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The EU bioeconomy towards 2040

An exploratory baseline with a whole-economy, an agricultural and a bio-based industry model

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Contents

Abstract

As the European Union (EU) seeks to transition towards a more sustainable and resilient future, the bioeconomy emerges as a pivotal driver, offering opportunities to advance simultaneously in sustainability and competitiveness. The bioeconomy encompasses a wide range of activities delivering sustainable solutions based on renewable biological resources, from agriculture and forestry to biotechnology and bio-based industries, to produce food, materials, and energy, and contribute to ecosystem health.

The present report summarises enhancements made with three recognised (bioeconomy) economic modelling tools (**MAGNET**, **AGMEMOD** and **BioMAT**) to better capture the nuances of bio-based markets and provides a plausible medium-term baseline that combines the strengths of the simulation models. MAGNET (Modular Applied GeNeral Equilibrium Tool) is a recursive dynamic, multi-region, macroeconomic CGE simulation model with a focus on natural resources and bio-based activities. AGMEMOD (AGricultural MEmber State MODelling) is an econometric, dynamic, partial-equilibrium multi-country model initially developed for EU agricultural crop markets, whilst the model captures the interactions with non-EU countries' agricultural systems. BioMAT (Bio-based MATerials), which follows the same framework as AGMEMOD, is a multi-regional PE model that provides projections for markets of bio-based product groups as well as for associated biological feedstock needs.

A baseline or 'business-as-usual' scenario until 2040 was built representing a continuation of current trends and societal attitudes, assuming no major changes in societal behaviour or in relevant policies. A main purpose of the baseline scenario is to serve as reference pathway for measuring the impacts of alternative bioeconomy futures. This report depicts the main results of the baseline consistent with five societal challenges the bioeconomy should address, as defined in the objectives of the EU bioeconomy strategy 2018.

Regarding **food and nutrition security**, the baseline developments show an increase of crop production volumes due to yield productivity growth. However, agricultural land in the EU becomes slightly less productive due to the new CAP measures (fallow land, Eco-scheme measures). Mostly driven by world market developments, EU food prices are slightly higher. Nevertheless, food becomes more affordable as the average amount of income spend on food decreases by 12.3%. The quantity of calories consumed increases slightly with rising income levels, including a very small increase in less healthy calories from red meat and sugars. The use of biomass for feed use in the animal sector, although already high, increases further towards nearly 59%. This is in line with the consistently high share of animal protein intake in the consumers' total protein intake in coming decades.

Regarding the objective of **managing natural resources sustainably**, biofuel domestic use is gradually declining up to 2040 because total transport fuels are expected to be substituted by electric riding/battery driven transport after 2023 which should reduce greenhouse gas emissions. At the same time crop-based feedstock for biofuels is replaced by advanced biological feedstock. It is assumed that the released crop-based feedstock for biofuels after 2023 will become available as extra biological feedstock for the material industry.

Mitigating and adapting to climate change is taking place. Under assumptions regarding carbon permit prices on selected activities, the total quantity of direct emissions in the EU27 is estimated to fall from approximately 4.1 billion tonnes of CO_2 equivalent (CO_2e) in 2017 to 3.2 billion tonnes of CO_2e by 2040 (decrease of approximately 20%). This is accompanied by emissions per unit of GDP declining by 33%. However, since many of the emissions in primary agriculture are

process driven and in the absence of any specific adaptation and mitigation measures, a stable pattern of output in the EU is reflected in the direct emissions trends. As a result, the share of agriculture, forestry and fishing emissions of the EU total rises to 15.8% by 2040.

Examining the **dependence on non-renewable, unsustainable resources**, the bioeconomy industry shows a steady development, but speed is insufficient to achieve higher shares without additional green investments and policy support. In addition, the available biological feedstock for food, feed, seed, biofuels, and material uses in the EU is insufficient to fulfil the requirements of a strongly increasing bio-based industry in the coming decades, though the dependency on imports is decreasing. However, EU regulations on sustainably sourcing of feedstock to diminish deforestation (Deforestation directive) and less productive land availability in the EU for biomass production will start to play a role in the future and may limit the expansion of the bioeconomy in the EU. On the other hand, the exploiting of agricultural and forestry residues, as well as the use of other renewable options other than biomass use (e.g. electric battery technologies as an alternative of biofuels in transport sector) will diminish the requirements of biomass for the material and energy industries. Elsewhere, while the total amount of EU municipal waste continues to increase slightly, there is a moderate fall in EU household waste driven by a falling population and changing household consumption patterns.

Regarding **competitiveness**, the production index of EU average bio-industrial real growth rises from 112 in 2025 to 143 by 2040. In the case of EU biochemicals (i.e., composite of bio-based chemicals, bio-based pharmaceuticals, and bio-based plastics), real production growth is above the EU bio-industrial average, reaching an index value of 160. Overall **employment** in the non-food bioindustry sectors rises by approximately 7%, although the contraction in employment in the food sector results in an overall reduction in all bio-industrial employment of approximately 6%. Overall, for the collective of EU bio-industrial activities, the trade balance for the EU bioindustry improves.

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1. Introduction

The present report summarises the enhancements made with recognised (bioeconomy) economic modelling tools to better capture the nuances of bio-based markets and provides a plausible medium-term baseline that combines the strengths of the simulation models. As such, this study is envisaged as an initial preparatory step for scenario-based analyses that might serve as further insides into different pathways for the EU bioeconomy, in the event of the upcoming update of EU Bioeconomy Strategy and Action Plan expected at the end of 2025. The design of the modelling framework, which started in 2023, considers a range of modelling enhancements and alignments that are relevant to policy documents and topics as presented in the following.

The **Bioeconomy Strategy** published in 2018 is underpinned by five interlinked bioeconomy objectives, namely (i) ensuring food and nutrition security, (ii) managing natural resources sustainably, (iii) reduced dependence on non-renewable resources, (iv) mitigating and adapting to climate change, and (v) strengthening European competitiveness and creating jobs. The modelling tools use the objectives as an indicator framework to be as close as possible to the existing EU Bioeconomy Monitoring System.

The **Bioeconomy Progress Report** (EC, 2022) emphasized the cross-sectoral perspective of the bioeconomy to improve policy coherence and to identify and resolve trade-offs, for example on land and biomass demands. These policies contribute to build a bioeconomy that addresses the three dimensions of sustainability, which are (1) *environment* - management of land and biological resources within ecological boundaries; (2) *economy* - sustainable value chains and consumption; and (3) *society* - social fairness and just transition. The Progress Report stressed the need for additional focus on some key aspects of the 2018 EC Bioeconomy Strategy to meet the high stakes and ambitions of the **European Green Deal**, which are i) ensuring environmental integrity, ii) closing the projected 'biomass gap' between supply and demand of biomass for food, feed, seed, energy and materials in the EU, iii) resolving multiple pressures on land for mitigation, nature protection and the supply of biomass, iv) better understanding of the overall consumption of biological resources is needed to help shifting to more sustainable consumption patterns.

Next, the **2023 (April) Council Conclusions** on the challenges and opportunities of the bioeconomy[1] highlighted the need for an updated EU Bioeconomy Strategy. Also, the Council asked the Commission to improve its impact assessments to better consider policy consistency between legal acts and strategies on (1) the development of the bioeconomy; (2) their joint contribution to European Union goals; and (3) their cumulative effect on land use, supply of raw material and energy resources.

Last but not least, the **2024 Council conclusions**[2] urged "the Commission to finalise the update of the bioeconomy strategy by the end of 2025, to ensure that the bioeconomy contributes substantially to the green transition of the economy, to recognise biotechnology and the bio-based economy horizontally as an elementary part of the EU's industrial policy, and to ensure coordination in order to enhance policy coherence".

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[1] https://knowledge4policy.ec.europa.eu/bioeconomy/eu-council-conclusions-bioeconomy-25-april-2023_en#:~:text=The%20Council%20conclusions%20explicitly%20acknowledge,social%20progress%20towards%20a%20sustainable

[2] https://data.consilium.europa.eu/doc/document/ST-10127-2024-INIT/en/pdf

The **EU biomanufacturing sector** is facing several challenges like the upscaling of technology innovations to the market, complexity of regulations in force, access to finance and skills, value chain obstacles, public acceptance and economic feasibility. Therefore, the EC has put forward a set of actions in its 20 March 2024 Communication to tackle these challenges and to boost the biotechnology and biomanufacturing in the long term.

The incoming European Commission mandated for the period 2024-2029 under the renewed stewardship of Ursula von der Leyen, has set out seven key priorities. Of most direct relevance to this research are the plans for (i) sustainable prosperity and competitiveness and (ii) sustaining our quality of life through a competitive and resilient agrifood system, safeguarding biodiversity and preparedness for climate change.

Many of the published initiatives are relevant for the bioeconomy: the New Industrial Deal, the Competitiveness Compass, the Life Sciences Strategy, A European Chemicals Industry Action Plan. Furthermore, the Vision for Agriculture and Food, adopted in February 2025, has set out perspectives to expand bioeconomy, to valorise by-products and waste, to accelerate market access for biopesticides and to support the uptake of low-carbon fertilisers from recycled nutrients and digestate from biogas.

The **upcoming Bioeconomy Strategy** (2025) aims to improve resource efficiency, sustainability and circularity, build lead markets and tap the significant growth potential of bio-based materials substituting fossil-based materials, and related industries. At the same time, it could further reduce dependencies on imported raw materials for the EU chemicals industry.

This study uses a **(bio)economy modelling framework** to address some of the complex questions and challenges related to the bioeconomy. The point of departure for this study was the accumulated expertise that had been gained from the H2020 EU BioMonitor project. Taking an EU member state focus, the modelling task of BioMonitor created a platform consisting of a suite of five simulation modelling representations that capture both the vertical and horizontal dimensions of biomass usage (i.e., biomass supply chains across different activities and biomass competition effects between food, feed, energy and materials). Two of the models were forest market models (EFISCEN, EFI-GTM), whilst the remaining three dealt with the specifics of nascent bio industrial activity (BioMAT), the agrifood sector (AGMEMOD) and the broader macroeconomy (MAGNET) with coverage of bio-based food, feed, energy and material activities. Using soft model linkages, a comprehensive and harmonised (across models) baseline scenario was constructed, which would subsequently serve as a basis for further exploratory foresight scenarios. The outcomes of these scenarios were categorised through the lens of the EU's five bioeconomy objectives as outlined in the Bioeconomy Strategy (EC, 2018).

For this study, three of the models, AGMEMOD, BioMAT and MAGNET, are considered. The models are connected to each other via a harmonized set of assumptions. Each model has its specific scope (see annex) and set of indicators. Indicators are complementary to each other and have been tested on coherency across their developments over time. In the annex, a detailed description of the modelling tools and the assumptions for the baseline can be found.

Section 2 presents and discusses the baseline situation for a set of carefully considered indicators in tables and figures. In section 3, the results are discussed in the context of the potential and synergies and trade-offs that are thrown up from the baseline results. This section also highlights some of the caveats of the research. The annex describes the chosen models with regard to key drivers, temporal, and indicator coverage. In addition, it explains the selection of models and the aggregation of products.

2. Baseline results

The baseline or 'business-as-usual' scenario builds upon the BioMonitor project and represents a continuation of current trend and societal attitudes, assuming no major changes in societal behavior (Philippidis et al., 2023). A main purpose of the baseline scenario is to serve as reference pathway for measuring impacts of alternative bioeconomy futures. Thus, the guiding criterion behind the baseline is to characterise within the used models a continuity of trends on the future situation of bioeconomy markets and attitudes by society until 2040. Where possible, the baseline scenario results as produced by the models depart from a harmonised set of assumptions that drive the market developments for key bio-based sectors (e.g., agriculture, bioenergy, biochemistry). A detailed discussion of these drivers, assumptions used and sources of data is given in the annex.

In general terms, the trends assumed in the models refer to a continuation of macroeconomic and population developments, technology change, world oil prices, climate change, and consumption patterns as currently expected until the year 2040 (the end year of our analysis). Moreover, the baseline encapsulates a series of reasonable biomass-related public policy instruments and regulations (i.e., agricultural policy, energy policy), whose evolution and design, as far as feasible, reflects current and anticipated developments. Taking into account the time frame of policies, a greater degree of certainty on public policy design is available to 2030, while beyond this point (i.e., until 2040) 'reasonable assumptions' have been introduced (thus budget limits for policy, the structure of CAP payments across activities, blending rates for bio-based energy inputs etc. are kept the same as known in the last year).

For the interpretation of the bioeconomy baseline outlook results, it is important to bear in mind that projections are neither forecasts, nor predictions. Usually baseline results are driven by several underlying assumptions and exogenous variables, which are determined outside the model. In this respect a baseline assumes normal biophysical and climate conditions, steady demand and yield trends and no market disruption, provoked by, for example, wars, outbreak of diseases, food safety issues, extreme weather conditions (Salputra et al, 2017; EC, 2023). Consequently, all assumptions imply relatively smooth market developments, although in reality markets tend to be much more volatile. Therefore, the baseline scenario must not be considered as a forecast, but rather as a possible pathway that the EU bioeconomy market is expected to follow given unchanged policies, a continued development of demand and technological progress, and a continuation of normal geopolitical, macroeconomic and weather conditions.

This section presents the highlights the main results of the bioeconomy baseline scenario, which assumes the continuation of recent driving factors on the production, usage and trade of bio-based products and sectors until 2040. As explained in previous section, these factors reflect trends on macroeconomy, demography, technology change, consumption preferences, policies and social attitudes in the absence of any drastic change by policy or society. In following sub-sections, the performance of the baseline scenario is quantified in figures and graphs via a set of indicators (consistent with the five societal challenges of the bioeconomy (Philippidis et al., 2024):

- Ensuring food and nutrition security (section 2.1).
- Managing natural resources sustainably (section 2.2).
- Reducing dependence on non-renewable, unsustainable resources whether sourced domestically or from abroad (section 2.3).
- Mitigating and adapting to climate change (section 2.4).
- Strengthening European competitiveness and creating jobs (section 2.5).

2.1. Ensuring food and nutrition security

Table 1 covers the indicators that inform about the performance of the first bioeconomy societal objective “ensuring food and nutrition security”.

Table 1. Indicators on ”Ensuring food and nutrition security”.

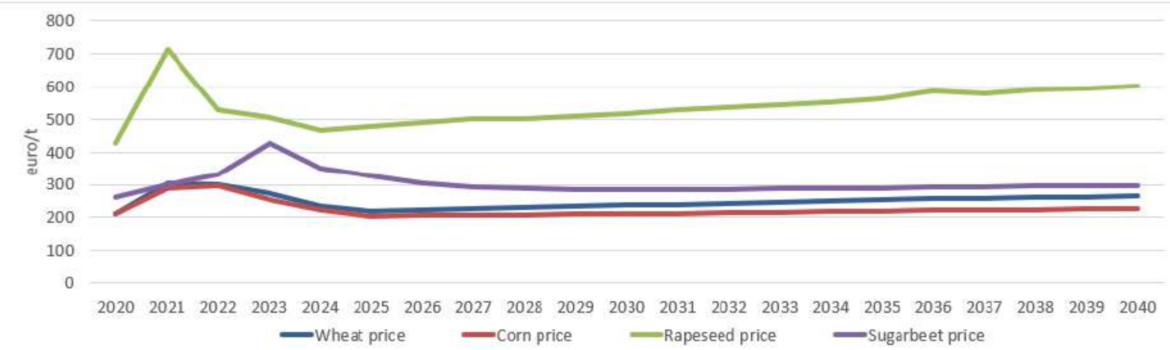
Indicator (definition)	Metrics	Model
Agri-food prices (by commodity, EU MS)	euro/100kg	AGMEMOD
Net-trade of agri-food (by commodity, EU MS)	kton	AGMEMOD
Plant-based and animal-based proteins consumption (by commodity, showcased for the Netherlands and Germany)	gram proteins/ capita/day	AGMEMOD
Food budget share in household consumption, EU MS)	share	MAGNET
Average kilo calories per capita per day (EU, MS)	kilocalories/capita/day	MAGNET

Source: JRC, own elaboration.

2.1.1. Agri-food prices

Figure 1 shows the price development for the main agricultural crops produced in the EU in the baseline scenario as produced by the AGMEMOD model.

Figure 1. EU price developments of main agricultural commodities in baseline, 2020-2040.



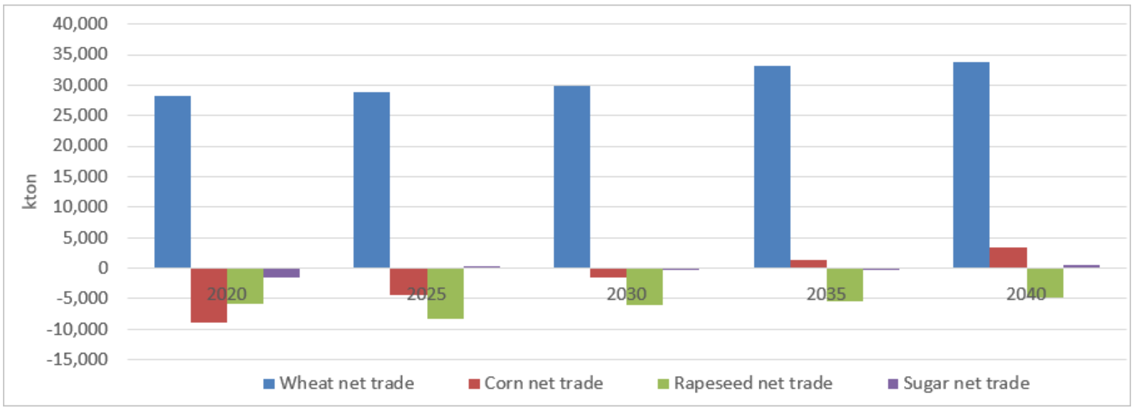
Source: AGMEMOD-BioMAT.

The patterns up to 2040 reflect the influence of factors that drive DG-Agri’s MTO agricultural outlook (EC, 2023). EU prices follow the world market price developments as projected by the OECD taking into account the supply and demand for commodities in non-EU regions.

2.1.2. Net-trade of agri-food commodities

Figure 2 gives the development of net-trade position of EU up to 2040. It shows that the EU is a net-exporter of wheat and a net-importer of rapeseed and sugar. For corn the position turns from a net-importer in the 2020s, towards a net-exporter in the 2030s.

Figure 2. EU net-trade of main agricultural commodities in baseline, 2020-2040.

