Sustainable biofeedstock supply chains for advanced biofuels in Europe towards 2050

This article summarises a study conducted by Concawe in collaboration with Utrecht University and TNO, providing a cost-optimised assessment of Europe's biomass-to-advanced-biofuel supply chains across Annex IX lignocellulosic feedstocks under different biomass availability and demand scenarios. Using high-granularity data and geospatial optimisation modelling, it evaluates advanced biofuel pathways such as gasification and Fischer-Tropsch (GFT) and hydrothermal liquefaction (HTL) under both centralised and decentralised supply chain configurations, and identifies efficient deployment and infrastructure-integration strategies for scaling up advanced biofuel production in Europe.

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Introduction

Advanced biofuels are expected to play an important role in decarbonising the EU transport sector, particularly in hard-to-electrify segments such as aviation, maritime transport and heavy-duty vehicles, contributing to the EU's target for a climate-neutral economy by 2050. Their successful deployment will rely on ensuring sufficient biomass availability, managing production costs, and developing resilient and efficient supply chains, all of which are key elements for realising Europe's long-term bioenergy potential.

Several studies, including one conducted by Concawe in collaboration with Imperial College London (ICL),[1] have quantified the potential availability of biomass in Europe (based on RED[1] II, Annex IX) at country level. While these studies incorporate technical and sustainability constraints, they exclude the economic and logistical aspects of biomass mobilisation. Yet, the costs of production, transport and conversion will be decisive for the competitiveness of advanced biofuels. Moreover, identifying optimal supply chain strategies, tailored to geography and existing infrastructure, remains critical for determining the most efficient and sustainable deployment pathways across Europe.

In this context, Concawe, together with Utrecht University and TNO, conducted a study to address the following key questions:

1. What are the optimal supply chain configurations (centralised vs decentralised) and main cost drivers for advanced biofuel supply chains in Europe?
2. How do geography and existing infrastructure influence supply chain economics?
3. In what ways do technology selection and economies of scale affect total production costs?

Previous studies have typically focused on regional or national cases with limited treatment of transport infrastructure.[2] By contrast, this study explores these dynamics at a pan-European scale, combining high spatial resolution with detailed modelling of intermodal transport logistics.

Project methodology

Supply chain model overview

To address the above questions, a supply chain optimisation model based on Mixed-Integer Linear Programming (MILP) was developed to determine the economically optimal advanced biofuel supply chains across Europe for 2030 and 2050, under different biomass availability and demand scenarios.

The model covers the EU-27 plus the UK[2] with high regional granularity (NUTS 3).[3] As the MILP framework does not explicitly include geographical coordinates or transport networks, it was coupled with the GIS-based Biomass Intermodal Transport model (BIT-UU), which calculates least-cost transport routes between biomass sources and conversion sites across Europe, integrating all major transport modes

1 Renewable Energy Directive

2 Countries such as Norway and Switzerland were not included in the analysis, as the data and information available in the literature, including that used in the ICL-Concawe study, focus primarily on the 27 European Union member states plus the UK, which was formerly an EU member.

3 NUTS = Nomenclature of territorial units for statistics — https://ec.europa.eu/eurostat/web/nuts

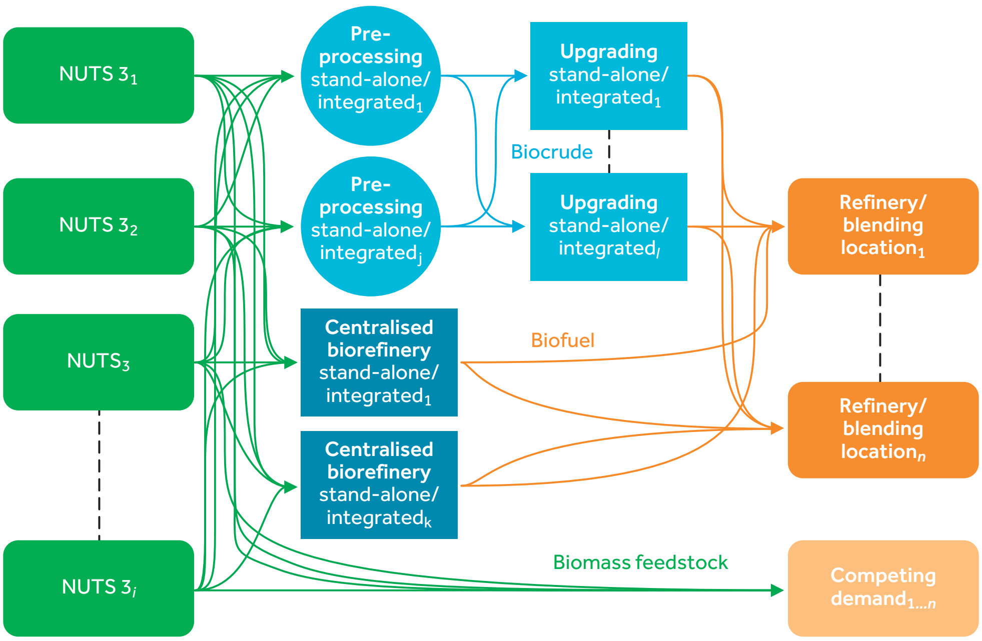
(road, rail, and inland waterways and shipping). In addition to advanced biofuels, the model also calculates the optimal distribution of biomass for other energy uses, such as electricity and heat, ensuring a comprehensive representation of the total bioenergy network.

