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Biomass production, supply, uses and flows in the European Union

Integrated assessment

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15 Biomass for selected bio-based industrial value chains in a dynamic global economy

Myrna van Leeuwen, Robert M'barek, Kirsten Boysen-Urban, Patricia Gurría, Tevecia Ronzon, Viktoriya Sturm

Key messages

- Europe, Asia and North America have very similar shares in the global bio-based chemical markets of around 30%.
- It is estimated that 13.2% of corn, 7.4% of wheat, and 8.2% of sugar beets in the EU is used for material purposes.
- The main (processed) feedstocks (incl. imports) used for bio-based products are plant oil (30%) and starch (25%).
- In terms of volume, biofuels (42%) is the most important application category within bio-based chemicals, followed by bio-based agrochemicals (21%) and bio-based surfactants (12%).
- Under unchanged policies, the share of arable crops for material use is projected to rise slightly from 8.2% in 2020 to 9.7% in 2050, so the intended growth of bio-based materials may be met with a stronger increase of imported feedstock unless targeted policies and technologies (e.g. upscaling valorisation of unused biomass from waste streams and residues) to increase domestic production are deployed.

The European Commission defines bio-based products as products that are wholly or partly derived from materials of biological origin, excluding materials embedded in geological formations and/or fossilised[100]. As a central element of EU's Bioeconomy Strategy, bio-based products and its related processing plants, the biorefineries at scale, could play an important role in transforming industrial facilities towards the environmental ambitions of the EU, while creating jobs and growth in rural areas (European Commission, 2022). Bio-based products can also contribute to a sustainable economy by reducing dependency on fossil resources, and bring new functionalities (Spekreijse et al., 2019). Bio-based products comprise established products that have been in the market for long time, and some novel ones that are not fully commercialised yet.

While bio-based production is still small in scale, (bio-based) plastics is a good example to show the potential and challenges of the bio-based economy. Fossil-based plastic production in 2018 reached 62 million tonnes in Europe (EU-28 + Norway and Switzerland) while worldwide the production amounted to 359 million tonnes. In the meanwhile, the bio-based production worldwide reached only 7.4 million tonnes[101]. The demand of plastics is expected to increase to 1,200 million tonnes by 2050, where 135 million tonnes will be met with bio-based plastics and the biggest amount by plastics recycling[102].

While the additional economic value of an increased use for bio-based products for rural areas is undisputed, the question of competition for feedstock for food and non-food purposes remains a central question, also raised in the latest Bioeconomy Progress report (European Commission, 2022). In this chapter, we support this debate with the latest research on feedstock use of the main arable crops in bio-based chemical value chains.

Before turning to the feedstock use, we provide insights into the global bio-based chemical market, including comparisons of bio-based and fossil-based value chains. While the numbers provided are only a snapshot of a particular market situation and cannot be compared to the exceptionally high energy prices in the year 2022, they nonetheless point to the main factors determining the competitiveness of EU bio-based products – in the domestic and global market.