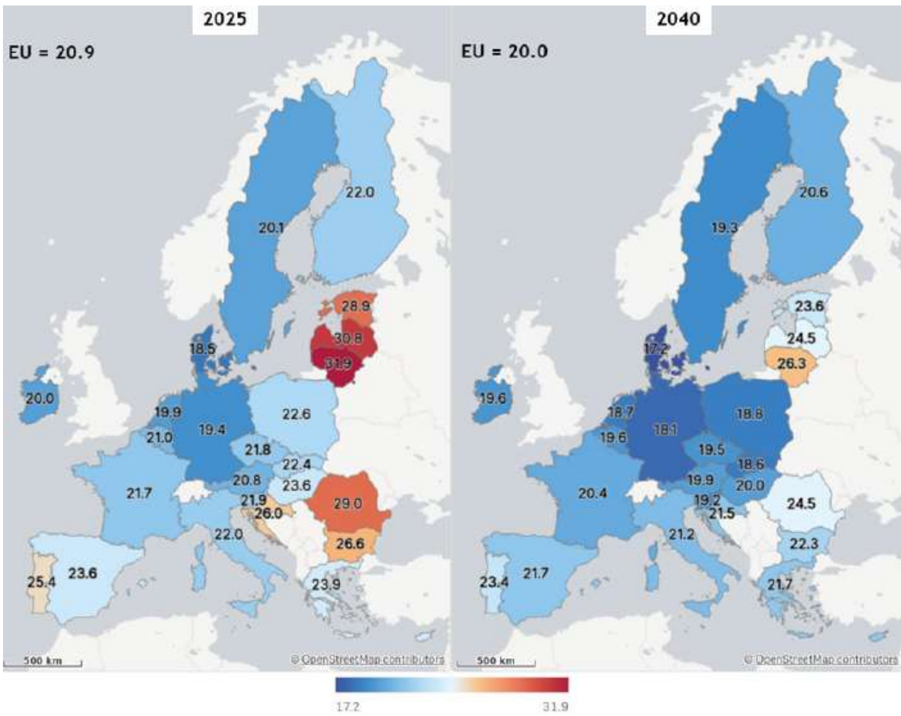


Source: AGMEMOD-BioMAT.

2.1.3. Food budget expenditure shares in the European Union

Figure 3 shows the evolution of the EU-wide average food expenditure shares in the household budget for the EU member states.

Figure 3. Food budget expenditure shares by EU member states (%).



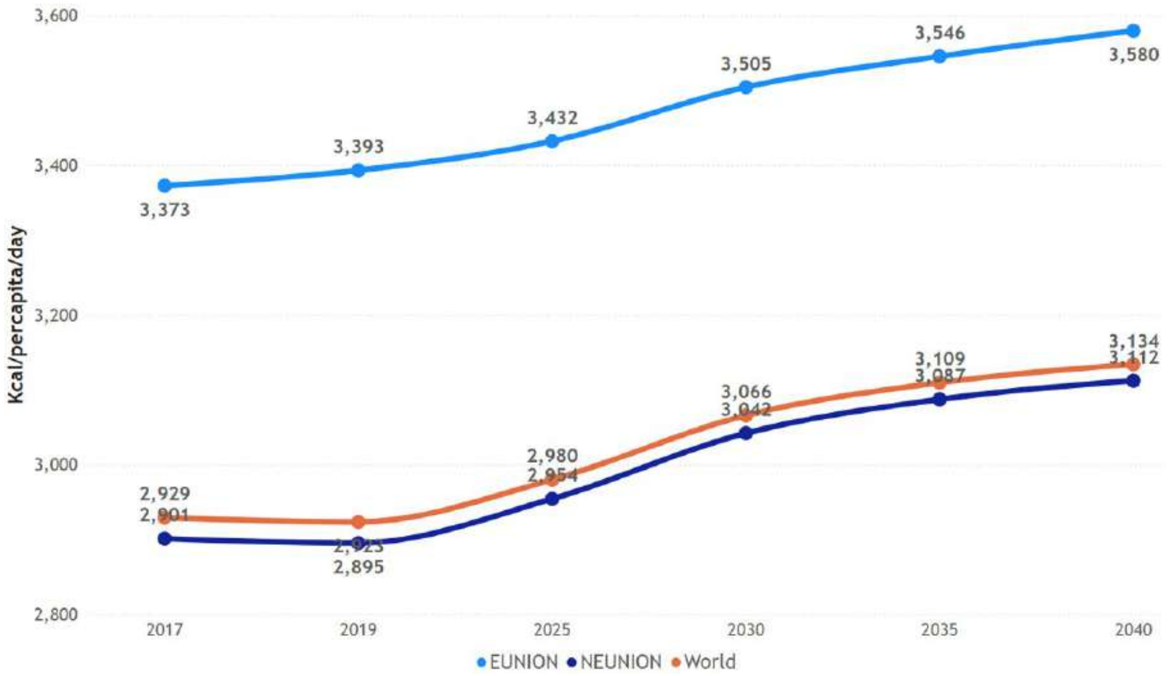
Source: MAGNET.

The expenditure share includes all food consumed in- and out-of-home. Following Engel's Law, as real per capita incomes rise in the EU, the share of the household budget dedicated to food declines. Given that the EU is already considered as a modern developed economy, the rate of decline is very minor (from 20.9% in 2025, to 20% by 2040). The results also show a closer degree of convergence between each of the member states' food expenditure shares around the EU average.

2.1.4. Kilocalories consumed per capita per day

Figure 4 shows the change in EU average kilocalorie intake. In MAGNET, the kilocalorie estimates are high on account of the fact that they are inclusive of all food purchased, therefore including food that may not be consumed (i.e., food waste). With a gentler relative rise in EU per capita incomes (vis-à-vis non-EU regions), the rise in EU per capita kilocalorie intake is slight (from 3,432 kcal/cap/day in 2025 to 3,580 kcal/cap/day in 2040).

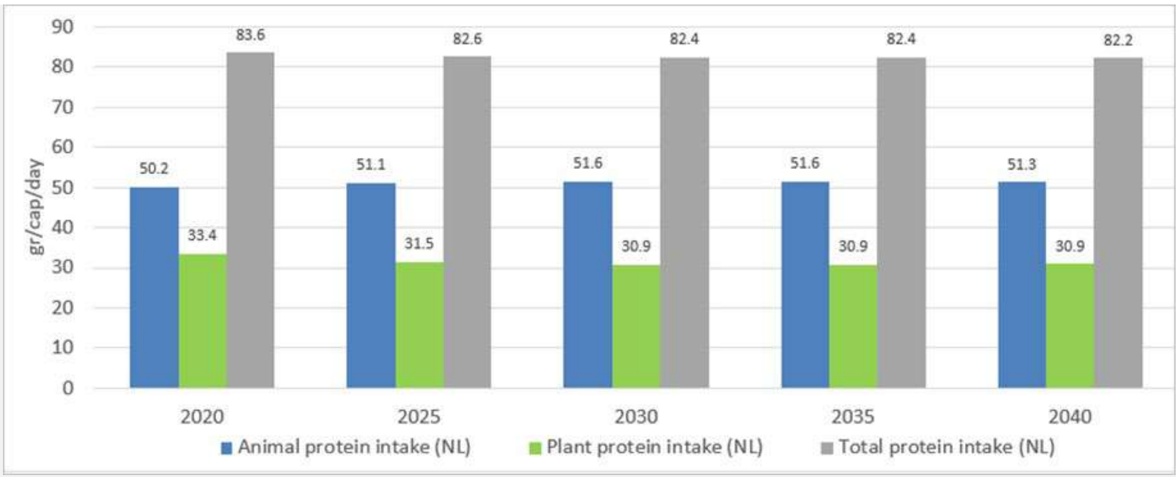
Figure 4. Evolution of kilocalorie consumption (kcal/capita/day).



Source: MAGNET.

Box 1. Example of daily animal and plant protein intake (the Netherlands)

This box shows that the animal protein intake per day (gr/capita) in the Netherlands constitutes the main share (more than 60%) in total protein intake in the start year 2020, which is expected to remain stable until 2040. Further, it shows that the total protein intake per day is slightly decreasing from 83,6 gr/cap to 82,2 gr/cap, though both are above the intake that Dutch Food Centre considers as a 'healthy' diet.



Daily animal and plant protein intake in the Netherlands in the baseline, 2020-2040. Source: AGMEMOD-BioMAT.

2.2. Managing natural resources sustainably

Table 2 presents the set of indicators that provide insight on the second bioeconomy societal objective “managing natural resources sustainably”.

Table 2. Indicators on ”Managing natural resources sustainably”.

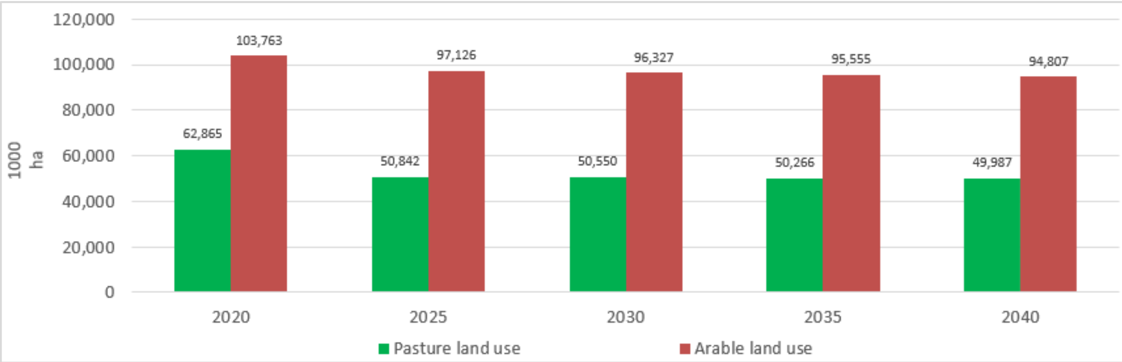
Indicator (definition)	Metrics	Model
Land use of agricultural production (by crop, EU MS)	1000 ha	AGMEMOD
Agricultural production (by crop/livestock, EU MS)	kton	AGMEMOD
Allocation of agricultural biomass over food, feed, seed, energy, materials uses (by crop, use type, EU MS)	%	AGMEMOD
Total waste in the EU	kton	MAGNET
Food waste (EU MS)	kgs/capita/year	MAGNET
Land footprints from consumer purchases of industrial products (EU MS)	m^2/capita/year	MAGNET

Source: JRC, own elaboration.

2.2.1. Land use of agricultural production

Eurostat reports that 62 mio ha land was used for pasture purposes in the EU in 2020, while 104 mio ha was allocated for arable cropping (Figure 5: EU pasture and arable land in the baseline, 2020-2040. Source: AGMEMOD-BioMAT). Sustainability measures of the new CAP 2023-2027 are expected to release more land from production (e.g., via fallow land). Hectares of pastureland in the EU might decrease by nearly 9% and arable land by nearly 5% in the baseline in 2040 compared to 2020 (Figure 5).

Figure 5. EU pasture and arable land in the baseline, 2020-2040.



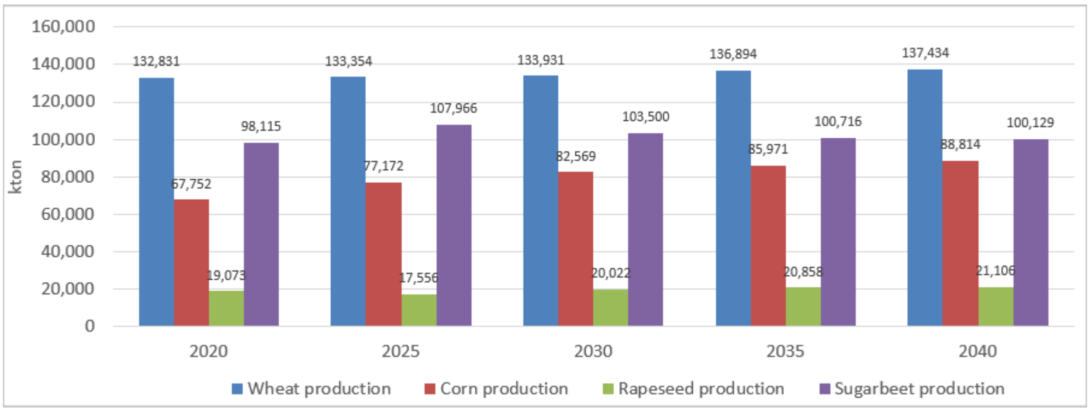
Source: AGMEMOD-BioMAT.

2.2.2. Agricultural production

Compared to 2020, the EU production of the main arable commodities is expected to increase until 2040. As the size of arable land for cropping will decline (see section 4.2.1) this will be induced by productivity growth (Figure 6).

Feed use is the main 'destination' for crop biomass (and indirectly goes to food use), driven by the demand for animal products. In case animal proteins are substituted by plant proteins we notice a switch from (indirect) feed use to (direct) food use. However, the production of main agricultural commodities is not changing a lot due to a diet change, but rather it is the allocation over the uses that changes.

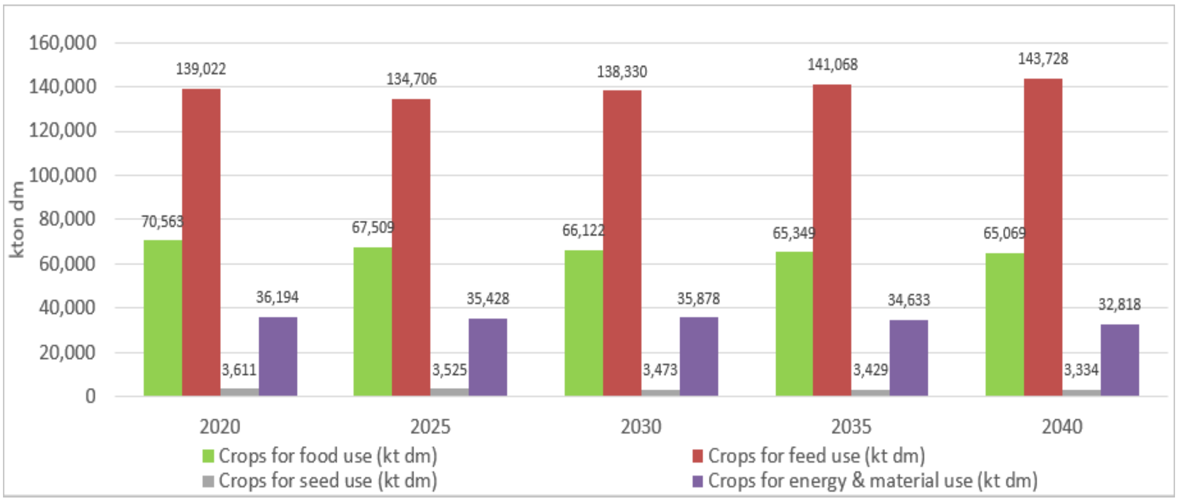
Figure 6. EU production of main agricultural commodities in the baseline, 2020-2040.



Source: AGMEMOD-BioMAT.

Over the twenty-year period from 2020, the total available agricultural crop biomass in the EU as a whole (in kton dry mass), will decline by 2% in the baseline (Figure 7). Because the share of biomass for feed use is expected to increase (55.7% in 2020 to 58.7% in 2040) it comes at the expense of biomass dedicated to food (28.3% in 2020 to 26.6% in 2040), seed and material uses (14.5% in 2020 to 13.4% in 2040).

Figure 7. EU allocation of crop biomass over uses in the baseline, 2020-2040.



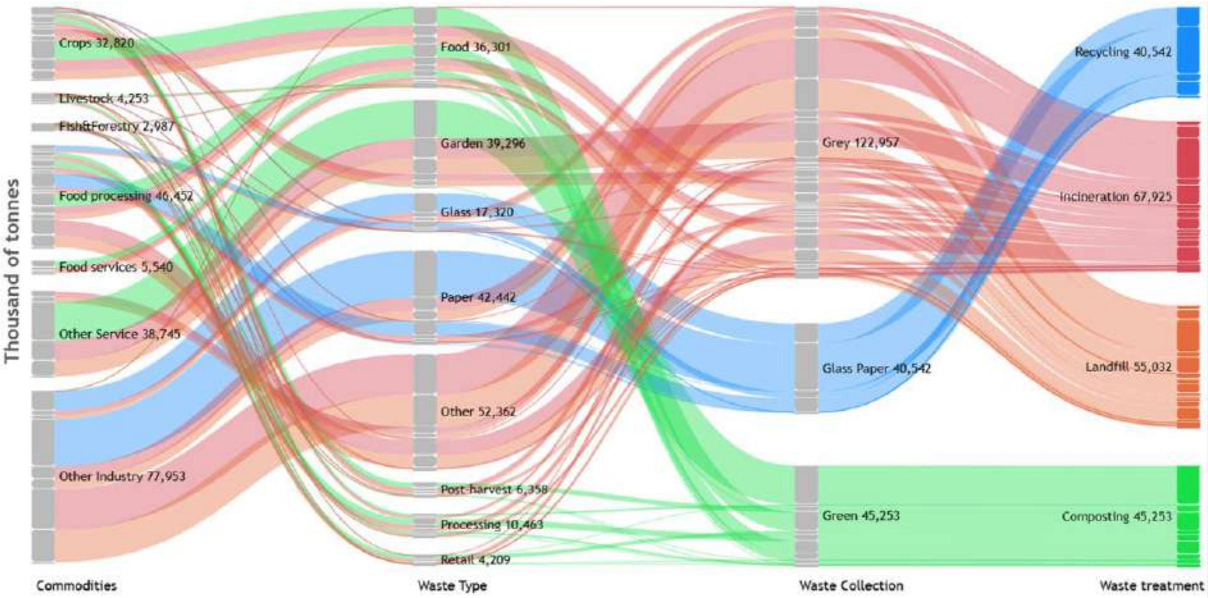
Source: AGMEMOD-BioMAT.

2.2.3. EU waste flows

In Figure 8 and Figure 9 are shown the Sankey representation of EU waste in the EU for the years 2025 and 2040. The concept of waste in MAGNET is limited to five categories of municipal waste (food, garden, glass, paper, other) and three classes of producer waste along the food chain (harvesting, processing, retail/transport). In the business-as-usual baseline, one assumes no deviation from current waste behaviour trends, such that overall waste (as defined in MAGNET) rises from 208.8 million tonnes in 2025 (Figure 8), to 213.0 million tonnes in 2040 (Figure 9). Of this total, food waste by households and food losses from harvesting, processing, retail and transport, totals 57.3 million tonnes in 2025, falling slightly to 55.3 million tonnes by 2040. In part, this decline in total food loss and waste (FLW) trend is driven by the assumed contraction in EU population from 452.6 million to 443.0 million (-2%), although a further key driver that is consistent with Bartelings and Philippidis (2025) is the shift in household eating patterns toward a relatively greater share of out-of-home consumption due to rising per capita wealth. This is particularly prevalent in the newer EU member states with the switch from high waste per euro spent on 'in-home' food product categories (e.g., vegetables and fruits) toward a relatively lower rate of waste per euro spent associated with out-of-home consumption.