Figure 1 illustrates the conceptual structure of the simulated supply chains, and the main input categories used in the optimisation are listed below:

- **Biomass availability and production costs:** based on RED II, Annex IX, Part A feedstocks, modelled at high spatial resolution (NUTS).
- **Transport routes, infrastructure and costs:** including solid biomass and liquid products (biocrude or biofuels) moved via different transport modes and distances.
- **Biofuel production costs:** for two thermochemical pathways — gasification and Fischer–Tropsch (GFT) and hydrothermal liquefaction (HTL) — assessed for stand-alone operation and potential integration with existing industrial sites (e.g. biofuel plants or refineries).
- **Advanced biofuel and competing demand:** reflecting demand projections consistent with RED III,[4] FuelEU Maritime[5] and ReFuelEU Aviation,[6] as well as competition from other bioenergy (electricity and heat) and material uses.

Further details on the methodology, model components and input datasets used for the optimisation are presented in the following sections.

Figure 1: Structure of the spatially explicit supply chain optimisation model



Centralised configuration: biomass pre-processing, conversion and biofuel upgrading occur at a single location.

Decentralised configuration: biomass pre-processing (e.g. biocrude production) and biofuel upgrading take place at separate sites.

Stand-alone configuration: facilities operate independently, without integration benefits from co-location with existing industrial sites.

Each biofuel blending location (at oil refineries) and non-transport bioenergy demand point (major cities) is connected to all potential supply locations across the EU-27 + UK (NUTS 3 level).

4 https://eur-lex.europa.eu/eli/dir/2023/2413/oj/eng
5 https://transport.ec.europa.eu/transport-modes/maritime/decarbonising-maritime-transport-fueleu-maritime_en
6 https://transport.ec.europa.eu/transport-modes/air/environment/refueleu-aviation_en

Biomass availability and production costs

Although biomass availability has been estimated in several previous studies, the spatial resolution of these assessments has generally been limited to the country level. This coarse granularity restricts the accuracy of supply chain simulations. As a result, such studies cannot fully capture the logistical challenges and regional variability affecting biomass mobilisation and transport.

To address this limitation, the present study recalculated biomass availability at a higher spatial resolution, at least at the regional (NUTS 3) level within each country for 2030 and 2050. This enhanced granularity allows for more realistic supply chain modelling, reflecting regional differences in resources, infrastructure and transport networks.

The study focuses on lignocellulosic biofeedstocks, summarised in Table 1 which also presents the methodological approach applied for their calculation. For all feedstocks, three biomass availability scenarios were developed—Low, Medium and High—to account for varying levels of innovation and improvements in agricultural and forestry management practices.

Table 1: Overview of the biofeedstocks considered in the study and the methodology applied for each feedstock group to estimate biomass availability at high spatial granularity

Scenario modelling	Low, Medium and High biomass availability scenarios were developed, accounting for different levels of innovations and improvements in agriculture and forestry management practices (in 2030, 2050).
Agricultural biomass	
Feedstocks	Lignocellulosic crops on marginal lands, primary agricultural residues (cereal straw, maize stover, oil crop residues, prunings).
Calculation approach	Crop growth model (AquaCrop developed by the FAO[a]) was used. Climate change, weather, precipitation and soil properties were considered.
Granularity	High resolution (1–10 km^2).
Biomass costs	Production costs were calculated using the calculated biomass yields and accounting for land rent, machinery costs, labour and fertiliser/pesticides input.
Forestry biomass and wood waste	
Feedstocks	Low-grade stemwood, primary and secondary forest residues, post-consumer wood and paper cardboard.
Calculation approach	Country level data from the ICL study were used and scaled to higher granularity (e.g. based on forest density).
Granularity	Regional scale (NUTS 3).
Biomass costs	From the S2Biom project database (all cost factors related to harvesting operations).

