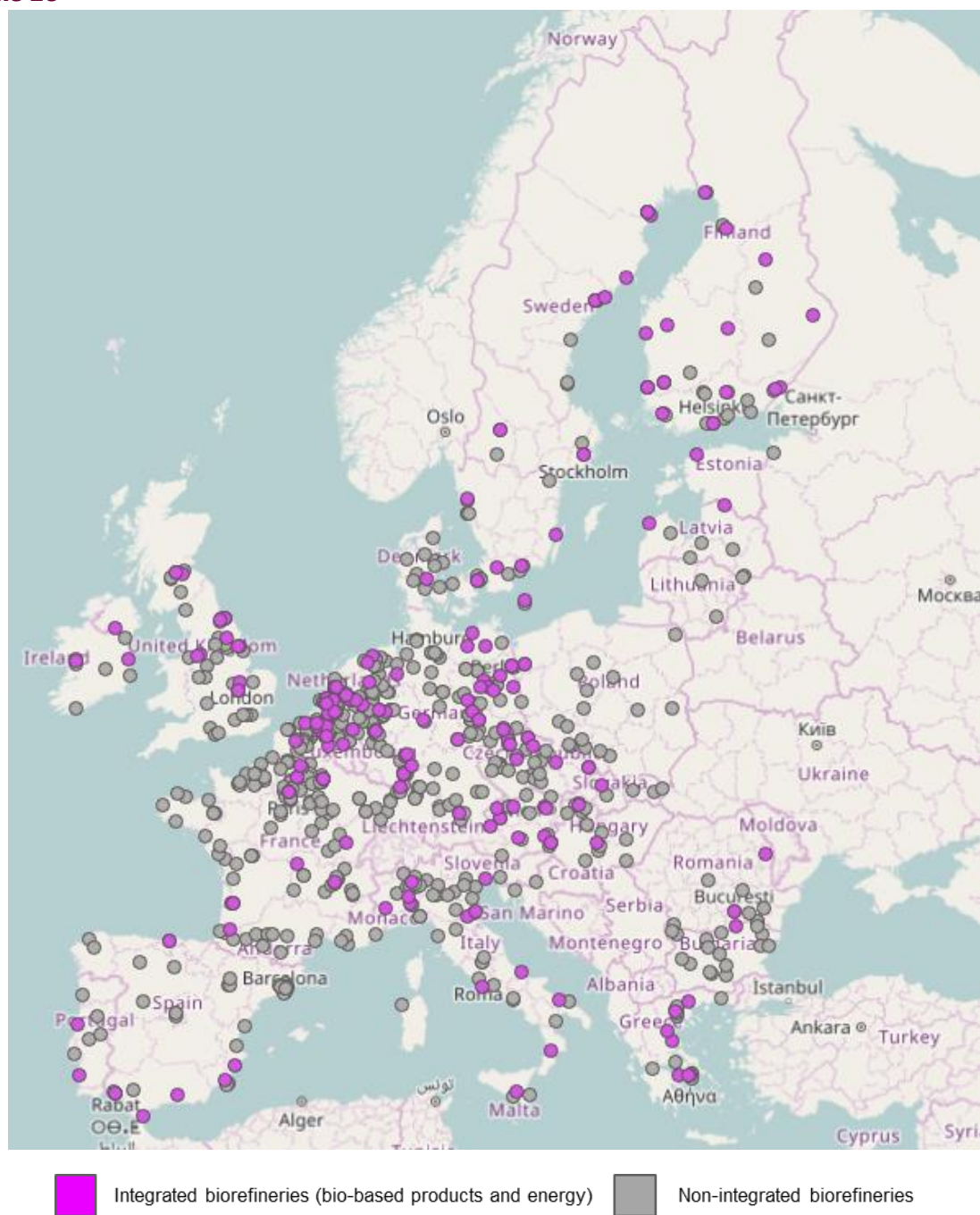
The following info sources were incorporated to build the database:

- Biorefineries database built by Claudia Pecoraro in 2015 at the Directorate-General for Research and Innovation
- A database used for the JRC survey to European companies done by E4tech/AgraCEAS (<https://ec.europa.eu/jrc/en/publication/eu-bio-based-industry-results-survey>)
- Nova/BIC database on biorefineries in the EU (<http://biconsortium.eu/news/mapping-european-biorefineries>)
- Nova iBIB database (<http://bio-based.eu/ibib/>)
- List of BIC members
- Agrobiobase website (<http://agrobiobase.com/en/database>)
- BiofuelDigest website (<http://www.ascension-publishing.com/BIZ/ABTDv18.xls>)
- ePURE list of bioethanol plants (<https://epure.org/resources/fact-sheets/>)
- E4tech database used for the report on the sugar platform (<http://www.e4tech.com/reports/from-the-sugar-platform-to-biofuels-and-biochemicals>)
- List of commercial biorefineries included in the BioRefineries Blog (<https://biorrefineria.blogspot.com.es/p/listado-de-biorrefiern.html?m=1>)
- List of bioenergy plants provided by the ETIP (European Technology and Innovation Platform) (<http://www.etipbioenergy.eu/databases/production-facilities>)
- Kompass Online Directory on business information (<https://bq.kompass.com/>)

Additionally, data were validated through information obtained from grey literature, online press and companies' webpages as well as support by external experts.