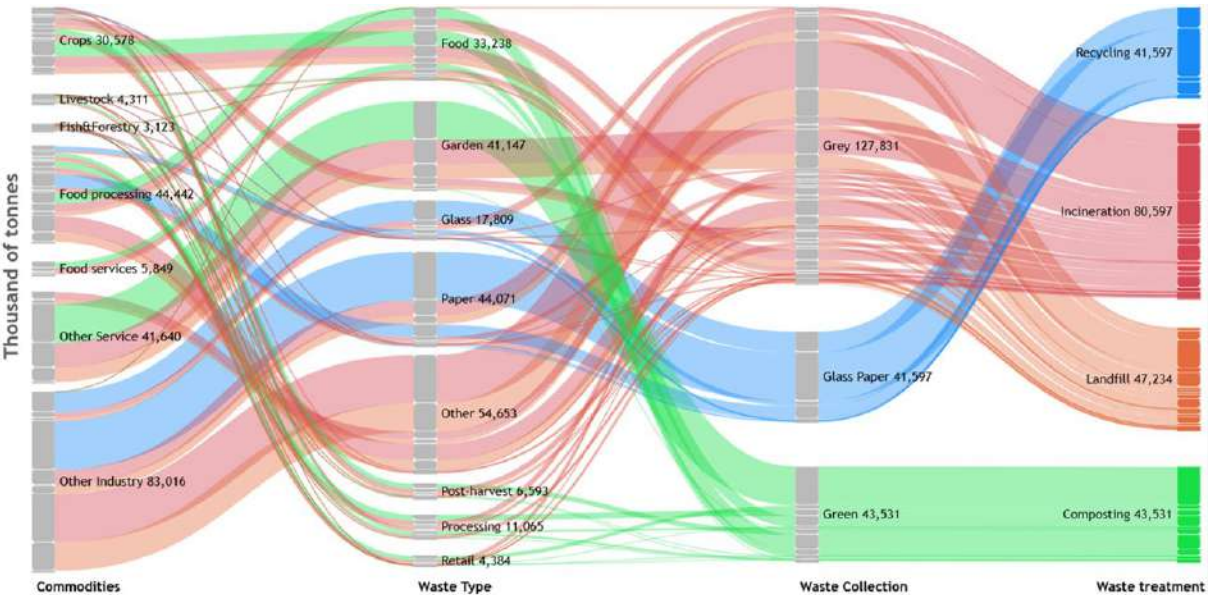
In 2025, the quantity of food loss and waste (57.3 million tonnes) is allocated to landfill (13.3 million tonnes of the total 55.0 million tonnes in landfill), composting (27.5 million tonnes of the total 45.3 million tonnes in composting) and incineration (16.5 million tonnes of the total 67.9 million tonnes in incineration). Subject to the driving demand forces for biomass use in electricity and heat generation through the incineration pathway, of the estimated food loss and waste in 2040 (55.3 million tonnes), 18.8 million tonnes is allocated to incineration treatments. As a result, there is a slight fall in the composting treatment pathway that reuses food waste biomass as material inputs (i.e., fertiliser, advanced generation liquid biofuel, and solid biofuel for bioelectricity) to 25.5 million tonnes by 2040, and the proportion of food loss and waste that ends up in landfill (11.0 million tonnes).

Figure 8. EU27 waste flows in 2025 (kton).



Source: MAGNET.

Figure 9. EU27 waste flows in 2040 (kton).

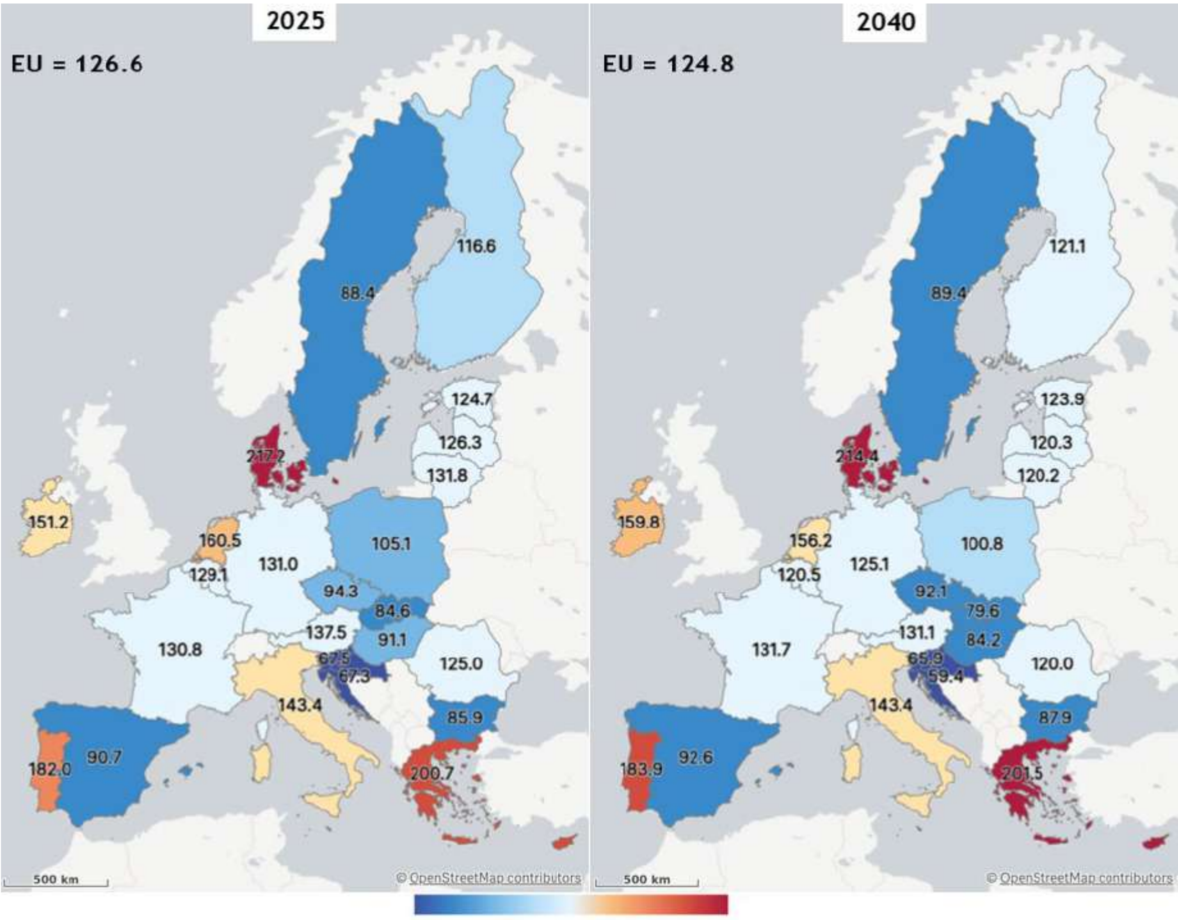


Source: MAGNET.

2.2.4. EU food waste

Figure 10 shows the evolution in FLW per capita across the member states in the baseline (2025, 2040). Measured in terms of FLW in kilograms per capita (kg/capita/year), the baseline assumes no modification in food waste habits. At the EU level, baseline trends show a moderate fall from 126.6 kg/capita in 2025, to 124.8 kg/capita in 2040. Despite the assumed -2.2% reduction in the EU aggregate population over this time period (453 million to 443 million persons in 2025 and 2040, respectively), FLW trends exhibit a stronger proportional fall (3.5%) due to the switch in food consumption patterns towards more out-of-home consumption (as noted in section 2.2.1 above). Examining the trend across the EU member states, in many newer EU members in the Baltics, Balkans and central eastern borders, the transition to more affluent out-of-home eating patterns results in notable falls in EU FLW per capita. In the case of Belgium, the Netherlands, and Denmark, relatively strong projected population increases are assumed, driving down FLW per capita estimates over the analyzed 15-year time frame.

Figure 10. Total food waste and losses kilograms per capita in 2025 and 2040.



Source: MAGNET.

2.2.5. Land footprints

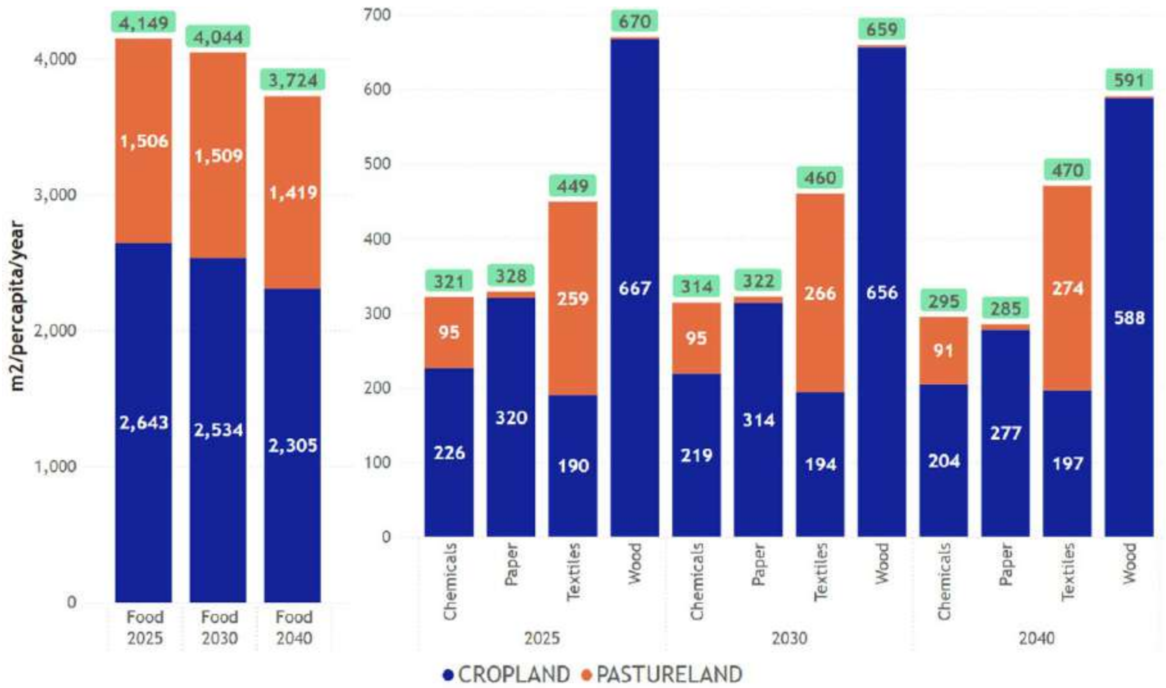
The consumer land footprint (m2/capita/year) is an intensity measure of the total amount of the agricultural land commodity (both domestic and foreign sourced) embedded within the different stages of production of products and services that are purchased by consumers.

Figure 11 presents the estimated cropland and pastureland footprints embedded within final purchases of food (including all food services), clothing (including textiles, wearing apparel and leather goods), wood, paper and chemical (chemicals, pharmaceuticals, plastics and rubbers) products for the years 2025, 2030 and 2040. The general trend is that of a steady decline in the land footprint over time as the baseline assumes world-wide incremental rises in land productivities (i.e., higher biomass yields per area unit). As the main employer of agricultural land, in 2025, it is estimated that EU final purchases of food and drink require an average of 2,643 m2/capita/year and 1,506 m2/capita/year of cropland and pastureland, respectively. This gives a total agricultural land requirement of 4,149 m2/capita/year. By 2040, this total agricultural land requirement reduces to 3,724 m2/capita/year.

A similar declining land footprint trend is also observed in the selection of industrial activities (except textiles) on the right side of Figure 11.

As expected, paper and wood industries employ mainly cropland, whilst in textiles (including wool, hides etc.) and chemicals (oils and fats), the split between crop and pastureland is more evenly distributed. As in the case of food purchases, rising land productivities are leading to reductions in land requirements per capita per year on purchases of these industrial products. The exception is in the textile industry, where interestingly, the switch in EU final consumption patterns in the baseline toward extra-EU sources of textile imports lead to a projected rise in the per capita land footprint between 2025 and 2040.

Figure 11. Cropland and pastureland footprints from EU final purchases of industrial products.



Source: MAGNET.

2.3. Reducing dependence on non-renewable resources

Table 3 depicts the set of indicators that provide insight on the third bioeconomy societal objective “reducing dependence on non-renewable resources”.

Table 3. Indicators on ”Reducing dependence on non-renewable resources”

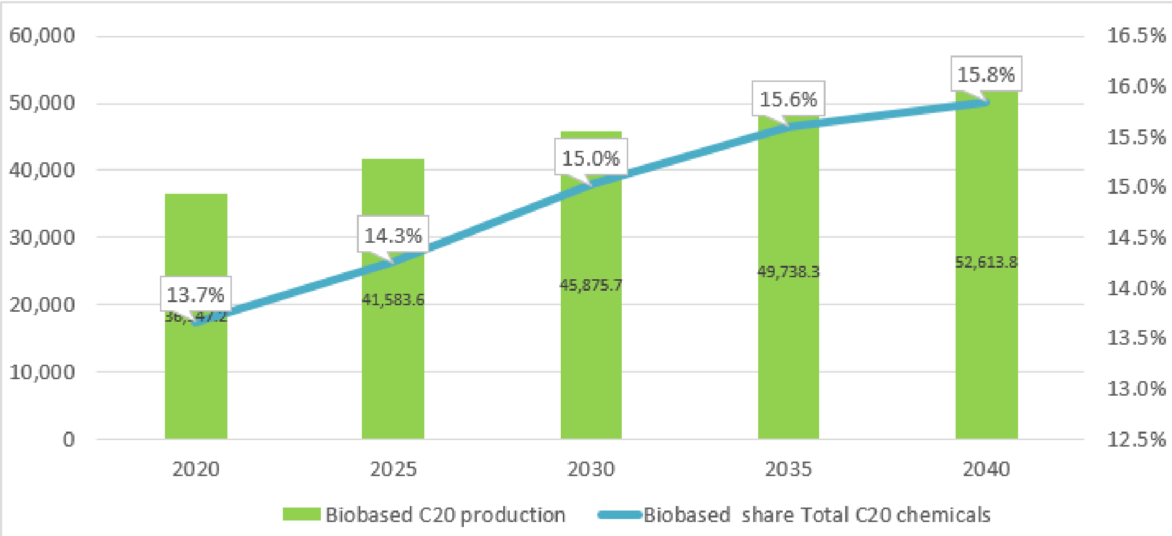
Indicator (definition)	Metrics	Model
Bio-based shares in total organic chemicals (by application, EU MS)	% in volume	BioMAT
Production and use of bio-based chemicals (by application, EU MS)	kton	BioMAT
Net-trade of bio-based chemicals (by application, EU MS)	kton	BioMAT
Biological feedstock use in chemicals, paper and pharma (by biological feedstock, application, EU MS)	kton	BioMAT
Allocation of biological feedstock over chemicals (by biological feedstock, by application, by EU MS)	%	BioMAT
Net-availability of biomass feedstock for materials in EU (by bio-based applications, EU MS)	kton	AGMEMOD -BioMAT
Total biofuel domestic use (by fuel type, EU MS)	ktoe	AGMEMOD
Share of total biofuel domestic use in total transport fuel domestic use (by fuel type, MS)	% in volume	AGMEMOD
Total domestic production of biofuels (by fuel type, EU MS)	ktoe	AGMEMOD
EU bio-based chemicals turnover share in total chemicals	share	MAGNET
Energy price indices (fossil, biorenewables, other renewables, nuclear, EU, globally)	index %	MAGNET

Source: JRC, own elaboration.

2.3.1. Market trends of bio-based chemical applications

In the baseline, the EU bio-based chemical production (NACE C20) is projected to increase with about 45% from 2020 to 2040 (Figure 12). In terms of the development of the share of bio-based chemicals in total chemicals that one will increase with 2.1 percent points to 15.8% in 2040. Note that biofuels are excluded from the bio-based chemical C20 sector as the biofuel market has been regarded in the central AGMEMOD model.

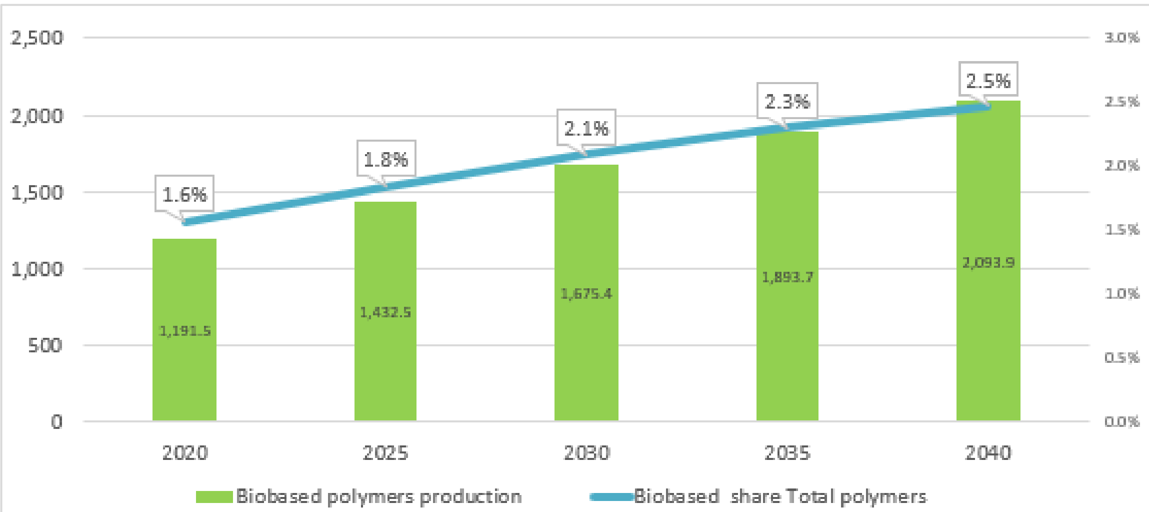
Figure 12. EU bio-based production (kton) and bio-based shares (%) in EU total C20 chemicals in the baseline, 2020-2040.



Source: AGMEMOD-BioMAT.

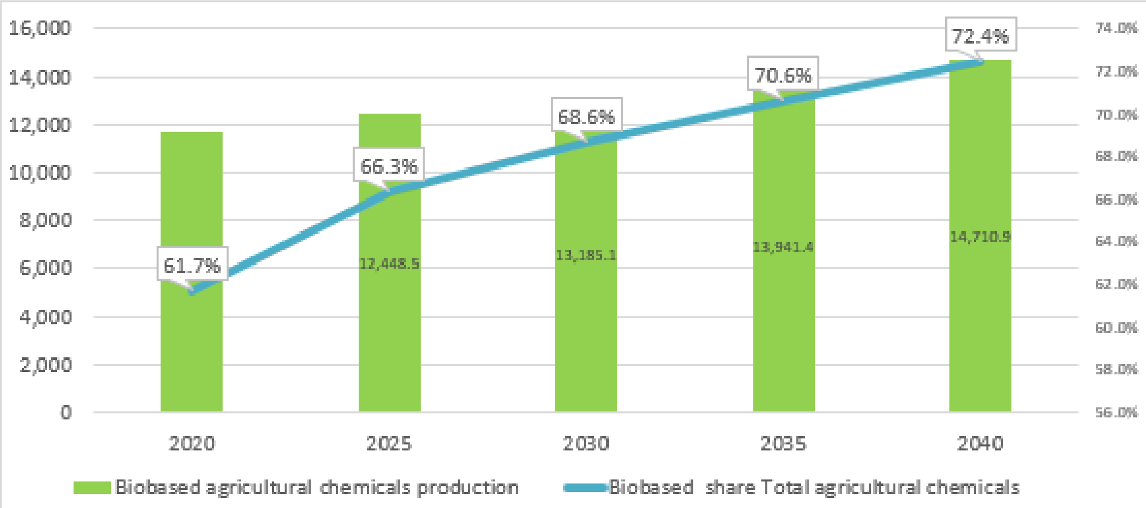
Depending on the type of biochemical application the bio-based share in the total of the corresponding application varies. For example, although it will almost double in absolute terms between 2020 and 2040, the bio-based share in EU's total polymer production is only 2.5% in 2040 (Figure 13). On the other hand, the bio-based share of EU agricultural chemicals is relatively significant in 2020 and expected to increase from 62% in 2020 to 72% in 2040 (Figure 14). This detail provides insight in the future potential of specific chemical applications to replace fossil-based inputs by renewable inputs (e.g. biomass).