[a] Food and Agriculture Organization of the United Nations

It should be noted that not all feedstocks listed in Annex IX of RED II/III were included. Specifically, used oils and fats (Annex IX, Part B) were excluded, as a well-established collection and utilisation infrastructure exists. From Annex IX, Part A, some feedstocks were omitted due to technical, logistical or data-related constraints. These include:

- High-moisture feedstocks such as manure and sewage sludge, which require on-site processing close to their source.
- Municipal biowaste, due to its heterogeneity and need for specialised sorting and pretreatment.[7]
- Secondary agricultural residues, which are difficult to quantify consistently at high spatial resolution.[8]
- Newcomers in Annex IX such as intermediate crops, added to Annex IX after the study's launch, for which reliable modelling tools and datasets are not yet available.

The considered feedstocks cover ~80% of total biomass availability under Annex IX, Part A of RED II calculated in the ICL study.

Biomass and biofuels transport

For the transport modelling, all relevant modes used to supply solid biomass, liquid biocrude and biofuels were considered. These include road transport (trucks), rail, inland waterways and short-sea shipping, as well as intermodal combinations for long-distance supply routes. To optimise the biomass supply chains, the model incorporated the existing European transport infrastructure and network topology (see Figure 2), based on different data sources and tools. For the cost calculations, both fixed and variable transport costs were included and inflated to 2023 EUR.

Figure 2: Transport network topology of the EU showing links (or segments) of road, rail, inland waterways and short sea shipping

[7] Although these feedstocks were not included in the supply chain modelling, their volumes were accounted for by allocating them to bioenergy (electric power and heat generation — E/H) demand to allow flexibility for biofuel supply chains. Their availability volumes (based on the ICL study) were subtracted from the total bioenergy (E/H) demand (see Figure 3, page 10).

[8] Ibid.

Advanced biofuel process technologies and integration strategies

Technology selection and costs

From the available technologies for producing advanced biofuels from lignocellulosic biomass, gasification and Fischer–Tropsch and hydrothermal liquefaction were selected for this study. GFT, currently at a technology readiness level (TRL) of 6–7, is a well-established pathway for producing high-quality drop-in fuels.[3] However, it is capital-intensive and therefore best suited for large-scale, centralised configurations.[4]

In contrast, HTL, with a TRL of 5–6, is an emerging technology being demonstrated at smaller scales.[3] It produces a high-quality biocrude and efficiently processes wet feedstocks. In this study, HTL was assumed to be deployable under both centralised and decentralised configurations.

Although other thermochemical routes with higher TRL than HTL, such as fast pyrolysis, are also available, HTL was prioritised due to the better availability of cost data in the literature. Overall, the analysis was limited to two processes (GFT and HTL) to account for modelling constraints, particularly those related to computational feasibility. These technologies also serve as representative examples of large-scale, capital-intensive centralised plants and smaller, flexible decentralised systems requiring further upgrading later on, respectively.

The cost data for both technologies were derived from scientific publications after a comprehensive review of available information. For each, capital (CAPEX) and operational (OPEX) expenditures were estimated (inflated to 2023 EUR), including potential credits from co-products such as surplus electricity generation. For 2030, the current cost basis was applied, reflecting the expected delayed large-scale deployment of these technologies, while for 2050, a cost reduction factor was assumed to account for technological learning and capacity growth, consistent with International Energy Agency (IEA) projections.[4]

Up to the maximum demonstrated capacity per configuration (see Table 2 on page 9), the economies of scale for process equipment were estimated from literature data.[5,6] As the CAPEX-capacity relationship is inherently non-linear, it was linearised through curve segmentation for integration into the optimisation model.