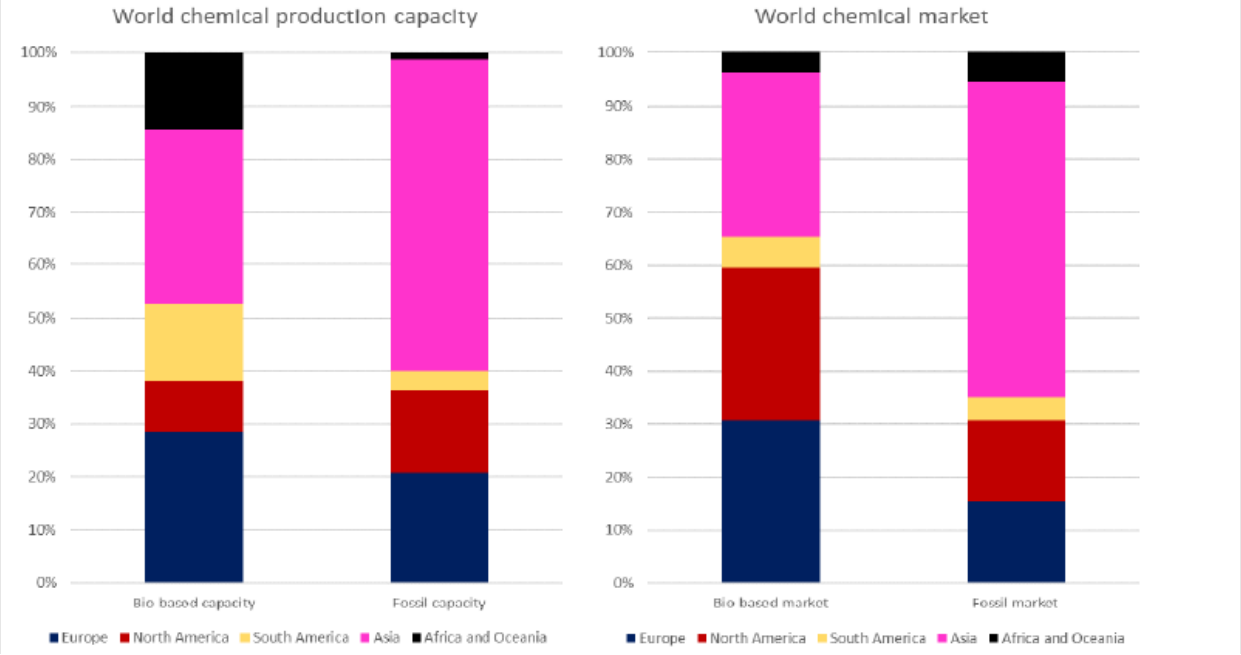
[100] https://single-market-economy.ec.europa.eu/sectors/biotechnology/bio-based-products_en.
[101] https://nova-institute.eu/press/?id=164.
[102] http://bio-based.eu/downloads/world-plastic-production-and-carbon-feedstock-in-2018-and-scenario-for-2050/.

The reader should note that due to the different sources of information and the limited data availability, the definitions applied for bio-based chemical products are variable in this chapter, for instance excluding or including biofuels.

15.1 EU bio-based chemicals production in the global market

Asia is the global leader in fossil-based chemical production (comprising of chemicals, plastic and pharmaceuticals) by a share of 58%. Europe follows with a 21% share as presented in Figure 148. In terms of bio-based chemical markets (economic values), Europe, Asia and North America have very similar shares of around 30% each (Spekreijse et al., 2021).