Figure 13. EU bio-based production (kton) and bio-based shares (%) in EU total polymers in the baseline, 2020-2040.



Source: AGMEMOD-BioMAT.

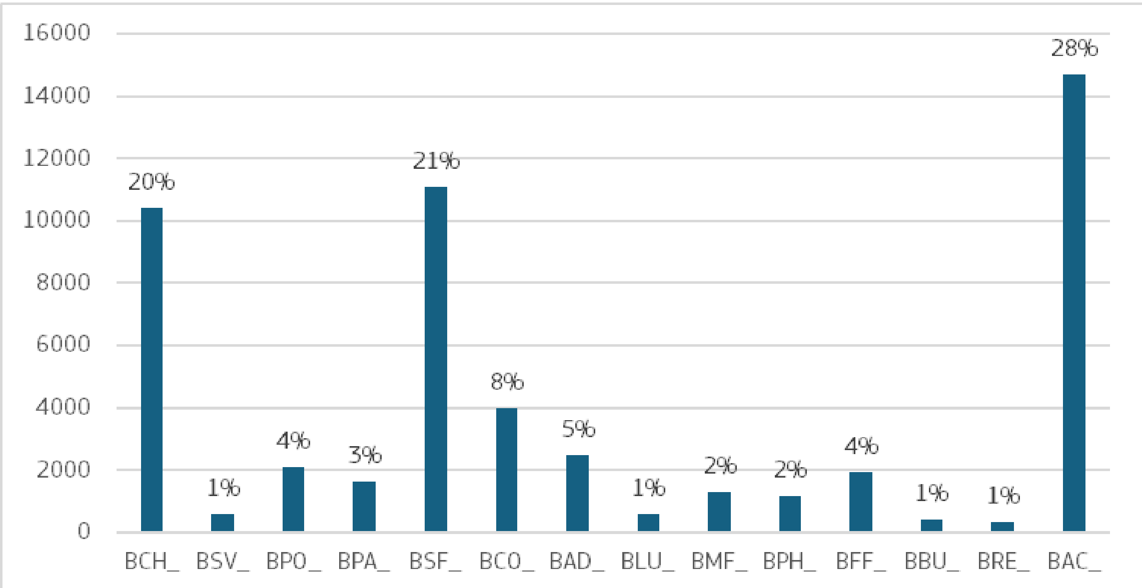
Figure 14. EU bio-based production (kton) and bio-based shares (%) in EU total agricultural chemicals in the baseline, 2020-2040.



Source: AGMEMOD-BioMAT.

Figure 15 shows that nearly 30% of the total EU bio-based C20 production comes from bio-based agricultural chemicals, followed by bio-based surfactants (21%) and biochemical platform applications (20%). Although it has high potential for contributing to the EU bioeconomy, the share of bio-based polymers in EU total bio-based chemical production is expected to remain relatively small (4%) in the coming decades under a business-as-usual situation.

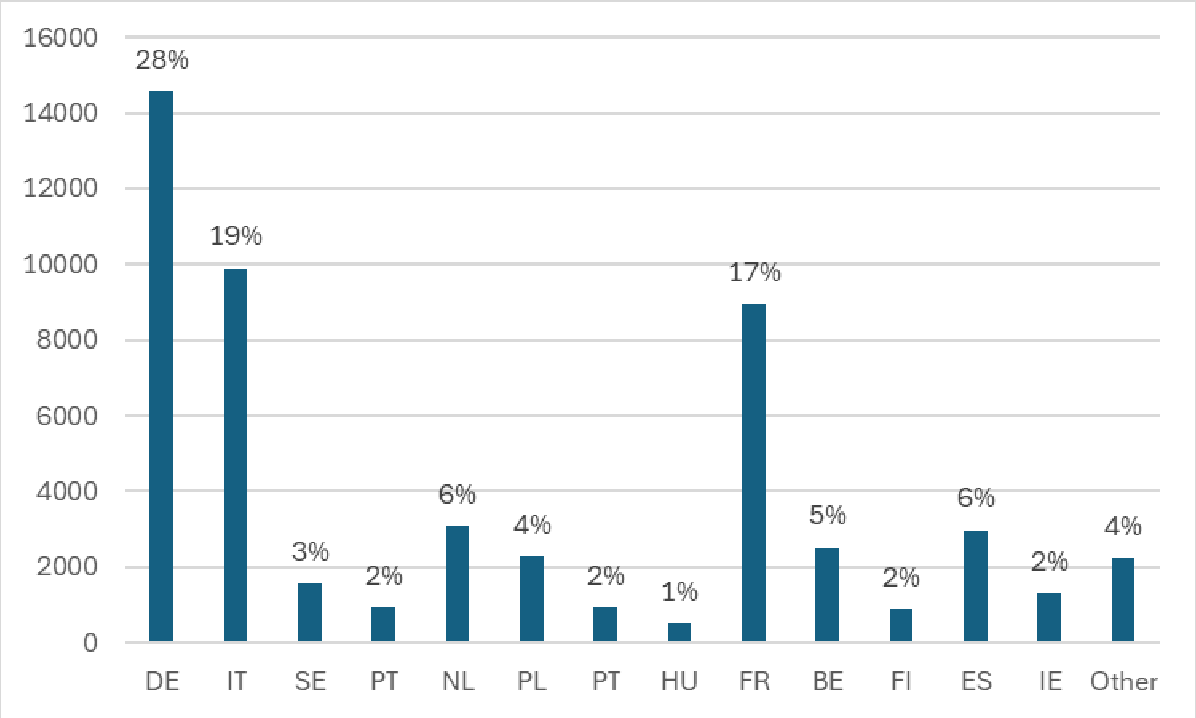
Figure 15. Production of chemical applications in EU total bio-based chemical production (kton and %) in the baseline, 2040.



Source: AGMEMOD-BioMAT. Abbreviations: BCH= bio-based chemical platforms, BSV= bio-based solvents, BPO=bio-based polymers for plastics, BSF= bio-based surfactants, BLU=bio-based lubricants, BAD=bio-based adhesives, BCO=bio-based cosmetics, BPA=bio-based paintings & ink, BPH=bio-based pharmaceuticals, BFF=bio-based food & feed, BAC=bio-based agricultural chemicals, BMF=bio-based manmade fibres, BBU=bio-based materials, BOT= bio-based other products.

Within the EU production of chemical applications, main producing countries are Germany (28%), Italy (19%), France (17%), Spain (6%) and the Netherlands (6%) (Figure 16).

Figure 16. Country structure in EU total bio-based chemical production (kton and %) in the baseline, 2040.

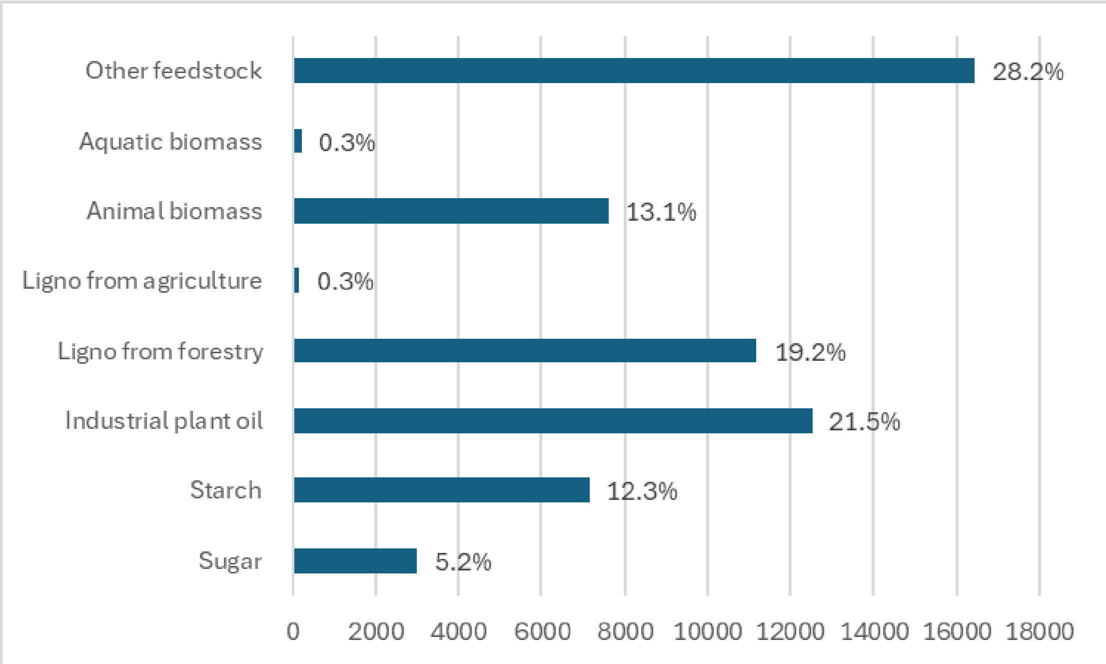


Source: AGMEMOD-BioMAT. Abbreviations: DE=Germany, IT=Italy, SE=Sweden, PT=Portugal, NL=the Netherlands, PL=Poland, HU=Hungary, FR=France, BE=Belgium, FI=Finland, ES=Spain, UK=United Kingdom, IE=Ireland, Other=other member states.

2.3.2. Biological feedstock mix used for bio-based materials

Figure 17 shows that plant oils are the main biological feedstock type as input used to produce EU bio-based chemicals (NACE C20) in 2040, followed by ligno from forestry (19%), animal biomass (13%) and starch (12%). Note that the other feedstock category (which encompass types not mentioned elsewhere, like by-products) amounts to more than one quarter in total biomass needs.

Figure 17. Biological feedstock use (kton and %) in EU total bio-based C20 products in the baseline, 2040.



Source: AGMEMOD-BioMAT.

Depending on the biochemical application the share of specific biological feedstock types in total biological feedstock use varies. For example, Table 4 makes clear that chemical platform products (approx. 25%), bio-based agricultural chemicals (approx. 15%) and agricultural chemicals (approx. 14%) use relatively most of the total biological feedstock that goes into bio-based C20 applications.

Table 4. Share of biological feedstock used by application in EU total bio-based chemical production (%) in baseline, 2020-2040.

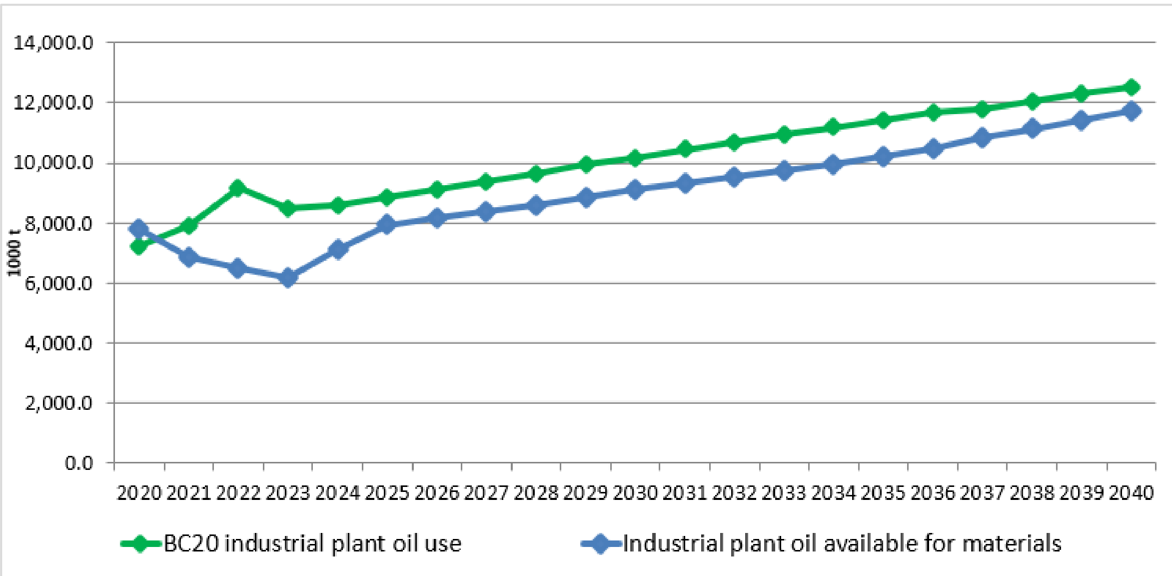
	2020	2025	2030	2035	2040
Bio-based chemical platforms	19.0%	22.1%	22.9%	23.7%	25.0%
Bio-based solvents	3.9%	3.7%	3.6%	3.5%	3.3%
Bio-based polymers	4.0%	4.3%	4.5%	4.8%	5.1%
Bio-based surfactants	15.4%	14.2%	14.1%	14.3%	14.6%
	2020	2025	2030	2035	2040

Bio-based lubricants	0.9%	0.9%	0.9%	1.0%	1.0%
Bio-based adhesives	3.9%	4.0%	4.0%	4.1%	4.2%
Bio-based cosmetics	7.1%	8.0%	7.8%	7.8%	7.5%
Bio-based paintings, ink	4.4%	4.7%	4.8%	5.3%	5.4%
Bio-based pharmaceuticals	3.5%	3.9%	3.9%	4.1%	4.6%
Bio-based food & feed	14.7%	11.3%	11.0%	9.4%	7.2%
Bio-based agricultural chemicals	16.6%	15.2%	14.4%	14.0%	14.0%
Bio-based manmade fibres	4.5%	5.6%	5.8%	5.9%	5.8%
Bio-based building materials	1.5%	1.7%	1.9%	2.1%	2.2%
Bio-based other products	0.9%	0.7%	0.6%	0.6%	0.6%
Bio-based C20 products	*100.0%*	*100.0%*	*100.0%*	*100.0%*	*100.0%*

Source: AGMEMOD-BioMAT.

As shown before, industrial plant use (from rapeseed, soybean, sunseed and palmoil) is the main feedstock used in bio-based chemical applications. Figure 18 shows that the available domestic supply (in volumes) of industrial plants for chemical material use by the EU is insufficient to fulfil the amount of industrial plants required to produce the expected amount of bio-based chemical applications during the entire baseline period. Note that the net-availability of plant oils – also mentioned 'self-sufficiency rate' – for all uses (i.e. food, feed, energy, materials) is also negative and to be closed via imports. Further, we have assumed that the import of unsustainable palmoil to the EU has been banned from 2024 onwards.

Figure 18. Supply and use of industrial plant oil feedstock for EU bio-based chemicals (excl. biofuels) (kton) in the baseline, 2020-2040.

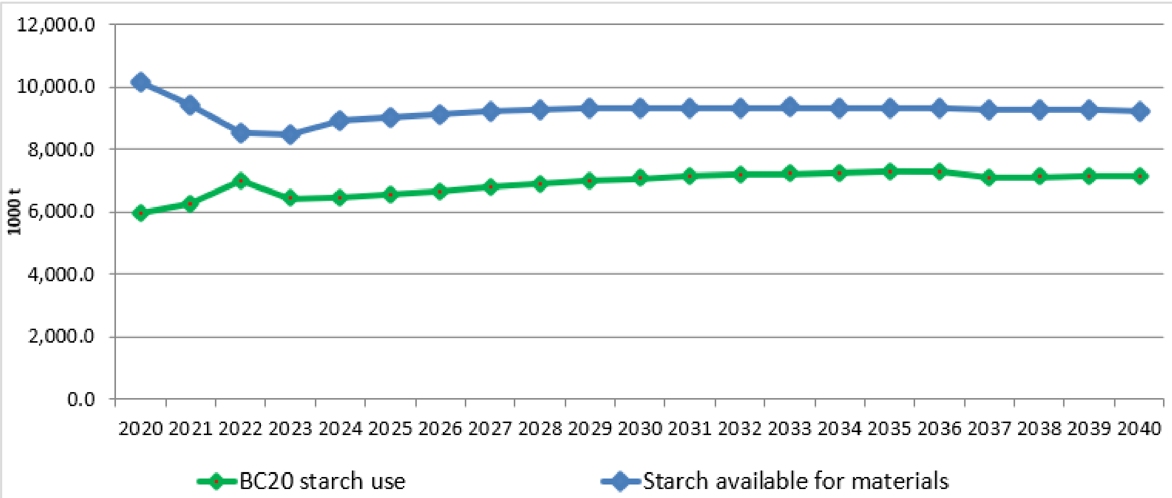


Source AGMEMOD-BioMAT.

When considering the projected development of bio-based chemicals until 2040 under the baseline, there is sufficient starch available in the EU (Figure 19). However, it is expected that there will be a shortage in case the growth of the bio-based chemicals share in total chemicals would become higher than as projected in the baseline situation (15.8% in 2040, see Figure 12).

Note that consequences to fulfil higher bio-based share targets in the industry, e.g., via obligatory mandates, for biomass feedstock requirements can be investigated via 'what-if' scenario analysis (see Section 5.2).

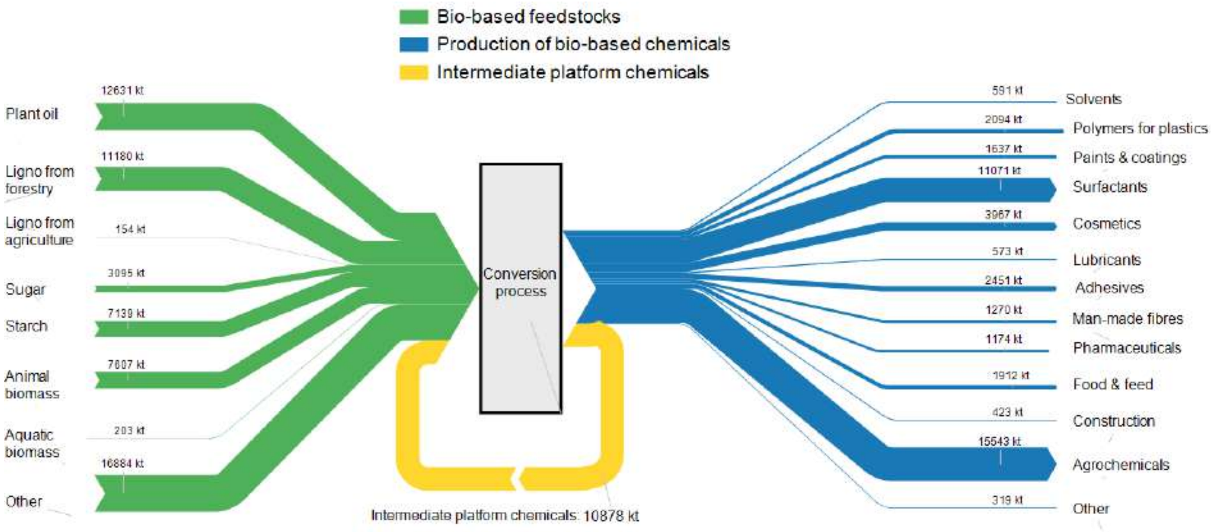
Figure 19. Supply and use of starch feedstock for EU bio-based chemicals (excl. biofuels) (kton) in the baseline, 2020-2040.