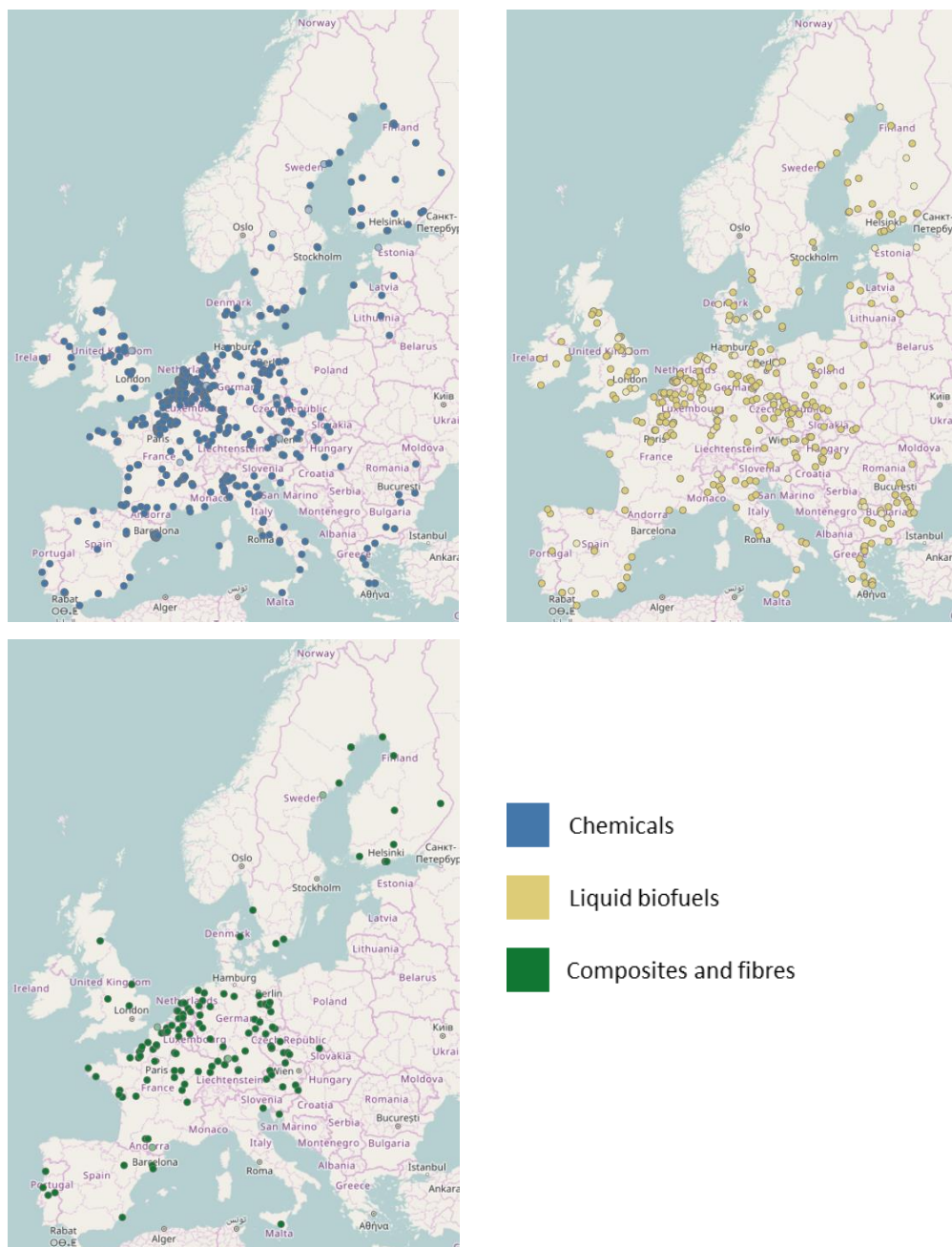
## RESULTS

### Map of biorefineries producing bio-based chemicals, liquid biofuels and composites and fibres in the EU



The map shows a total of 803 biorefineries identified in the EU that produce bio-based chemicals, liquid biofuels, and composites and fibres. Purple dots indicate biorefineries in which integrated production of bio-based products (chemicals and/or composites) and bio-based energy (biofuels and/or other types of energy from biomass) is taking place, and that thus reflect the strictest definition of biorefinery. They are 177 in total.

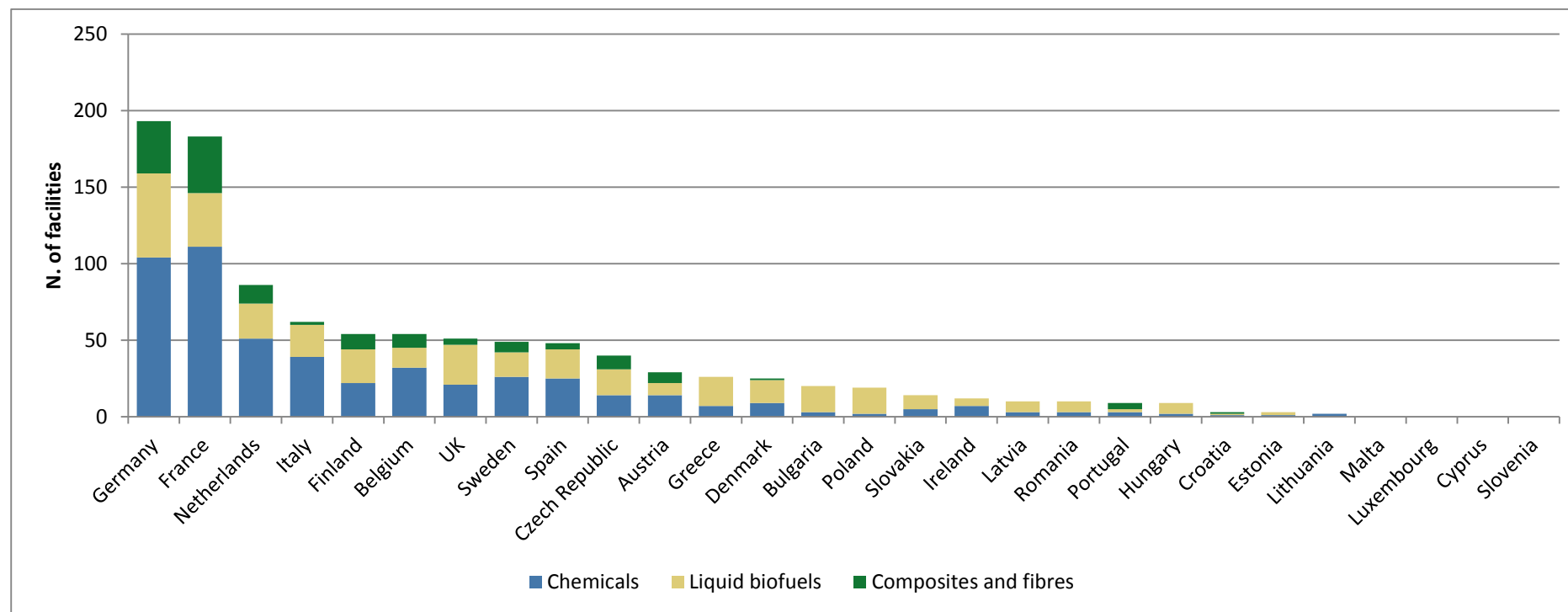
## Disaggregation of biorefineries per type of bio-based production



The maps show 507 biorefineries producing bio-based chemicals, 363 producing liquid biofuels and 141 producing bio-based composites and fibres. Some facilities (for example integrated biorefineries) produce more than one product category. Therefore, those plants are counted more than once and are shown in more than one map. Dots in lighter colour in each map indicate facilities that are currently inactive (but not necessarily as a permanent status).