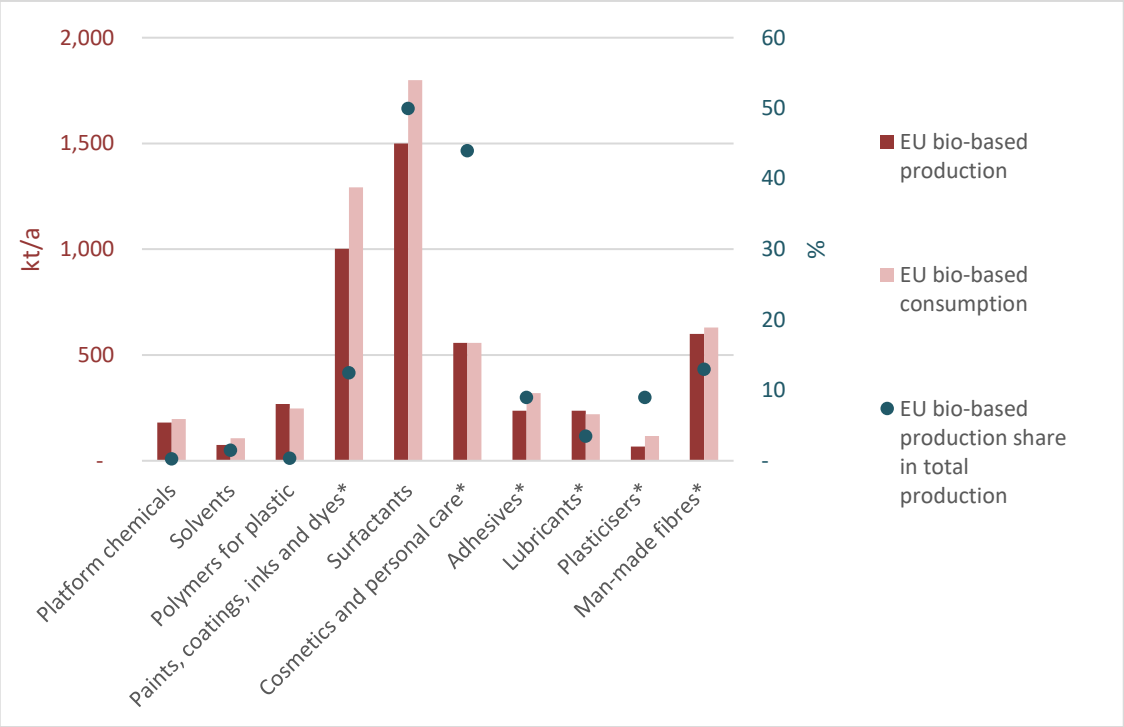
Figure 148. Share of fossil and bio-based chemicals (including chemicals, plastic and pharmaceuticals) for the global production capacities (based on ktonnes/years) and market (based on EUR millions/year).



Source: Spekreijse et al., 2021.

Spekreijse et al. (2019) estimate the size of total bio-based production for 10 selected chemical product categories. Taking the period 2000-2016 as reference, surfactants and paints, coatings, inks and dyes had the highest share of bio-based production, remaining below or around 10% for the majority of the products. For most of the products, EU's bio-based consumption was higher than the domestic production, indicating a net import position.

Figure 149. Size of total bio-based production for 10 selected chemical product categories.



Note: No total EU production data were found; it has been assumed that total EU production (fossil- and bio-based) equals the total EU market (fossil- and bio-based consumption).

Source: Adapted from Spekreijse et al., 2019.

15.2 Exploring bio-based and fossil cost shares at industry level

The competitiveness of bio-based industrial products is often seen in the context of its fossil-based counterparts. Indeed, the importance of the costs for either fossil or bio-based feedstocks has been demonstrated for example in Philippidis et al. (2019), where higher oil prices trigger a certain growth of bio-based alternatives.[103]

In Spekreijse et al. (2021), cost-share data has been compared with fossil industries, focussing on sectors, processes, feedstocks, and regions, grouped at industry level (i.e. chemicals, plastics, and pharmaceuticals). The key difference between the fossil and bio-based industries is the higher cost shares in feedstock for bio-based industries, particularly in the plastics sector and for those value chains that use vegetable oil as feedstock.

As a limitation of the quantitative analysis, it should be noted that bio-based cost shares are based on the bio-based products that have successfully reached large-scale production. These results are therefore biased towards bio-based products that can compete with their fossil-based counterparts. The cost shares of all bio-based products, regardless of their success in large-scale production, would better reveal where the hurdles are for the large-scale production of innovative bio-based products. Table 16 provides a summary of the information available on production and costs for seven selected value chains.

[103] The reader should however bear in mind that high oil prices also dampen the overall economic activity and therefore, depending on the price shock, reduce ceteris paribus the overall size of the market due to reduced consumption, limiting also the perspectives of the bio-based alternatives.

Table 16. Summary of production and cost data collected per value chain (ktonnes/year).