Source AGMEMOD-BioMAT.

The Sankey diagram (Figure 20) presents the volumes of different types of biological feedstocks (on the left side) used by the chemical industry in the EU27 in 2040 to produce bio-based chemical products, and their volumes within different application categories (on the right side). In terms of volume, "plant oil" (21%) and "starch" (12%) are the main agricultural crop feedstocks required for the production of bio-based chemicals (excluding biofuels). Although it should be noted, that requirements of "other feedstock" (e.g. crop residues) and "animal fat use" respectively encompass more than one quarter and 13% in total biological feedstock used by the bio-based chemical sector in 2040. Regarding the bio-based production of the chemical industry (excluding biofuels), again in terms of volumes, "bio-based agrochemicals" (36%) and "bio-based surfactants" (25%) are the contributing the most. It needs to be clarified that as average product prices within each application category can differ. This distribution can also differ in terms of production values. Furthermore, the figure shows the quantities of platform chemicals used as intermediate input by the chemical industry (yellow loop).

Figure 20. Use of biological resources by EU total bio-based chemical applications (kton), 2040.

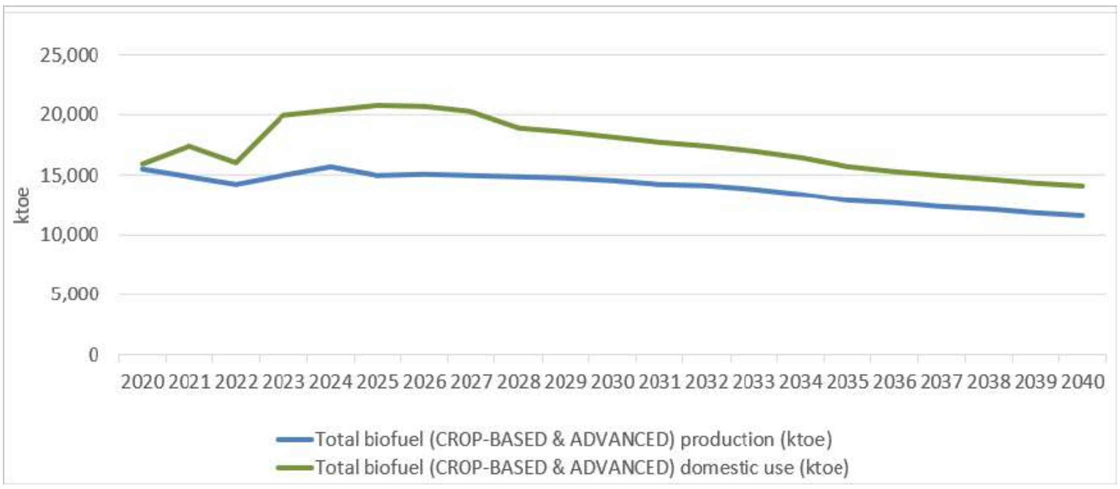


Source: AGMEMOD-BioMAT.

2.3.3. Market trends of biofuels

The biofuels domestic use (green line in Figure 21) of the EU is calculated by multiplying the projected total domestic use of gasoline and diesel (crop-based and advanced biofuels) with the corresponding mandate shares while considering the capped use of crops for biofuels. The figure shows a jump in the domestic use of biofuels after 2022 due to the adopted minimum binding mandates for biofuel use in transport fuels (RED III policy). However, biofuel domestic use is gradually declining up to 2040 because fuel transport fuels is supposed to be substituted by electric riding after 2023 which should reduce greenhouse gas emissions. The blue line in Figure 21 shows the future development of total biofuels production in the EU. To close the gap between EU biofuel domestic use and production the biofuel is imported from non-EU regions for direct consumption.

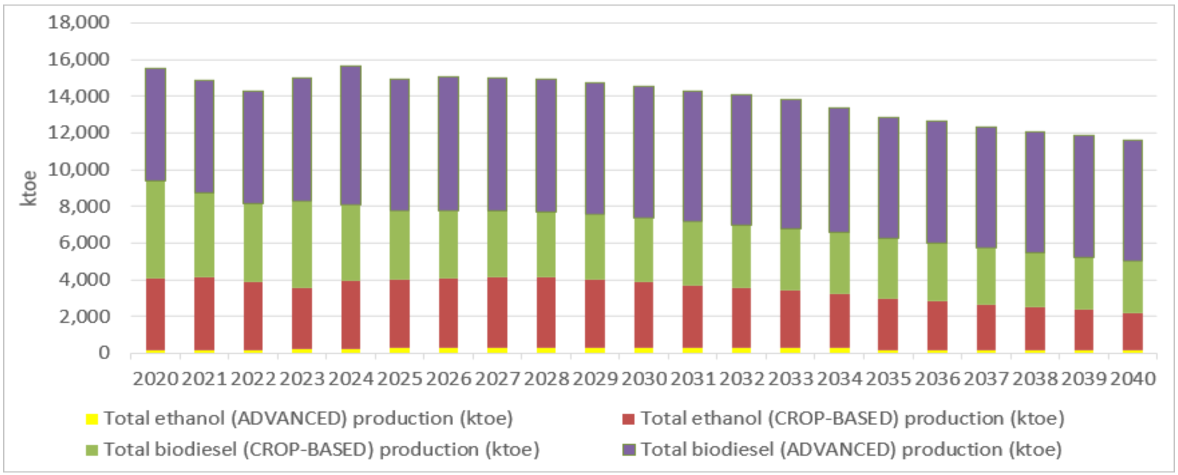
Figure 21. EU biofuel production and domestic use (crop-based and advanced) in baseline (ktoe), 2020-2040.



Source: AGMEMOD-BioMAT.

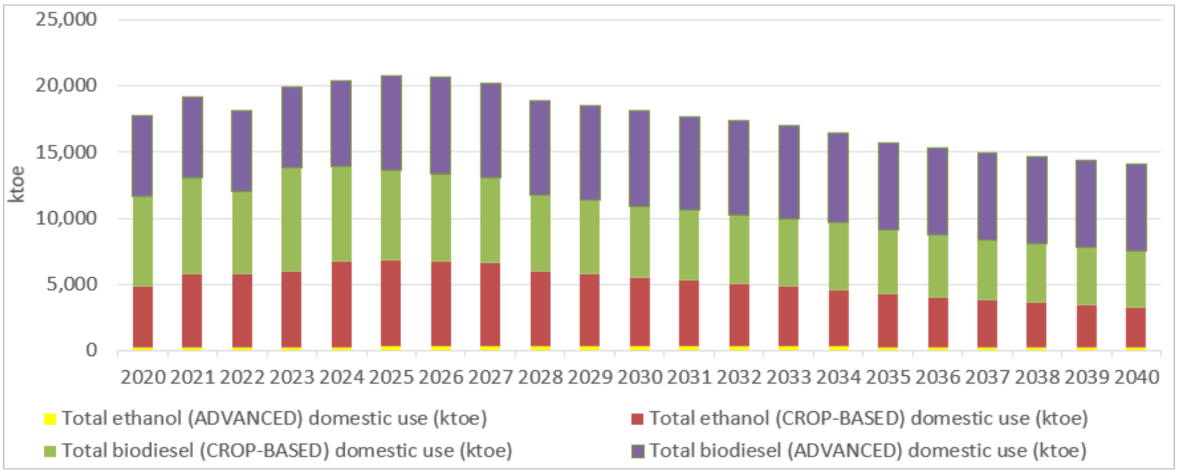
Figure 22 presents the development of crop-based and advanced ethanol and biodiesel production in the EU. Crop-based ethanol is produced from wheat, maize, rye and sugar beets. Cop-based biodiesel is produced from rapeoil, sunoil, soybean oil and palm oil. Figure 23 does the same for the development of ethanol and biodiesel domestic use. Note that in the course of time biofuel production and domestic use are gradually reduced due to the phasing out of fossil fuels in transport while battery driven transport gets a higher share, while at the same time crop-based feedstock for biofuels are replaced by advanced biological feedstock for biofuels.

Figure 22. EU ethanol and biodiesel production (ktoe) in baseline, 2020-2040.



Source: AGMEMOD-BioMAT.

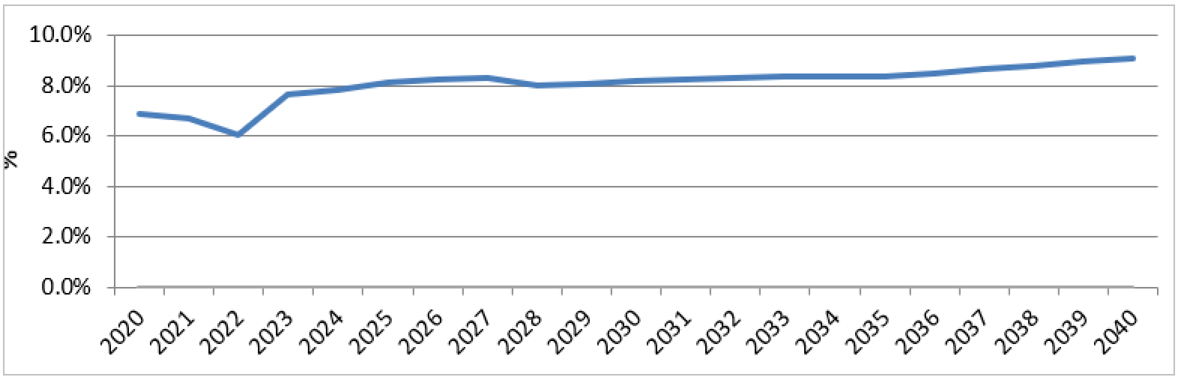
Figure 23. EU ethanol and biodiesel domestic use (ktoe) in baseline, 2020-2040.



Source: AGMEMOD-BioMAT.

Figure 24 shows a jump in the domestic use of biofuels after 2022 which is due to the adopted minimum binding mandates for biofuel use in transport fuels (RED III policy). Share of EU biofuel will increase to almost 10% in 2040.

Figure 24. Share of EU biofuel domestic use in EU total transport fuel domestic use (%) in baseline, 2020-2040.

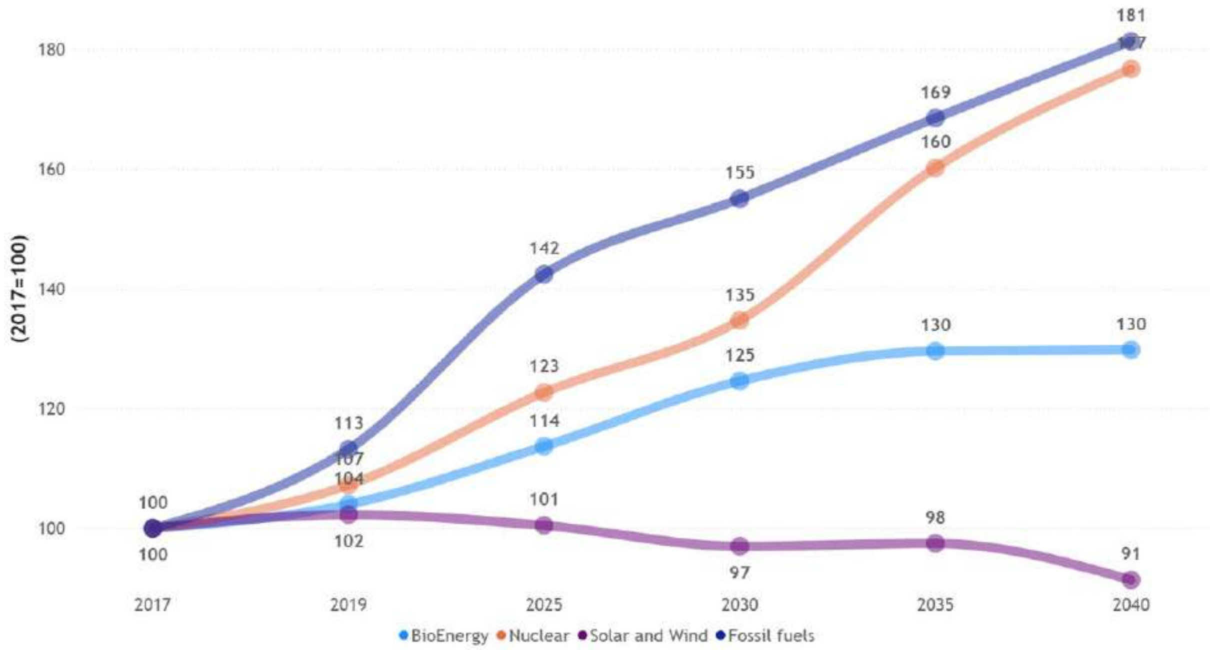


Source: AGMEMOD-BioMAT.

2.3.4. Energy prices

Figure 25 reports 'relative' price index trends for different energy sources in the baseline. The figure covers trends in liquid and solid bio-based energy, fossil price trends, nuclear energy and other renewables (i.e., solar, wind, hydroelectric). Taking an index value of 100 for 2017, by 2025, the fossil fuel price index in the EU rises to 142, and subsequently 181 by 2040. This is driven by assumed rises in world oil prices as well as rising carbon taxes consistent with assumed expected emissions reductions. Rising demands for alternative bioenergy (particularly advanced biofuels, biogas and solid biomass for electricity and heat), pushes up the index of bioenergy prices to 130 by 2040. A similar rising trend in the price index is occurring for nuclear energy, although this is due to the assumed plateauing and reductions of nuclear energy supply as other sources of energy take more prominence as we move toward 2040. The continued rapid expansion of other renewables (particularly solar and wind) leads to continued per unit cost falls, where by 2040, the index of other renewable energy prices falls to 91.

Figure 25. Changes in the index of prices for selected energies (2017=100), see also annex.



Source: MAGNET.

2.4. Mitigating climate change

Table 5 depicts the set of indicators that provide insight on the fourth bioeconomy societal objective "mitigating and adapting to climate change".

Table 5. Indicators on "Mitigating and adapting to climate change".

Indicator (definition)	Metrics	Model
Total direct emissions by broad activities and households	mtCO2e	MAGNET
Tonnes of emissions per unit of GDP	TCO2e/$	MAGNET
Emissions footprints on final purchases of industrial products	kgCO2e/capita	MAGNET

Source: JRC, own elaboration. Note: indicators are available in general for all regions included in the MAGNET.

2.4.1. EU direct greenhouse gas emissions

As a headline figure, the total quantity of direct emissions in the EU27 is estimated to fall from approximately 4.1 billion tonnes of CO2 equivalent (CO2e) in 2017 to 3.2 billion tonnes of CO2e by 2040 (decrease of 20%). These reductions are based on assumed carbon prices imposed only on emissions trading scheme (ETS) activities of 111€/t (2025), 140€/t (2030) and 201€/tonne (2040). [3] To measure the reduced degree of coupling between emissions and economic growth in the EU27, the intensity level of emissions (tonnes of CO2e) per currency unit of economic activity (tCO2e/$)) is calculated. The results in MAGNET suggest that this statistic falls from 195.7 tCO2e/€ in 2025, to 138.1 tCO2e/€ in 2040 (not shown).

Figure 26 shows the total direct emissions driven by broad classifications of economic activities and consumers, for the years 2025, 2030 and 2040. Not surprisingly, of the EU's 3.584 billion tonnes of direct emissions in 2025, the largest single source comes from energy (power) generation activities (combustion emissions), accounting for 0.932 billion tonnes (26.0% of total EU direct emissions). The transport sector[4] accounts for 0.791 billion tonnes (22.1% of total EU direct emissions). Given primary agriculture is the largest, emitter of nitrous oxide and methane emissions, the composite of primary agriculture, forestry and fishing accounts for 0.495 million tonnes of emissions (13.8% of total EU direct emissions).

With assumed reductions in economy-wide EU emissions driven by the ETS sectors, as well as assumed switches in the energy generation portfolio toward electrification based on a heightened use of renewables (bio- and non-bio), there are notable reductions in combustion emissions from the energy generation industries. In 2040, direct emissions in this collective of activities falls to 0.613 billion tonnes. As a key strategic industry which is assumed to remain outside of the ETS, agricultural emissions rise slightly by 2040. Many of the emissions in primary agriculture are process driven, such that the stable pattern of output in the EU is reflected in the direct emissions trends.[5] As a result, the share of agriculture, forestry and fishing emissions of the EU total rises to 15.8% by 2040. In the case of consumer purchases driven emissions, the trend from 2025 to 2040 remains relatively flat, as a reduced emissions intensity in production (as noted above) is mitigated to a large extent by rising real per capita incomes and, subsequently, private household purchases. Consequently, the share of consumer driven emissions rises from 15.6% in 2025, to 17.5% by 2040.