Table 2: Technology selection (GFT, HTL), and corresponding product yields [4,5,7] and maximum plant scale,[5,6] applied under different supply chain configurations (centralised, decentralised)

	Centralised				Decentralised			
Technology	Yield ($GJ_{biofuel}/GJ_{biomass}$)		Maximum scale (ktoe/year biofuel)		Yield ($GJ_{biocrude}/GJ_{biomass}$) or ($GJ_{biofuel}/GJ_{biocrude}$)		Maximum scale (ktoe/year biocrude or biofuel)	
	2030	2050	2030	2050	2030	2050	2030	2050
GFT	0.38	0.45	338	398	-	-	-	-
HTL	0.47	0.66	414	578	0.44	0.62	254	345
Upgrading biocrude—stand-alone	-	-	-	-	1.06	1.06	1,549	1,608

Biorefineries location and integration strategies

Access to transport infrastructure and opportunities for integration with existing industrial sites are key factors influencing the location and economics of new biorefineries. Integration with existing industrial plants can offer significant capital synergies, as well as access to utilities and hydrogen streams required for advanced biofuel production and upgrading (see Table 3).

Accordingly, this study assumed that centralised facilities (GFT and HTL) could be located within intermodal terminals (e.g. ports) or industrial sites such as biofuel plants, pulp mills or refineries, where integration benefits can be realised through shared infrastructure and reduced investment costs. In contrast, decentralised HTL facilities could be built near biomass production areas or adjacent to pulp mills or biofuel plants, which are often close to feedstock sources. The cost reduction factors associated with these integration levels were derived from de Jong *et al.* (2015).[8]

Table 3: Possible host locations of advanced biofuel production and their integration benefits

Location/host side	Integration strategy	Integration benefits
Oil refineries	Retrofitting or repurposing	Access to utilities (natural gas, electricity) and fossil fuel infrastructure
Kraft pulp and paper mills	Co-location	Access to utilities (natural gas, electricity) and solid fuel infrastructure
Existing biofuel plants	Co-location	Access to utilities (natural gas, electricity) and infrastructure
Intermodal terminals	Greenfield	Access to intermodal transport infrastructure
NUTS 3 regions	Greenfield	Access to local biomass

Integration with existing refineries offers the greatest technical and economic synergies, given the similarity of equipment and operational experience in thermochemical processing and hydroprocessing. Therefore, the model considered centralised GFT and HTL plants located at retrofitted refinery sites as a potential configuration. An extra case was also examined to assess the feasibility of repurposing existing refinery hydroprocessing units, further enhancing integration and cost efficiency.

Biomass demand across sectors

The final input for the supply chain modelling involved defining the total biomass demand at both EU and country levels. First, the biomass demand for material and biochemical uses, as estimated in the ICL study,[1] was incorporated to account for competing non-energy applications, with these quantities subtracted from the total availability estimated earlier in the study.

For energy-related demand, publicly available data consistent with the latest EU legislative frameworks (RED III and the Fit for 55 package[9]) were applied. Two main data sources (DI Fuels study[9] and S&P study commissioned by Concawe[10]) were used to define advanced biofuel demand: for 2030, a single demand was set at 19 Mtoe, while for 2050, two scenarios (Low and High demand) were developed due to the larger variability in long-term projections (see Figure 3). Considering two different demand scenarios enables the model to capture the optimal behaviour of the supply chain network under varying demand conditions.

Figure 3: Overview of advanced biofuel and bioenergy (electricity and heat) demand[9,10] considered for the supply chain simulations

Advanced biofuel (Annex IX, Part A)

2030
19.3 Mtoe (based on the 'DI Fuels' study[9] by DG RTD[a])

2050
1) Low demand case = **37.6 Mtoe** (RED Scenario—'DI Fuels' study[9] by DG RTD[a])
2) High demand case = **88.2 Mtoe** (More Molecule Scenario—S&P study[10])

Bioenergy (electricity and heat)[b]

2030
107.3 Mtoe[9]

2050
185.0 Mtoe[9]

[a] DG RTD = European Commission Directorate-General for Research and Innovation
[b] Demand allocated only to lignocellulosic feedstock

[9] EU legislation package designed to enable all sectors of the EU economy to meet at least a 55% reduction in greenhouse gases by 2030.

The total demand was spatially distributed according to projected transport activity per Member State, as reported in the EU Reference Scenario 2020.[11] Refineries were set as the advanced biofuel demand nodes in each country, reflecting their role as existing fuel blending and liquid storage hubs within the supply chain.