A certain degree of correspondence between the location of biorefineries and the locations of ports and of chemical clusters in the EU can be observed in the maps. The highest density of biorefineries is in Belgium, the Netherlands and some highly industrialised regions of Germany, France and Italy. The lower number of biorefineries in the Eastern part of the EU demonstrates an untapped potential. The following graphs provide more details on the distribution of biorefineries per country.

## Geographical distribution of biorefineries per type of bio-based production

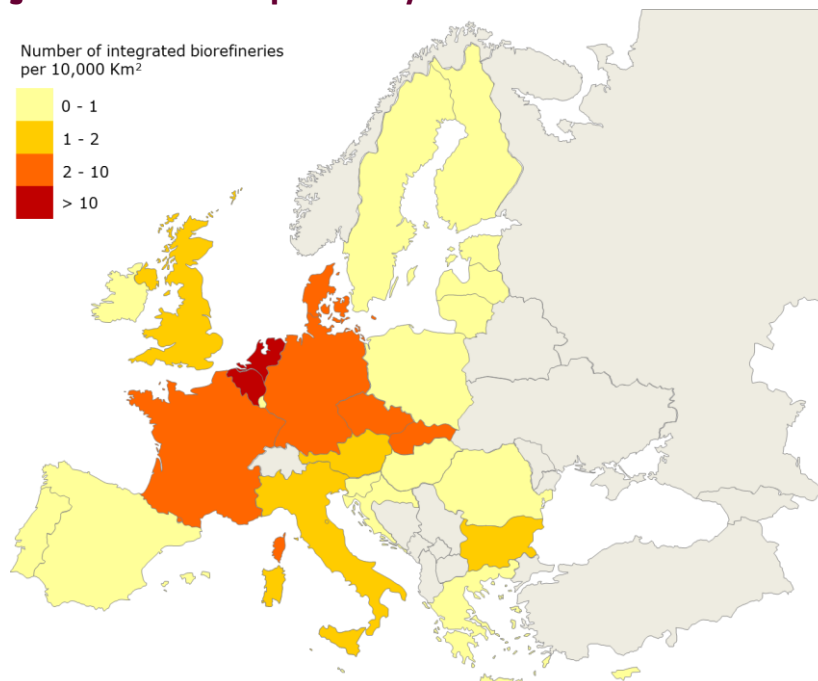


It should be noted that some biorefineries (for example integrated biorefineries) produce more than one product category and are therefore counted more than once in the graph. Also, it is important to take into consideration that the graph is based on the number of biorefineries per country, independently of their size, and not on production quantities.

According to the retrieved information, Germany and France dominate the scene in all product categories, followed with some distance by the Netherlands and Italy. In all four countries, bio-based chemicals represent the highest production in terms of number of biorefineries, while countries with lower number of facilities seem to have higher focus on liquid biofuels.



## Density of integrated biorefineries per country



The map shows the density of integrated biorefineries (as defined in the first map) per country. The data were obtained by dividing the number of integrated biorefineries by the country's area in square kilometres. It can be observed that the highest density of integrated biorefineries can be found in the Netherlands and Belgium, and generally in central EU.