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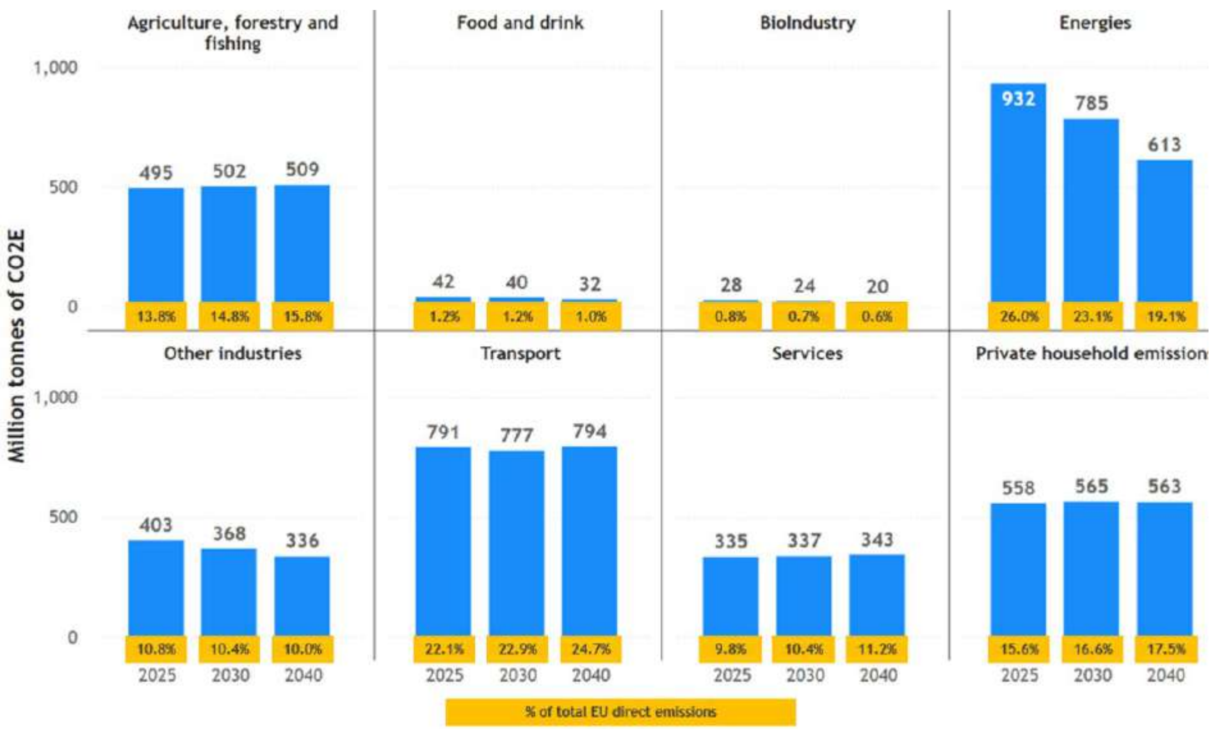
[3] The carbon price of €140/tCO_2 by 2030 is taken from the International Energy Agency's 2022 World Energy Outlook. The 2040 value is a time linear assumption.

[4] In this baseline, changes in transport-based emissions to account for electrification of public and haulage road transport have not been explicitly modelled. As a result, the reported reductions here may be on the pessimistic side.

[5] The baseline does not include additional adaptation and mitigation strategies in the agricultural sector.

Figure 26. Direct emissions from selected EU activities and consumers.



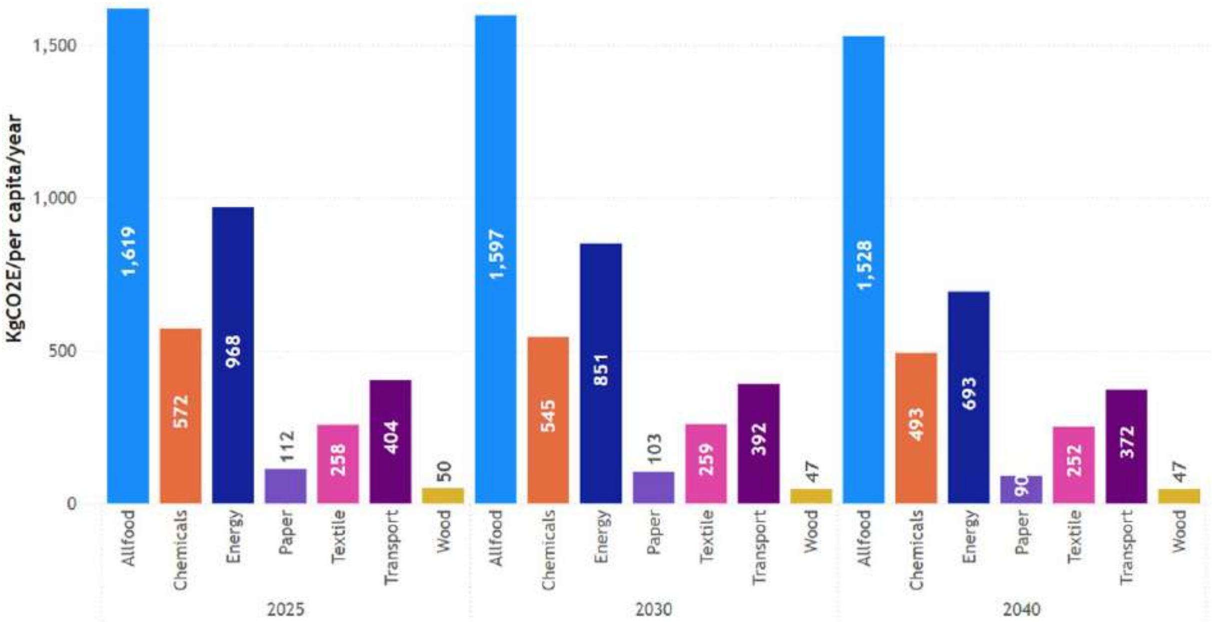
Source: MAGNET.

2.4.2. EU emissions footprints

In an analogous fashion to the consumer land footprints presented above, this consumer footprint estimates the emissions (of both domestic and foreign origin) embedded in different stages of the supply chain, associated with the final purchases of different goods and services. Figure 27 shows the estimated emissions footprints (kilograms of CO2e per capita per year) embedded within final purchases of food (including food services), chemicals (aggregate of chemicals, pharmaceuticals, plastics and rubbers), energy, paper, textiles (including wearing apparel and leather goods), transport and wood products for the years 2025, 2030 and 2040.[6] As expected, the main driver of these results is the assumed economy-wide reductions in greenhouse gas emissions, both in the EU and the rest of the world. With a reduction in the fossil energy intensity of industrial and services activities, there are gradual declines in the emissions footprints across all product categories. Not surprisingly, this decline is most marked in final demands for energy, with a reduction from 968 kgCO2e/capita/year in 2025, to 693 kgCO2e/capita/year in 2040 (28% reduction).

[6] In MAGNET, final demand for chemicals is a composite of bio-based and fossil produced products.

Figure 27. Emissions footprints from EU final purchases of industrial products.



Source: MAGNET.

2.5. Strengthening competitiveness and creating jobs

Table 6 depicts the set of indicators that provide insight on the fifth bioeconomy societal objective "strengthening competitiveness and creating jobs".

Table 6. Indicators on "Strengthening competitiveness and creating jobs".

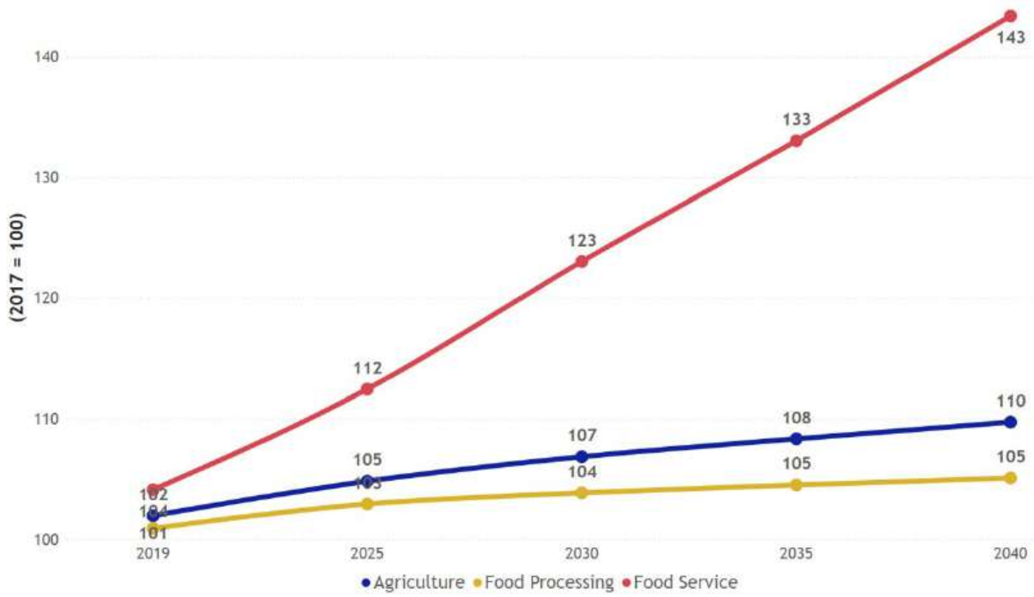
Indicator (definition)	Metrics	Model
Bioeconomy production in bio-industrial activities	% change index	MAGNET
Biochemicals turnover by EU MS	€millions	MAGNET
Bioeconomy employment by sector and gender (under development) by EU MS	heads	MAGNET
Bioeconomy trade balances by broad activities	€millions	MAGNET

Source: JRC, own elaboration

2.5.1. Bioeconomy production by broad activities

Given the sectoral scope of the MAGNET model, Figure 28 and Figure 29 show the evolution of the index of EU output changes (2017=100) across a selection of bio-based activities. With relative income elastic demands, and an assumed projected population decline in the EU beyond 2025, primary agricultural and food processing output remains relatively static moving toward 2040 (Figure 28). On the other hand, with a higher income elasticity of demand, the demand for food services continues to increase strongly, suggesting a rising calorific intake sourced from out-of-home prepared foods.

Figure 28. Relative output trends (2017=100) for agriculture, food processing and food services in the EU.

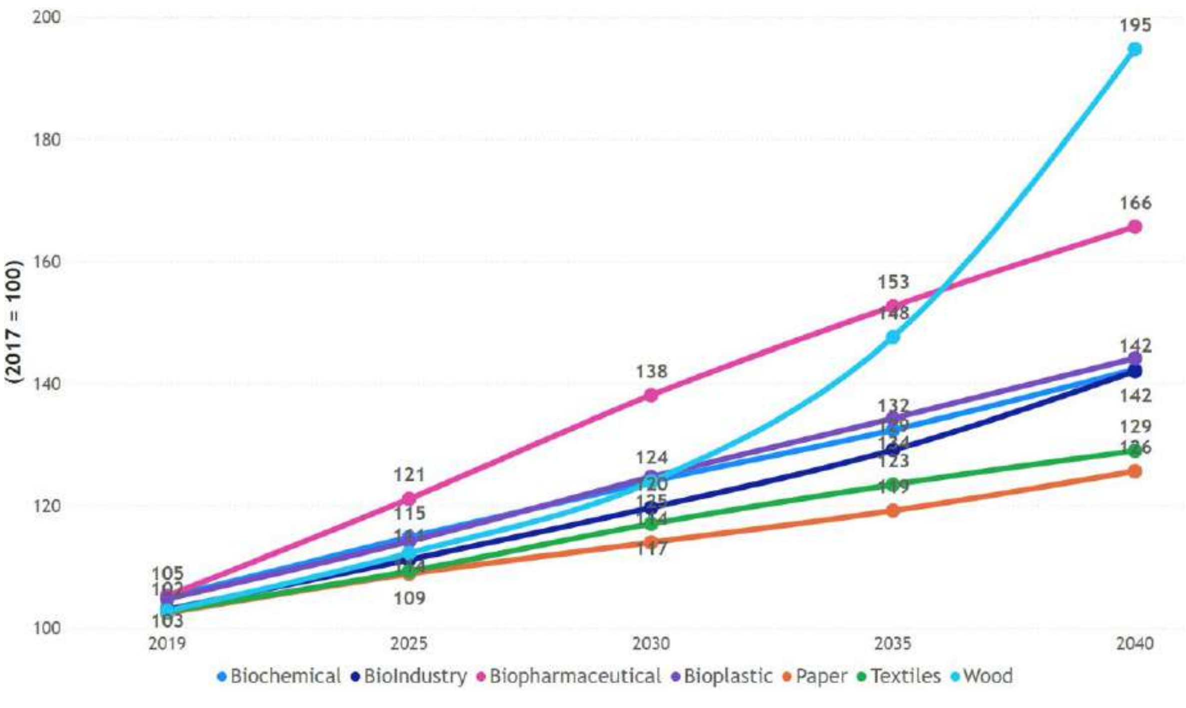


Source: MAGNET.

Figure 29 presents the baseline index of real growth in selected bio-based industrial activities. Overall, the index of average bio-industrial real growth rises from 111 in 2025 to 142 by 2040. By 2040, the industries of 'textiles, wearing apparel, and leather' and paper undergo real growth below this average (2040 indices of 129 and 126, respectively). Indeed, in both activities, growth is considerably more sluggish than in the rest of the world due to an assumed slower rate of economic growth in the EU bloc. In the case of EU wood products production, there is rapid growth, with a 2040 baseline production index of 195. This follows from the baseline assumption regarding the capacity of EU and non-EU forestry roundwood production. With relatively sluggish growth in global roundwood production, and faster rates of assumed economic growth in the non-EU regions, a supply bottleneck occurs, with large increases in extra-EU demands for downstream EU wood products.

In the case of EU biochemicals (i.e., composite of bio-based chemicals, bio-based pharmaceuticals, and bio-based plastics), real production growth is above the EU bio-industrial average, reaching an index value of 160 in the 2040 baseline. In addition to general macroeconomic drivers (productivity and rising per capita incomes), less emissions intensive bio-based chemical sectors also benefit from climate policies and (to a lesser extent) assumed steady rises in oil prices.

Figure 29. Relative output trends (2017=100) for selected bio-industrial activities in the EU.



Source: MAGNET.

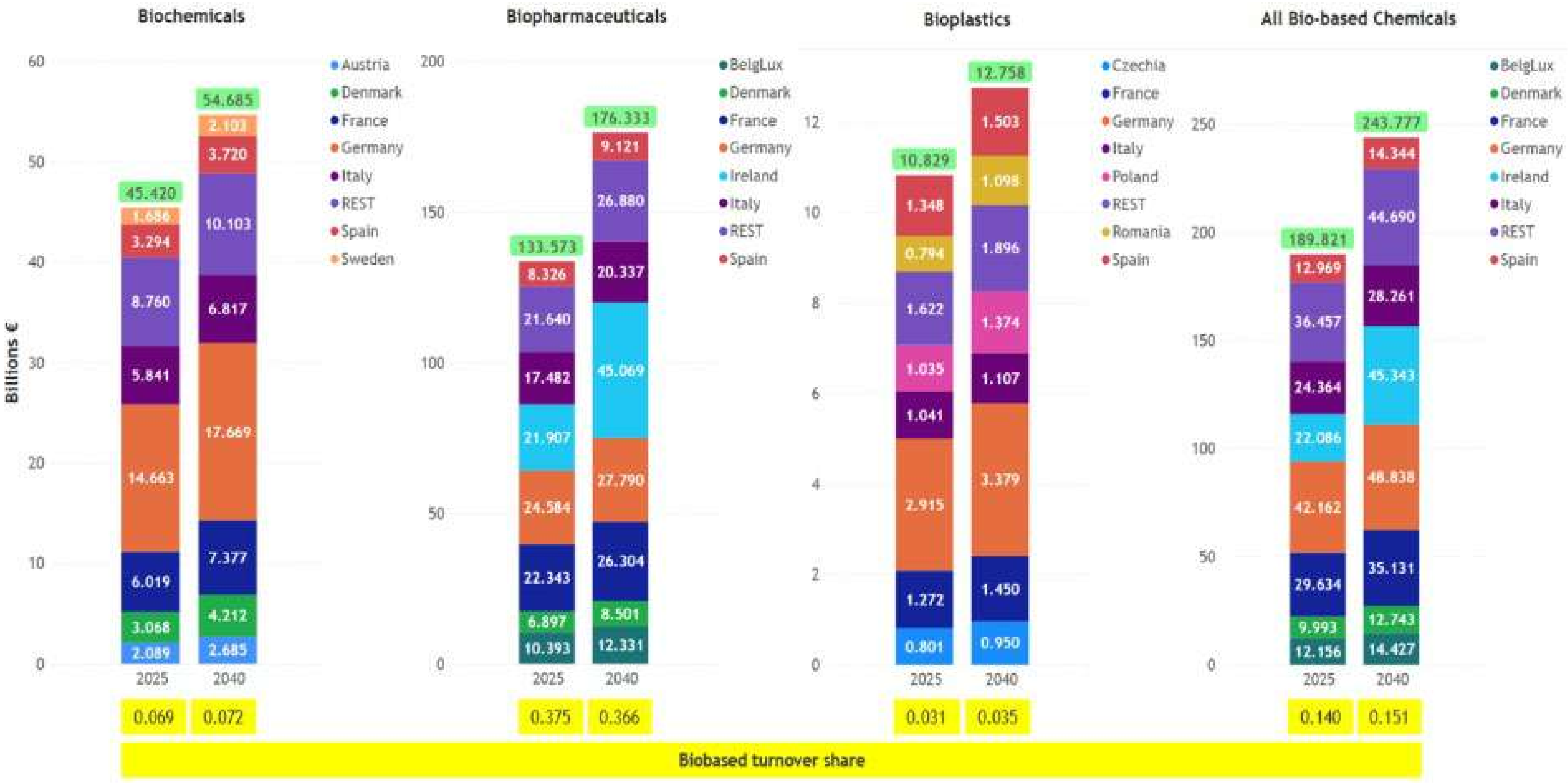
2.5.2. Biochemicals turnover by EU member states

With the split of all three chemical sectors in the database, MAGNET can measure the turnover share of bio-based chemical activities as a proportion of total turnover of the chemical industry. These estimates are shown in the annex chapter 5.4.2 by EU member state.[7] For example, in Austria, it is estimated that of the estimated total turnover in the bio-pharmaceutical industry is €2,783 million (2017 prices), which is equivalent to 25.3% of the total Austrian turnover for the pharmaceutical industry. At the bottom of the table is presented the EU27 average bio-based turnover shares, which for chemicals, pharmaceuticals and plastics are estimated at 6.6%, 33.8% and 3.0%, respectively. This corresponds to a turnover of €39,582 million, €106,453 million and €10,083 million for bio-based chemicals, bio-based pharmaceuticals and bio- based plastics, respectively.

Examining further the trends in the biochemicals sectors, Figure 30 shows the turnover (€billions, 2017 prices) of the biochemicals sectors, by EU member states for the years 2025 and 2040. In the 2025 baseline, the total turnover of the EU bio-based chemicals industry is estimated at €45.4 billion, rising to €54.7 billion by 2040. Similar trends for 2025 and 2040 are also observed in the EU's bio-based pharmaceuticals (€133.6 billion and €176.3 billion, respectively) and bio-based plastics (€10.8 billion and €12.8 billion in 2025 and 2040, respectively). Examining the EU member states' turnover for the EU bio-based chemical industry, in absolute terms, the largest turnover is from Germany (€14.6 billion and €17.7 billion in 2025 and 2040, respectively). In EU bio-based pharmaceuticals, France, Germany, Ireland, and Italy lead the way with the largest turnover, although by 2040, Ireland has the largest bio-pharmaceutical sector by some margin (€45.1 billion), driven in large part by significant projected economic growth.[9] In terms of bio-based plastics, Germany once again has the largest absolute turnover (€2.9 billion and €3.4 billion in 2025 and 2040 respectively), although there are several EU member state larger players with similar sized bio-plastic activities (e.g., Czechia, France, Italy, Poland, Romania, Spain). Aggregating over all three bio-based chemical industries, the EU biochemical turnover is recorded as €189.8 billion and €243.8 billion in 2025 and 2040, respectively.

[7] These data are closely aligned with the JRC DataM bioeconomy turnover estimates for 2017.

Figure 30. Biochemical industry turnover in the baseline (2025 and 2040) (2017 prices).