Industrial sector	Chemicals			Plastics		Pharmaceuticals	
Intermediary chemical	**Acetic acid**	**Propylene glycol**	**Succinic acid**	**PET**	**PUR**	**Lactic acid**	**Levulinic acid**
Drop in or dedicated	drop-in	drop-in	drop-in	drop-in	drop-in	dedicated	dedicated
Total (fossil & bio-based) production	16546	2520	50	24059	22334	769	6
Bio-based production ktonnes/year	346	424	10	559	7.5	769	6
- Europe	72	28	10	0	0	149	3
- North America	34	196	0	0	7.5	245	0
- Asia	240	200	0	161	0	375	3
- Rest of the world	0	0	0	0	0	0	0
Bio-based share in total production	2.1%	17%	20%	2.3%	0.03%	100%	100%
- Europe	0.4%	1%	20%	0	0	19%	50%
- North America	0.2%	8%	0	0	100%	32%	0%
- Asia	1.5%	8%	0	100%	0	49%	50%
- Rest of the world	0	0	0	0	0	0%	0%
Price bio-based €/kg	0.94	1.34	2.61	1.13	2.04	1.17	4.50
Price fossil-based €/kg	0.56	1.34	2.25	1.05	1.76	1.75	N/A
Cost disadvantage (-) /advantage (+) ratio	-66.70%	0%	- 16%	-7%	-16%	+ 33%	N/A

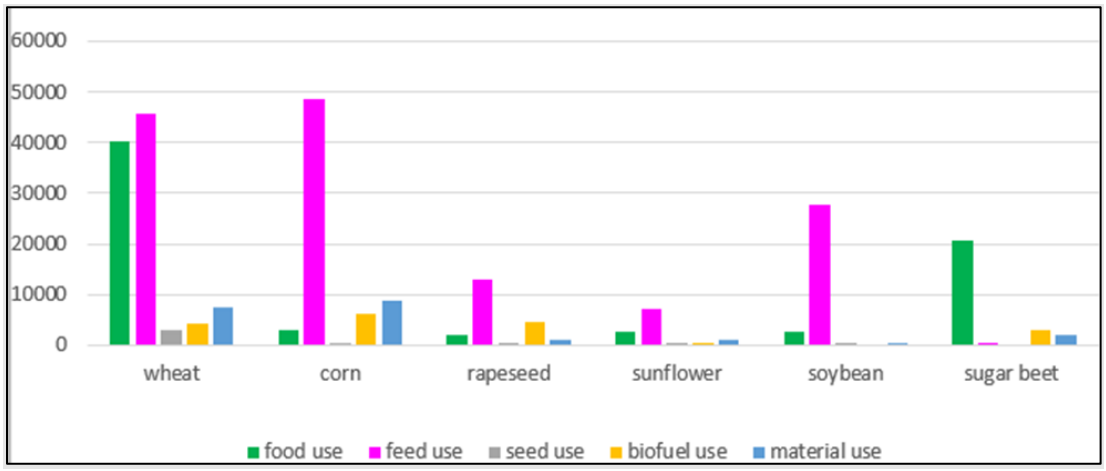
Source: Spekreijse et al., 2021.

15.3 EU feedstock use for selected bio-based industrial products

With regard to the use of marketable agricultural products, i.e. without grazing, the H2020 project BioMonitor provides insights into the EU (and Member State) allocation of arable biomass over uses. The results depicted are based on the combined use of the AGMEMOD (AGriculture MEmber State MODelling) and the newly developed BioMAT (Bio-based MATerials) models. The BioMAT model is a multi-regional partial equilibrium model of innovative bio-based products markets. It applies the same framework as AGMEMOD, accounting for the supply, import, export, use, and price of innovative bio-based materials in EU Member States (Van Leeuwen et al., 2022).

Looking at the overall use of arable biomass from agricultural production for the year 2020 (see Figure 150), corn and soybean are mainly used as feed. Common wheat is used mainly for food and feed, whereas sugar beet is used in particular for food. Regarding the material use (i.e. excluding biofuels) of agricultural products, we observe that a share of 13.2% of corn, 7.4% of wheat, 8.2% of sugar beets and 4.1% of seeds is allocated to material purposes. The values in kton of dry matter are reported in Figure 150.