## Feedstock categories:

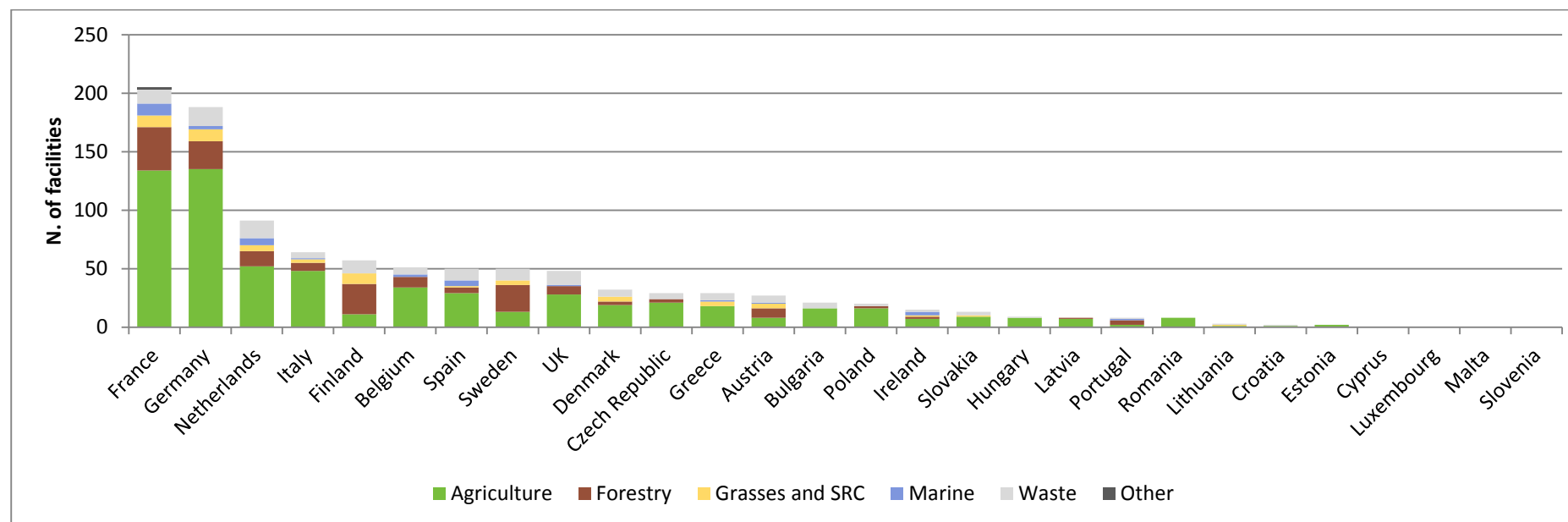
Origin	Feedstock categories	N. of facilities
Agriculture	Sugar/starch-based feedstock	216
Agriculture	Oil/fat-based feedstock	275
Marine	Oil/fat-based feedstock	34
Agriculture	Agricultural residues (in the field)	76
Agriculture	Secondary residues and by/co-products of industry utilising agricultural products	111
Agriculture	Intermediate products derived from agriculture-based feedstock*	23
Agriculture	Vegetable fibres	67
Agriculture	Other agricultural products	13
Forestry	Wood	77
Forestry	Forestry intermediate products OR secondary residues and by/co-products of industry utilising forestry products	124
Grasses and SRC	Grasses and SRC (short-rotation coppice), including derivatives	57
Waste	Waste	136
Other	Other	2

\*Intermediate products refer to bio-based chemicals (e.g. ethanol, lactic acid, PLA, etc.) used as feedstock for new bio-based products (usually polymers and composites).

It is important to notice that some biorefineries employ feedstock belonging to more than one category and are therefore counted more than once in the table.

As illustrated in the previous graph by country, the main feedstock source in the EU in terms of number of biorefineries (not of quantities employed) is represented by agriculture, followed by forestry, waste, marine and other (i.e. insects-derived feedstock).

## Geographical distribution per type of biomass feedstock used



As previously stated, some biorefineries employ feedstock belonging to more than one category and are therefore counted more than once in the graph. Also, it is important to take into consideration that the graph is based on the number of biorefineries per country, independently of their size, and not on biomass quantities used.

From the data available it can be observed that:

- The predominant type of feedstock in almost all countries derives from agriculture, with the exception of Finland, Sweden and Portugal in which forestry-derived feedstock dominates (i.e. is used in more than 50% of biorefineries in the country);
- Marine-derived feedstock (like fish oil and macro/micro-algae) is employed by a relevant number of facilities e.g. in France (10 facilities), The Netherlands (6), Spain (5), Germany (3) and Ireland (3);
- Waste-derived feedstock is especially represented in Germany (16 facilities), The Netherlands (15), France (12), UK (12), Finland (11), Sweden (10) and Spain (10).



## FUTURE STEPS

Further research aims at determining the level of development of the bio-based industry in the EU and the potential for future growth in terms of number and location of new biorefineries. Future steps in this direction are being carried out by linking the location of current bio-based facilities with the specific kinds of locally available biomass (with main focus on agriculture and forestry at the moment), to establish optimal locations of new biorefineries for the best exploitation of local resources.

The JRC is also planning to make future updates of the map of bio-based facilities, depending on policy needs and available resources.

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### AUTHOR:

PARISI Claudia

### CONTACT:

[Claudia.PARISI@ec.europa.eu](mailto:Claudia.PARISI@ec.europa.eu)

[Robert.M'BAREK@ec.europa.eu](mailto:Robert.M'BAREK@ec.europa.eu)

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