Source: MAGNET.

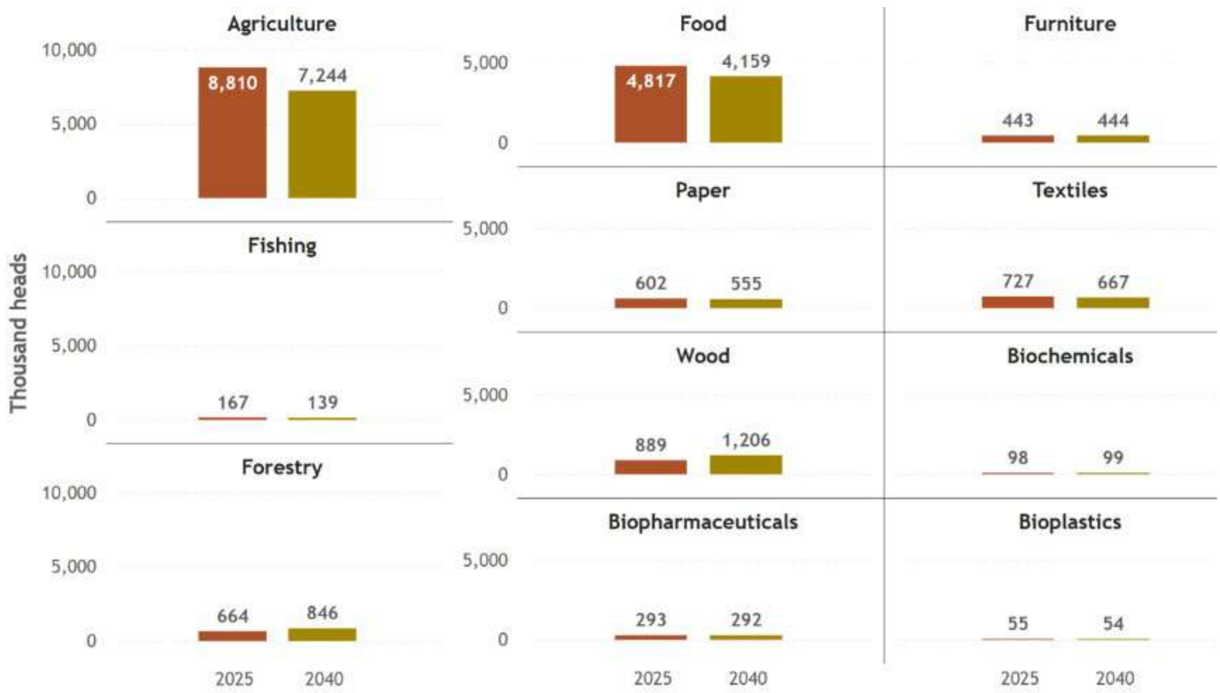
2.5.3. EU bioeconomy employment

Figure 31 shows the employment trends for a selection of primary and secondary bio-based activities in the European Union. These projections are based on satellite data which has been taken from the JRC's bioeconomy section on the DataM platform.[12] All estimates in Figure 31 are in thousands of heads.

In 2017 it is estimated that 9.894 million people were employed in primary agriculture (not shown). Given sluggish primary agricultural growth coupled with productivity improvements in the sector, the primary agricultural workforce shrinks to 8.810 million in 2025, and subsequently 7.244 million by 2040. In the food industry, over the same period, EU employment falls from 4.817 million in 2025 to 4.159 million by 2040. Summing over other selected bio-industrial activities,[13] Figure 31 shows that the workforce rises in the baseline from 3.107 million workers in 2025, to 3.317 million workers. This is largely driven by the wood products sector (due to extra-EU export driven growth discussed in section 3.5.1).

With relatively strong rises in the production of EU biochemical activities, there are initial increases in employment. In 2017, it is estimated that EU bio-based chemicals, pharmaceuticals, and plastics employed 92 thousand, 273 thousand and 54 thousand people, respectively (not shown). This represents a total of 419 thousand people. By 2025, these EU totals rise to 98 thousand, 293 thousand, and 55 thousand people, respectively (446 thousand persons, in total). By 2040, despite continued real growth, rising levels of capitalisation in these industries result in plateauing employment estimates of 99 thousand, 292 thousand and 54 thousand people in EU bio-based chemicals, pharmaceuticals and plastics, respectively (445 thousand persons in total).

Figure 31. Baseline employment trends in bioeconomy sectors (2025 and 2040).



Source: MAGNET.

2.5.4. EU Industrial trade balances

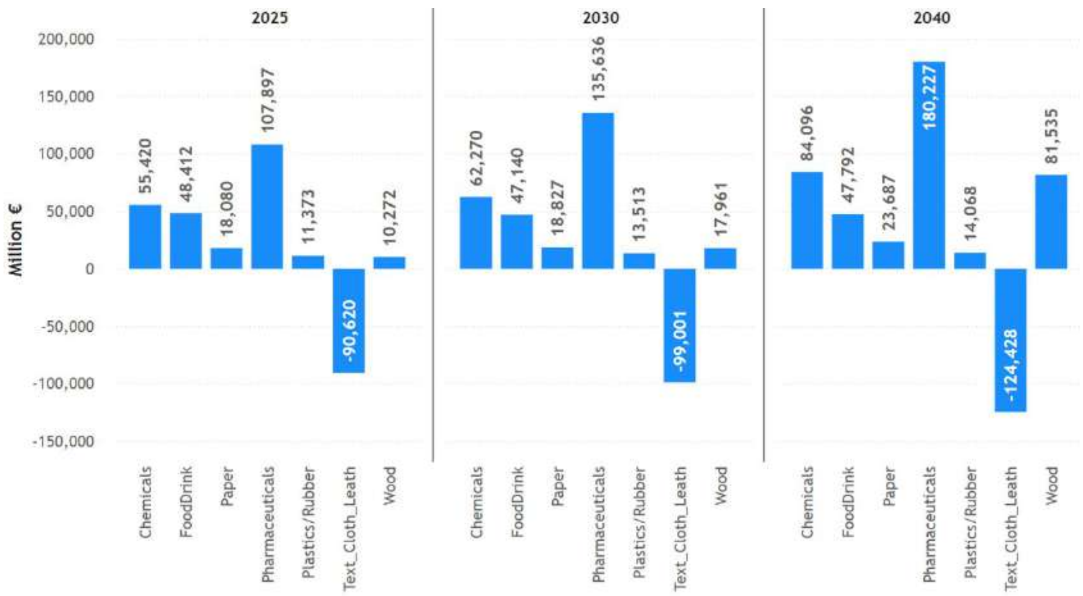
The trade balances for a selection of EU industrial products are presented in Figure 32 in MAGNET, assumed rates of real GDP growth are targeted based on economy-wide productivity growth (supply side). A growing economy also impacts upon value added which drives up per capita regional incomes (demand side). Mismatches in the relative growth in supply (sector specific productivity growth) and demand (income elasticities of product demand) are met through structural changes in the trade patterns.

In the food and drink industry, the trade surplus remains consistent across the time frame of the baseline. In 2025, 2030 and 2040, the food and drink net surplus is estimated at €48.412 billion, €47.140 billion and €47.792 billion, respectively. The main drivers of the surplus are dairy, white meat (e.g., pork) and beverages trade (not shown), although rapid expansion in the rest of the world's dairy and white meat sectors reduce the EU's trade surplus when moving toward 2040. Similarly, in the textiles, clothing and leather sector, where a trade deficit of -€90.620 billion is recorded in 2025, the trade balance position worsens due to assumed relatively slower productivity growth in the EU.

The EU wood and paper industries are in trade surplus, where in the former, the surplus improves considerably. With assumed restrictions on global rises in industrial wood availability limiting supply, and strong demand in the non-EU region driven by higher projections of relative macro growth, there are rising extra-EU exports of wood products to rapidly expanding activities such as construction and 'other manufacturing' (including furniture) sectors in third countries.

In the case of chemicals, pharmaceuticals and plastics/rubber products, the EU's trade competitive position (i.e., surplus) is maintained and even strengthened moving to 2040. A key driver of this result is the lower emissions intensity in tonnes per dollar of activity in the EU chemicals sectors (especially in pharmaceuticals) compared with non-EU regions. Thus, with falling global emissions and rising carbon prices, the relative competitiveness of the EU's chemical sectors improves, reflected as an improvement of the trade balance.

Figure 32. Selected EU industrial trade balance trends (2017 prices)



Source: MAGNET.

3. Discussion and conclusions

The main outcome of this study is the development of a credible baseline for the European bioeconomy in the EU member states. In an attempt to synergise the outcomes reported in the above sections within a digestible format, this final section of the report presents an overarching summary of the results with a focus on the emergent synergies and trade-offs based on the selection of KPIs chosen in section 2.3. Thus, Figure 33 illustrates the impacts of the bioeconomy on the objectives of the Bioeconomy Strategy in the baseline situation via the KPIs. It provides an overview of the prospects, synergies and trade-offs for the EU bioeconomy from 2025 to 2040 through the lens of the five societal challenges.

Note that the quantification of progress on each indicator is calculated as the percentage change between start year 2025 values and end year 2040 values. Green (orange) indicates more 'desirable' (less 'desirable') outcomes.

Figure 33. Outcomes of EU bioeconomy KPIs for the five societal challenges of the BioEconomy Strategy in the baseline, 2020-2040.

#	Key Performance Indicator	Baseline 2025	Baseline 2040	% change 2025-2040
	Ensuring food and nutrition security			
1.1	EU food crop prices (euro/t)	292	298	1.7%
1.2	EU net export of agri-food commodities (crops) (kton)	16,197	34,328	111.9%
1.3	Share of plant proteins in total proteins consumed (%)	40.8	41.4	1.7%
1.4	EU average food budget expenditure shares (%)	20.9	20.0	-4.50%*
1.5	EU average calories intake (calorie/capita/day)	3,432	3,580	4.3%*
	Managing natural resources sustainably			
2.1	EU total productive agricultural land (mio ha)	160.5	157.2	-2.0%
2.2	EU share of crop biomass for feed use (%)	56	59	4.4%
2.3	Total EU municipal waste (million tonnes)	208.8	213.0	2.0%
2.4	EU food waste (kg/capita/year)	126.6	124.8	-1.4%
2.5	Agricultural land footprints from food purchases (m^2/cap/yr)	4,149	3,724	-10.2%
	Reducing dependence on non-renewables			
3.1	EU share of bio-based chemical production in total (organic) chemicals (%)	13.7	15.8	15.3%
3.2	EU net-import plant oil feedstock for material production (kton)	-1002	-825	-17.7%
3.3	EU biofuel domestic use (ktoe)	20,764	14,065	-32.3%
3.4	EU crop-based ethanol fuels for domestic use	6,159	2,827	-54.1%
3.5	EU crop-based biodiesel for domestic use	7,105	4,438	-37.5%
3.6	EU total biochemicals turnover share (%)	14.0	15.1	7.9%
3.7	EU bio-based energy prices (index 2017=100)	113.7	129.8	14.2%
	Mitigating climate change			
4.1	EU total emissions per currency unit of EU GDP (tCO2e/$)	195.7	138.1	-29.4%
4.2	EU emissions footprints on food purchases (kgCO2e/pc/yr)	1,619	1,528	-5.6%
	Strengthening competitiveness and jobs			
5.1	Bio-industrial** production real growth index (2017=100)	111.1	142.0	27.8%
5.2	Total EU bio-based chemical turnover (€ billions)	189.8	243.8	28.5%
5.3	Total EU bio-industrial* employment (thousand heads)	3,107	3,317	6.8%
5.4	EU bioeconomy*** trade balances (€ millions)	160,833	306,977	90.9%

Source: MAGNET, AGMEMOD and BioMAT.

*Notes * From a food affordability perspective, less is better; from a food security perspective more is better (though not necessarily healthier).*

***Paper, textiles, wood and bio-based chemicals activities.*

**** Paper, textiles, wood and all chemical commodities (MAGNET does not separate bio- and fossil-based chemical commodities)*

In the following the highlights of the multi-indicator analysis as assessed in Figure 33 are presented.

Regarding the agri-food sector, the baseline developments show an increase of crop production volumes due to yield productivity growths. However, agricultural land in the EU becomes slightly less productive due to the new CAP measures (fallow land, Eco-scheme measures). Mostly driven by world market developments the EU food prices are slightly higher, which influences affordability negatively.

Nevertheless, food becomes more affordable as the average amount of income spend on food decreases by 12.3%. The amount of calories consumed do slightly increase with growing income levels, including a very small increase in less healthy calories from red meat and sugars.

The use of biomass for feed use in the animal sector is already high, but even increasing towards nearly 59%. This is in line with the remaining high share of animal protein intake in total protein intake by the consumer in coming decades. Despite a slight improvement, it is not in line with a balanced diet as for instance proposed by Eat-Lancet.

Biofuel domestic use is gradually declining up to 2040 because total transport fuels are supposed to be substituted by electric riding/battery driven transport after 2023 which should reduce greenhouse gas emissions. At the same time crop-based feedstock for biofuels are replaced by advanced biological feedstock for biofuels. We have assumed that the released crop-based feedstock for biofuels after 2023 will become available as extra biological feedstock for the material industry and will not flow into increasing exports.

The bioeconomy industry shows a steady development, but speed is insufficient to achieve higher shares without additional green investments and policy support. In addition, the available biological feedstock for food, feed, seed, biofuels, and material uses in the EU is insufficient to fulfil the requirements of a strongly increasing bio-based industry in the coming decades though the dependency of imports is decreasing. However, EU regulations on sustainably sourcing of feedstock to diminish deforestation (Deforestation directive) and less productive land availability in the EU for biomass production will starting to play a role in the future and may limit the expansion of biomass use for bio-based food, feed, materials and energy.

On the other hand, the exploiting of agricultural and forestry residues, as well as the use of other renewable techniques than biomass use (e.g. electric riding as alternative of biofuels in transport sector) will diminish the requirements of biomass for material and energy industry. The total amount of municipal waste increases in the EU. The other waste types (food waste, paper, glass, garden and rest waste) decrease.

Overall employment in the bioindustry sectors declines by 2%. This decline is mostly happening in the traditional bioindustry sectors like textiles. Employment increases in the biochemical sectors especially in the biopharmaceutical sector. For the bio-based production of chemicals an increase by 20% can be observed. However, the share of the bio-based chemicals remains still small.

Overall, the trade balance for the EU bioindustry increases, as for most commodities in the bioindustry exports increase faster than imports. The emissions per unit of GDP decline by 33%. The emission footprint also declines by 18%.

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List of boxes

List of figures

List of tables

5. Annex: Modelling approach

5.1. Overall approach

As noted in section one of this report, the aims of this project were to (i) build on the existing knowledge base in bioeconomy market modelling by enhancing existing state of the art modelling tools and (ii) with those enhancements, develop a credible ex ante bioeconomy (business-as-usual) baseline to 2040 for the EU member states. The point of departure for this project was the accumulated expertise that had been gained from the H2020 EU BioMonitor project. Taking an EU member state focus, the modelling task of BioMonitor created a platform consisting of a suite of five simulation modelling representations that capture both the vertical and horizontal dimensions of biomass usage (i.e., biomass supply chains across different activities and biomass competition effects between food, feed, energy and materials). Two of the models were forestry market models (EFISCEN, EFI-GTM), whilst the remaining three dealt with the specifics of nascent bio industrial activity (BIOMAT), the agrifood sector (AGMEMOD) and the broader macroeconomy (MAGNET) with coverage of bio-based food, feed, energy and material activities. Using soft model linkages, a comprehensive and harmonised (across models) baseline scenario was constructed, which would subsequently serve as a basis for further exploratory foresight scenarios. As a basis for evaluating the performance of the EU bioeconomy, a series of key performance indicators (KPIs) were selected across the three models. The selection criterion was based on the models' ability to summarise aspects of the currently defined five pillars of the EU's Bioeconomy Strategy (EC, 2018).

5.2. MAGNET

5.2.1. Description

The Modular Applied GeNeral Equilibrium Tool (MAGNET) is a recursive dynamic, multi-region, macroeconomic CGE simulation model with a focus on natural resources and bio-based activities (Woltjer and Kuiper, 2014). The principal data source for the model is in general the Global Trade Analysis Project (GTAP) database (Aguiar et al., 2019), with detailed transactions data on intermediate and final demands, as well as gross bilateral trade flows for 65 goods and services and 141 regions. The MAGNET version of this data has coverage of up to 124 activities and 138 commodities, due to additional in-house activity and commodity splits (mainly bio-based). The current version of the model was further extended to recognise the emerging importance of nascent bio-industrial sectors, in particular the bio-based chemical, pharmaceutical and plastic sectors (Philippidis et al., 2023). With the GTAP model at its core, MAGNET employs coded switches to activate a series of specialist modules of agricultural, bioenergy and bio-based industry markets. Thus, although it is economy-wide in scope, this tops-down model representation is able to capture multiple bioeconomy policies and the resulting competition effects for biomass. MAGNET provides typical market indicators (prices, outputs, demands, exports, imports), whilst through the support of satellite databases MAGNET is able to provide physical indicators (e.g., land areas, nutritive intake, employment, greenhouse gases and circularity indicators).

Table 7. Regional and sectoral dimensions in MAGNET.

Regions	Sectors
EU member states plus UK, Ukraine, Rest of Europe, Mercosur, Rest of the world.	MAGNET is a macroeconomic model with up to 155 commodities and 130 activities. It includes 25 primary agricultural and fish commodities, 10 food processing commodities and 5 feed commodities. Coverage also includes 8 liquid and solid bioenergy types, eight industrial bio-material sectors covering textiles, leather, paper, wood and three bio-based chemicals commodities)

Source: JRC, own elaboration.

5.2.2. Enhancements

For the MAGNET model, the representation of the three bio-based chemicals activities (biochemicals, biopharmaceuticals and bioplastics) was improved through the introduction of new updated top-down shares and more targeted EU biochemicals turnover numbers, both from the JRC bioeconomics division; technical improvements to the joint production representation of fossil and bio-based chemicals; and a conceptualised improvement on the representation of the relative cost disadvantage of bio-based technologies vis-à-vis their rival fossil counterparts. Moreover, as a new source of blue bioeconomy biomass, seaweed markets are also introduced. A final important development was the endogenous representation of investment through changes in rates of return, both across regions, and (if chosen) sectors. Thus, the MAGNET model now has become a truly recursive dynamic treatment of investment allocations to different activities as a function of expected returns on capital, whilst in principle, it also permits the modeller to examine outcomes arising from targeted green investments. In addition to these three principal enhancements, further refinements were included on the broader coverage of indicators (particularly ecosystem and social indicators) as well as the introduction of waste behaviour taxes in the waste module.