For non-transport bioenergy uses (electricity and heat), the latest projections from the PRIMES[10] model were applied (DI Fuels).[9] The allocation of bioenergy demand per country was based on projected bioenergy intensity as indicated in the EU Reference Scenario 2020,[11] with demand nodes assumed to be located in the major cities of each country.

Supply chain modelling results

Overview of simulated scenarios

During the methodology development, a series of scenarios were designed to explore variations in biomass availability, advanced biofuel demand toward 2050, and integration strategies. For each model simulation, different combinations of these scenarios were tested and categorised into base and alternative cases (see Table 4). In the base scenarios, the medium biomass availability case was applied, while different biofuel demand and integration configurations were assessed. In the alternative scenarios, the Low and High biomass availability cases were also simulated to evaluate the model's sensitivity to resource potential.

Table 4: Scenarios run in the optimisation biomass supply chain model

Base scenarios			
Scenarios	**Biomass availability scenario**	**Advanced biofuel demand scenario**	**Integration benefits[a]**
2030	Medium	Default	Default
2050–Low demand	Medium	Low	Default
2050–High demand	Medium	High	Default
2050–Repurpose	Medium	Low	Repurpose for oil refineries — default for the other industrial sites
Alternative scenarios			
Scenarios	**Biomass availability scenario**	**Advanced biofuel demand scenario**	**Integration benefits**
2030–Low	Low	Default	Default
2030–High	High	Default	Default
2050–Low demand (Low)	Low	Low	Default
2050–Low demand (High)	High	Low	Default
2050–High demand (High)	High	High	Default

[a] Default integration strategy refers to the following: terminals (greenfield), biofuel plants and pulp mills (co-location), and refineries (retrofitting).

[10] PRIMES: Price-Induced Market Equilibrium System — an energy system model designed to project the energy demand, supply, prices, trade and emissions for European countries and assess policy impacts.

Optimal technology mix and supply chain configurations

The optimal process technology mix and supply chain configurations derived from the modelling are shown in Figure 4 on page 13, illustrating the capacity allocated to each technology and configuration.

2030

In 2030, the results indicate an optimal balance between centralised GFT facilities and decentralised HTL systems. For large-scale processing, GFT shows better economic performance than centralised HTL and is therefore preferred. However, the economic advantage of large-scale GFT deployment is limited in some regions by biomass supply constraints, which favour the rollout of decentralised HTL configurations.

High-demand countries such as the Netherlands and the United Kingdom have insufficient domestic biomass resources, limiting the feasibility of localised GFT plants. As a result, these regions rely on biomass or biocrude imports from other parts of Europe. This dynamic drives the deployment of decentralised HTL systems in biomass-rich regions (e.g. Scandinavia and the Iberian Peninsula), where feedstocks are converted into biocrude near the source and subsequently transported over long distances to refineries in high-demand areas for final upgrading into drop-in biofuels.

The ranges (error bars) shown on Figure 4 indicate only a small impact from changing biomass availability scenarios. This is because the relative difference between biomass availability and demand in 2030 remains modest, resulting in limited stress on the supply chain network and, therefore, minimal variation in the optimal configuration.