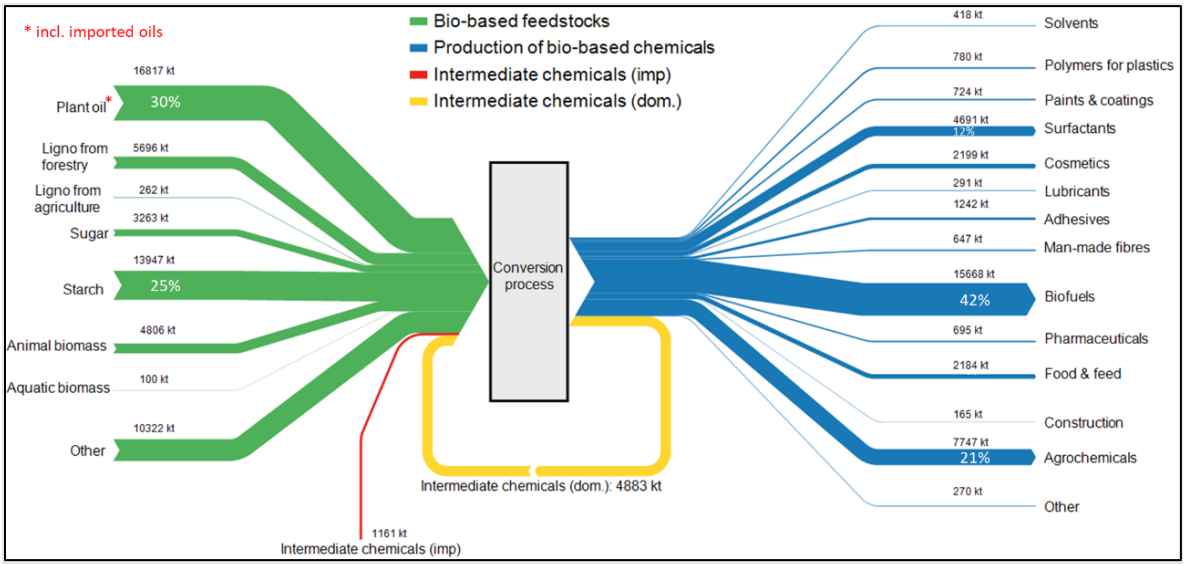
Figure 150. Uses per crop in the EU-27, 2020 in kton dry matter.



Source: AGMEMOD baseline results.

The combination of the agrifood modelling with the detailed depiction of the feedstock used for the production of bio-based industrial products allows to create a detailed flow chart for the first time. Figure 151 shows the different feedstocks used, summing up to around 55 million tonnes, including imports. This feedstock, mainly in the form of plant oil (30%) and starch (20%), enters the conversion process. As shown in Figure 151, the total physical quantity of bio-based chemicals (incl. biofuels) is estimated, according to the C20 NACE classification[104] "Manufacture of chemicals and chemical products", with biofuels accounting for approximately 42% of the total output, followed by agrochemicals (21%) and bio-based surfactants (12%). The developed approach enables also the creation of more detailed flow charts that show, for example, the use of different feedstocks for only one specific application category or the distribution of use of one specific feedstock over different application categories (Sturm et al, 2023).

Figure 151. Flow chart of the feedstocks for the selected bio-based industrial products (C20), EU-27+UK, 2018