5.3. AGMEMOD-BioMAT

5.3.1. Description

The AGricultural MEmber State MODelling (AGMEMOD) framework (Salputra et al., 2017) is an econometric, dynamic, partial-equilibrium multi-country model initially developed for EU agricultural crop markets, whilst the model captures the interactions with non-EU countries' agricultural systems. Commodity balance items (e.g., production, domestic use, stocks, exports, imports) and prices are projected and simulated based on macroeconomic assumptions and agricultural market variables consistent with the DG Agriculture EU Agricultural Outlook (EC, 2023) and EU and national based agricultural policy. AGMEMOD provides Member State specific projections on crops allocations for food, feed, seed, export, stocks and biofuels uses. The remainder, after netting out domestic production and imports, is deemed as usable for material use by the industrial sector.

The Bio-based MATerials (BioMAT) model (Van Leeuwen et al., 2022; Sturm et al., 2023) is a multi-regional PE model that provides projections for markets of bio-based product groups as well as for associated biological feedstock needs. BioMAT follows the same framework as the AGMEMOD model, capturing the production, domestic uses, imports, exports and prices of bio-based application categories in each of the EU Member States. As crops or products thereof covered by AGMEMOD are feedstocks for the production of bio-based products in BioMAT, a direct link between both models is established. In addition, BioMAT represents stylised bio-based value chains by capturing biological feedstocks (e.g. starch, plant oils, sugar, lignocellulosic from agriculture and forestry, animal biomass, aquacultures) in the form of raw materials and their subsequent downstream processing steps in the elaboration of bio-fuels and bio-based materials (principally chemicals). As there are hundreds of (chemical) products that can be produced using biomass as a feedstock, following Spekreijse et al. (2019) and Nova-Institute (2015a, 2015b), they have been clustered into product groups or application categories (e.g. surfactants, polymers, solvents, paints, lubricants). With coverage of the entire chemical sector, BioMAT also provides insights into the evolution of bio-based shares in the total organic chemical industry and in individual product application categories.

Table 8. Regional and sectoral dimensions in AGMEMOD.

Regions	Agro-food commodities covered in the baseline
EU member states, EU27, UK, Ukraine,	Soft wheat, durum wheat, barley, corn, rye, triticale, rapeseed, rape oil, rape meal, sun seed, sun oil, sun meal, soybeans, soy oil, soymeal, sugar, sugar beet, potatoes, beef & veal, lamb meat, pork, poultry, cow's milk, butter, cheese, skim milk powder, whole milk powder, tomatoes, apples, peaches & nectarines, oranges, olives, olive oil.

Source: JRC, own elaboration.

Table 9. Regional and sectoral dimensions in BioMAT.

Regions	Chemical applications
EU member states, UK	Platform chemical, polymers for plastics, solvents, paints, coatings, inks and dyes, surfactants, lubricants, cosmetics and personal care products, adhesives, man-made fibers, biofuels, pharmaceuticals, food and feed, construction, agrochemicals, other applications

Source: JRC, own elaboration.

5.3.2. Enhancements

In the case of AGMEMOD and BIOMAT, the representation of palm oil and palm kernel oil is made explicit in the former, whilst the use of this newly added source of biomass in the bio-based chemical industry is now characterised in the latter and with this enhancement, it improves insight on the net availability of biomass for material use. Further enhancements are made to AGMEMOD's conventional biofuels markets with upgrades in the representation of the supply and demand of biofuels in EU member states (in kilo oil equivalents - ktoe) and the flow of biomass feedstock types to produce biofuels (in kt raw product). To maintain consistency this activity also required adaption of BioMAT. Moreover, agrifood commodity markets are treated in AGMEMOD, and alignment with AGLINK's biofuel model has been considered at the EU level. Finally, with the availability of data on the detailed payments structure of the common agricultural policy (CAP) from DG Agriculture, both the MAGNET and AGMEMOD models now have an enhanced representation of the CAP Strategic plans for the multiannual financial framework period 2023-2027.

5.4. Sources of baseline assumptions

The enhanced forward-looking modelling capacity must ensure insights on future bioeconomy pathways under a baseline situation via the quantification of an indicator framework of the bioeconomy (Kardung et al., 2021). For the interpretation of the bioeconomy baseline outlook results, it is important to bear in mind that projections are neither forecasts, nor predictions. Usually baseline results are driven by several underlying assumptions and exogenous variables, which are determined outside the model. In this respect a baseline assumes normal biophysical and climate conditions, steady demand and yield trends and no market disruption, provoked by, for example, wars, outbreak of diseases, food safety issues, extreme weather conditions (Salputra et al, 2017; EC, 2023). Consequently, all assumptions imply relatively smooth market developments, although in reality markets tend to be much more volatile. Therefore, the baseline scenario must not be considered as a forecast, but rather as a possible pathway that the EU bioeconomy market is expected to follow given unchanged policies, a steady development of demand and technological progress, and a continuation of normal geopolitical, macroeconomic and weather conditions.

Next sub-sections present the main factors that drive the development of the baseline outlook for the EU bioeconomy as compiled by AGMEMOD-BioMAT and MAGNET. These factors are, respectively, for macroeconomic conditions, world market price developments, available woody biomass and policy settings.

5.4.1. Macro-economic projections

Macro-economic trends are exogenously determined in AGMEMOD-BioMAT and MAGNET and sourced from other pathways. Table 10 gives an overview of available pathways that are feasible for the bioeconomy baseline to be developed (in the columns) and the macroeconomic variables these sources entail and provide projections (in the rows). The last two columns indicate which source/pathway are applied to the models.

Table 10. Assumptions for macroeconomic drivers projected until 2040, per source.

	GECO (Keramidas et al. (2023)	DG-AGRI MTO (Oct 2023)	DG AGRI (2023), provided by JRC	Agreed source per model
Population	5-yrs intervals; until 2040; MS level	Annual data; until 2040; MS level	Annual data; until 2040*; MS level. Same numbers ad DG-AGRI	AGMEMOD- BioMAT: DG-AGRI/JRC MAGNET: DG-AGRI/JRC
Real GDP (base 2010)	5-yrs intervals; until 2040; MS level	Annual data; until 2040; MS level	Annual data; until 2040*; MS level. Same numbers ad DG-AGRI	AGMEMOD- BioMAT: DG-AGRI/JRC MAGNET: DG-AGRI/JRC
GDP deflator		Annual data; until 2040; MS level	Annual data; until 2040*; MS level. Same numbers ad DG-AGRI	AGMEMOD- BioMAT: DG-AGRI/JRC

				In MAGNET, this is an endogenous outcome of the model.
Exchange rate (NC/USD)		Annual data; until 2040; MS level	Annual data; until 2040*; MS level. Same numbers ad DG-AGRI	AGMEMOD- BioMAT: DG-AGRI/JRC MAGNET works in dollars; no explicit exchange rate

Source: JRC, own elaboration.

* Trends to 2035 taken from DG AGRI (2023) plus time linear extrapolation to 2040.

5.4.2. Agricultural and energy world market price projections

World market price developments are endogenously calculated in MAGNET, however exogenous in AGMEMOD-BioMAT and therefore the latter needs a source to comply with. Regarding world market prices for agri-food commodities (Table 3-2), AGMEMOD-BioMAT aligns with global prices used in DG-AGRI's agricultural outlook and provided by the global AGLINK model. In AGMEMOD-BioMAT these world price projections drive prices of associated agri-food commodities in the EU and its member state, and are annually updated (EC, 2023).

Table 11. World market price projections for agri-food products until 2040, per source.

	DG AGRI (2023)	Agreed source per model
Crop prices (wheat, barley, maize, rice, oilseeds/meal/oil)	Annual data (USD/tonne; nominal prices); until 2040	AGMEMOD-BioMAT AGLINK projections for baseline
Sugar raw, white	Annual data (USD/tonne; nominal prices); until 2040	AGMEMOD-BioMAT AGLINK projections for baseline
Dairy prices (cheese, butter, milk powder)	Annual data (USD/tonne; nominal prices); until 2040	AGMEMOD-BioMAT AGLINK projections for baseline
Meat prices (beef & veal, pork, poultry, lamb)	Annual data (USD/tonne; nominal prices); until 2040	AGMEMOD-BioMAT AGLINK projections for baseline

Source: JRC, own elaboration.

Regarding world market prices for energy products (Table 3-3), AGMEMOD-BioMAT again aligns with AGLINK price developments. Though MAGNET is more flexible in its choice, it also complies with AGLINK price projection for its baseline development and use these for calibrating prices for oil, gas and coal.

Table 12. World market price projections for energy products until 2040, per source.

	GECO (Keramidas et al. (2023)	DG AGRI (2023)	Agreed source per model
Ethanol price		Annual data (USD/hl; nominal prices); until 2040	AGMEMOD-BioMAT AGLINK projections for baseline
Biodiesel price		Annual data (USD/hl; nominal prices); until 2040	AGMEMOD-BioMAT AGLINK projections for baseline
Crude oil price	Endogenous	Annual data (USD/barrel; nominal prices); until 2040	AGMEMOD-BioMAT AGLINK projections for baseline MAGNET: AGLINK projections for calibrating oil price
Fertilizer price		Annual data (USD/tonne; nominal prices); until 2040	AGMEMOD-BioMAT AGLINK projections for baseline

Source: JRC, own elaboration.

Table 13. Estimates of turnover and top-down bio-based shares for EU bio-based chemical activities in MAGNET.

	Turnover (2017 €millions)			**Top down value shares (<1)**		
	Biochemicals	**Biopharma**	**Bioplastics**	**Biochemicals**	**Biopharma**	**Bioplastics**
Aut	1,742	2,783	111	0.157	0.253	0.014
Bel	1,409	8,836	136	0.024	0.307	0.010
Bgr	439	301	27	0.170	0.295	0.014
Hrv	86	407	27	0.066	0.328	0.031
Cyp	9	111	4	0.074	0.316	0.029
Cze	766	564	722	0.082	0.228	0.062
Dnk	2,124	5,670	52	0.335	0.487	0.013
Est	17	26	9	0.024	0.283	0.019
Fin	460	1,001	129	0.072	0.450	0.040
Fra	5,142	17,196	1,169	0.061	0.502	0.029
Deu	12,904	20,754	2,683	0.076	0.248	0.027
Grc	66	699	17	0.027	0.464	0.008
Hun	377	1,742	411	0.054	0.372	0.067
Irl	133	15,160	17	0.006	0.316	0.008
Ita	5,178	14,059	980	0.086	0.425	0.022
Lva	61	85	34	0.101	0.183	0.078
Ltu	171	108	17	0.052	0.139	0.012
Lux	54	33	57	0.026	0.057	0.025
Mlt	4	89	4	0.028	0.204	0.024
Nld	2,391	3,280	191	0.040	0.227	0.012

Pol	1,160	1,802	902	0.051	0.363	0.043
Prt	348	608	373	0.052	0.342	0.063
Rou	152	449	579	0.046	0.464	0.108
Svk	40	109	81	0.014	0.280	0.020
Svn	50	921	24	0.024	0.333	0.012
Esp	2,877	6,493	1,231	0.061	0.433	0.047
Swe	1,422	3,168	92	0.129	0.377	0.017
EU27	39,582	106,453	10,083	0.066	0.338	0.030

Source: MAGNET Database.

Table 14. Cost disadvantage ratio and subsidy rates for EU bio-based chemical activities.

	Cost disadvantage ratio*			Subsidy rate**		
	Biochemicals	Biopharms	Bioplas-tics	Biochemicals	Biopharma	Bioplastics
Aut	0.879	0.937	0.498	-0.121	-0.063	-0.502
Bel	0.598	0.959	0.430	-0.402	-0.041	-0.570
Bgr	0.889	0.954	0.496	-0.111	-0.046	-0.504
Hrv	0.762	0.966	0.643	-0.238	-0.034	-0.357
Cyp	0.778	0.962	0.633	-0.222	-0.038	-0.367
Cze	0.793	0.925	0.751	-0.207	-0.075	-0.249
Dnk	0.968	1.000	0.481	-0.032	0.000	-0.519
Est	0.595	0.949	0.555	-0.405	-0.051	-0.445
Fin	0.774	1.000	0.683	-0.226	0.000	-0.317
Fra	0.749	1.000	0.628	-0.251	0.000	-0.372
Deu	0.781	0.934	0.616	-0.219	-0.066	-0.384
Grc	0.620	1.000	0.430	-0.380	0.000	-0.570
Hun	0.730	0.980	0.763	-0.270	-0.020	-0.237
Irl	0.430	0.962	0.430	-0.570	-0.038	-0.570
Ita	0.800	0.994	0.582	-0.200	-0.006	-0.418
Lva	0.821	0.898	0.785	-0.179	-0.102	-0.215
Ltu	0.726	0.864	0.474	-0.274	-0.136	-0.526
Lux	0.611	0.740	0.605	-0.389	-0.260	-0.395
Mlt	0.624	0.911	0.600	-0.376	-0.089	-0.400
Nld	0.684	0.924	0.462	-0.316	-0.076	-0.538
Pol	0.724	0.977	0.695	-0.276	-0.023	-0.305
Prt	0.726	0.971	0.755	-0.274	-0.029	-0.245
Rou	0.707	1.000	0.830	-0.293	0.000	-0.170
Svk	0.499	0.949	0.562	-0.501	-0.051	-0.438
Svn	0.597	0.968	0.473	-0.403	-0.032	-0.527
Esp	0.749	0.996	0.711	-0.251	-0.004	-0.289
Swe	0.854	0.981	0.540	-0.146	-0.019	-0.460
EU27	0.778	0.971	0.657	-0.222	-0.029	-0.343

Source: MAGNET database
* The closer is the CDR to 1, the smaller is the cost disadvantage of the bio-based technology vs the fossil technology
** The subsidy (tax) rate is negative (positive) in MAGNET, where -0.121 is a 12.1% subsidy.

5.4.3. Woody biomass, paper and paper board projections

The BioMAT model requires insights in the future development of paper and paper board production in EU member states up to 2040 in order to calculate the use of starch (from wheat, corn, potatoes) as input for paper and paper board. For this annual data (tonnes) until 2040 on MS level was used from the EFI-GTM model in BioMonitor (Sturm et al., 2022). It provides a declining trend for EU paper production due to digitalisation.

The sector-wide MAGNET model has one forestry sector. It was aligned to EFISCEN forestry projections from the BioMonitor project with annual data (tonnes) until 2040 on MS level.

5.4.4. Policies and strategies

Table 15 contains the policy instruments of the Renewable Energy Directive and the way how these are treated in the models.

Table 15. Renewable Energy Directive.

Instruments	How used in models?	Assumption applied
Blending mandates for conventional/1G biofuel production	AGMEMOD-BioMAT: Biofuel module is updated and restructured. Demand for biofuels is policy driven via connecting mandates to total transport fuels. Results validated to AGLINK EU27 biofuel projections (more details, see section 2.3.1). MAGNET: CAPRI biofuel demand used for calibration purposes (in BioMonitor).	AGMEMOD-BioMAT: biofuel demand per MS is driven by biofuel mandates and capped use of crop-based biofuels MAGNET: calibration on CAPRI biofuel projection (from JRC); also check with AGLINK and AGMEMOD
Blending thresholds for advanced biofuel production (double counting)	AGMEMOD-BioMAT: see above. Advanced biofuels not modelled. MAGNET: in the absence of detailed projections, assumed mandates are employed.	MAGNET: assumes 4.5% (double counted) EU advanced liquid biofuel mandate by 2030 in the EU member states. This mandate can be increased/decreased to capture more/less ambitious scenarios.

Source: JRC, own elaboration.

Table 16 contains the policy instruments of the Common Agricultural Policy 2023-2027 and the way how these are treated in the models used in this study.

Table 16. Common Agricultural Policy.

Instruments	How used in models?
Non-productive area (fallow land, buffer zones, eco-scheme, EFA, …)	AGMEMOD-BioMAT: harmonised policy conceptual approach for implementing National Strategic Plans developed. So far applied in DE and NL, but needs updates (e.g. due to changing national plans). *Work in progress, in other projects.*
Voluntary coupled support	AGMEMOD-BioMAT: harmonised policy conceptual approach for implementing National Strategic Plans developed. So far applied in DE and NL, but needs update (e.g. due to changing national plans). *Work in progress, in other projects.* MAGNET: coupled support payments mapped to sectors and relevant drivers.
Decoupled support	AGMEMOD-BioMAT: harmonised policy conceptual approach for implementing National Strategic Plans developed. So far applied in DE and NL, but needs update (e.g. due to changing national plans). *Work in progress, in other projects.* MAGNET: A proportion of decoupled support payments (based on the proportion of the decoupled payment capitalised into the value of land) are inserted as a uniform land subsidy rate across all agricultural land bearing activities. Thus, the payment does not favour any specific activity. The remainder of the decoupled payment is applied uniformly across all value added.
Target land use under organic farming	AGMEMOD: organic farming not involved, but planned in the HORIZON Act4Cap27 MAGNET: currently no organic land modelled.

Source: JRC, own elaboration.

Key sources for the bioeconomy baseline design are DG-AGRI's Medium Term Outlook (https://agriculture.ec.europa.eu/data-and-analysis/markets/outlook/medium-term_en), the EC agricultural outlook (EC, 2023) and the Global Energy and Climate Outlook (GECO) business-as-usual baseline (Keramidas et al., 2018; Weitzel et al., 2019, Keramidis et al., 2020). The macroeconomic and population assumptions, as well as the evolution of the world oil price is taken DG-AGRI's MTO. Applications of the EC agricultural outlook provide medium-term projections for agricultural biomass that is available in the EU for competing applications, i.e. food, feed, seed, energy and material usages. It takes into consideration assumptions on policy support payments and the demand and supply of agri-food products in the non-EU as projected by the OECD. For this purpose, DG-Agri uses the AGMEMOD model to downscale its EU aggregated agri-food market projections (based on the AGLINK-COSIMSO model) towards agri-food market projections at the Member State level.

The GECO status quo scenario assumes that the progress in energy markets (i.e., decarbonisation, decoupling of energy usage from energy consumption, shifting of energy carriers toward electrification) is purely driven and justified by the dynamics of market force pressures (i.e., depletion of fossil resources) and anticipated technology change, with no additional climate agreements beyond 2017, nor investment strategies that promote a more responsible and sustainable model of growth (Panoutsou et al., 2020). Within this bioeconomy baseline, GECO baseline projections are used for EU and global greenhouse gas emissions, EU production of fossil fuels (coal, gas and oil), EU renewable electricity generation (nuclear, hydroelectric and wind/solar technologies) and EU biomass use for electricity and heat, at five-year time intervals up until 2040 for world regions as a whole and for each EU country. Global biogas projections are also borrowed from the International Energy Agency (IEA, 2023). The bioeconomy baseline is further enriched with assumptions on potential woody biomass availability (industrial roundwood production) obtained from secondary sources (Rougieux et al., 2024).

A feature of a baseline is that it takes into account those policy targets that are binding, e.g. percentage biofuels in total transport fuels, or percentage fallow land in total agricultural land. Also, it considers policy instruments in place to reach a specific objective, e.g. the use of coupled payments to support vegetables & fruit production.

AGMEMOD-BioMAT provides details on specific bio-based products. The baseline therefore includes the phasing out of unsustainable palm oil imports to the EU (linked to deforestation).

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