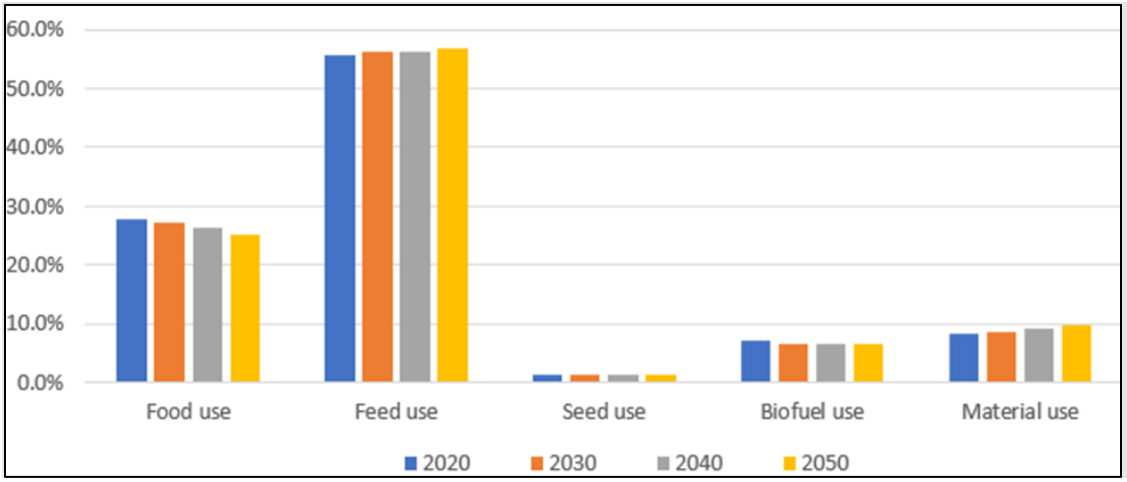


Source: Sturm et a.l, 2023.

[104] NACE is the statistical classification of economic activities NACE Rev. 2 .

In addition, the BioMonitor forward-looking modelling exercise provides projections until 2050 by applying different assumptions, including the scenarios from the Global Energy and Climate Outlook (GECO) published by the EC's Joint Research Centre.[105] With a shrinking population, the share of food use would be slightly reduced (towards one quarter), while still more than half of the arable crops go into animal feed. The share of arable crops for material use is projected to slightly rise from 8.2% in 2020 to 9.7% in 2050 (see Figure 152), that is, under the assumed status quo of policies, not adding pressure on markets and ecosystems.

Figure 152. Uses of arable crop in EU, 2020-2050, % share.



Source: AGMEMOD baseline projection results.

The modelling exercise calculates, for the current situation, a net import position for bio-based chemicals of about 8 million tonnes, which could more than double towards the end of the projection period, because of the increased domestic use.

15.4 Conclusions for Chapter 15

The EU is well-positioned in the world market for bio-based chemical products. Since higher cost shares in (bio—based) feedstock have been identified as the main difference between fossil and bio-based chemical products, (particularly in the plastics sector and for the use of vegetable oil), the EU's competitiveness is very much linked to the costs for feedstock.

Further insights into the value chains of EU bio-based products are provided through an analysis of the different feedstock used, namely the arable crops maize, wheat, and sugar beet, if looking at domestic production. When including biofuels in the definition of bio-based chemical products, the analysis shows that biofuels account for about 42% of the total output, followed by agrochemicals (21%) and surfactants (12%). A detailed flow from feedstock to the products is not yet available. Latest research shows that the main (processed) feedstocks (incl. imports) are plant oil (30%) and starch (25%).

Focusing on primary agriculture (arable crops), the share of material use of agricultural products in total use, i.e. mainly non-food/non-biofuels, is estimated to 8.2% in the EU-27, which is much smaller compared to the use for food (27%) and animal feed (56%). While under unchanged policies the share of arable crops for material use in the EU is projected to rise only slightly from 8.2% in 2020 to 9.7% in 2050, it can be expected that the import of feedstock for material use could rise further to allow for the intended growth of the bio-based industry, especially those not produced in the EU, e.g. palm oil. To this end, targeted policies and the deployment of technologies to valorise unused biomass from waste streams, residues and other sustainable sources, would be needed to increase domestic production.

[105] More information available in the BioMonitor Policy Brief 2021-03-11_BIO_PolicyBrief-3_digital.pdf (biomonitor.eu)

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