2050

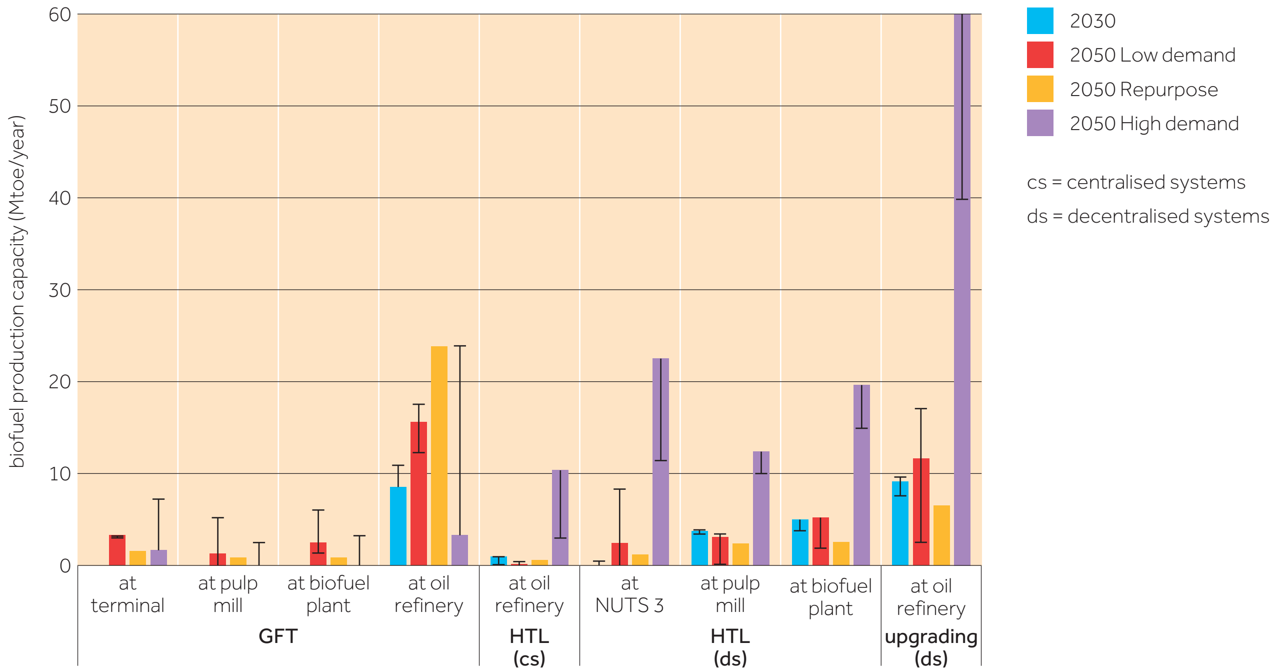
By 2050, the optimal supply chain structure and technology mix become more sensitive to variations in biofuel demand and biomass availability across the different scenarios. In the low-demand case, large-scale centralised GFT plants are strongly favoured over decentralised HTL systems. This reflects both the greater cost advantage of GFT, benefiting from long-term cost reductions through technological learning, and the fact that lower demand levels enable shorter transport distances and sufficient local biomass to meet national needs efficiently. Decentralised HTL and biocrude supply remains advantageous only for countries facing domestic biomass shortages, similar to the cases observed in 2030.

In contrast, under the high-demand scenario, total demand more than doubles, substantially increasing pressure on biomass supply efficiency across Europe. The need to mobilise feedstocks from remote or less accessible areas makes decentralised systems more advantageous, as converting solid biomass into biocrude near the source reduces overall logistics costs and improves supply chain flexibility.

Finally, in the refinery repurposing case, the model indicates a shift toward more centralised GFT facilities compared to the default configuration. This reflects the capital cost synergies achievable through deeper integration with existing refineries, where hydrocracking equipment and related infrastructure can be reused; this is particularly beneficial for GFT, given its high investment intensity in upgrading units.

Figure 4: Advanced biofuel production per plant type (Mtoe/year) in the base scenarios for 2030 and 2050

The error bars show the ranges of the alternative biomass availability scenarios (Low, High).



Geographical distribution of biorefineries

The trends described above, such as the balance between centralised and decentralised configurations in 2030 and the shift toward greater decentralisation under higher demand in 2050, are clearly reflected on the maps in Figures 5 and 6 (page 14) which show the spatial distribution of biocrude and biofuel plants.

Beyond these general trends, several region-specific conclusions can be drawn. North-western European countries, with high transport activity and significant liquid fuel demand but limited biomass availability, emerge as net importers of biocrude from biomass-rich regions, typically hosting upgrading facilities instead of conversion plants. In contrast, biomass-rich regions, most notably Scandinavia and the Iberian Peninsula, consistently appear as key suppliers, producing and exporting biocrude to offset deficits in other parts of Europe.

Large central European countries exhibit a diverse technology mix, as their geographical size and shared borders with multiple regions lead to locally optimised solutions across different areas. Meanwhile, smaller Central and Eastern European countries show greater sensitivity to demand fluctuations, where changes in consumption levels can significantly alter their optimal supply chain configurations.

Another important finding, evident in the maps, is the strategic role of refineries in the biofuel transition. Their existing large-scale infrastructure and compatibility with thermochemical biomass conversion technologies make them ideal integration hotspots for hosting future advanced biorefineries.

Figure 5: Optimal spatial distribution of modelled biocrude and biofuel plants required for advanced biofuels in the EU-27 + UK; Base scenario, 2030

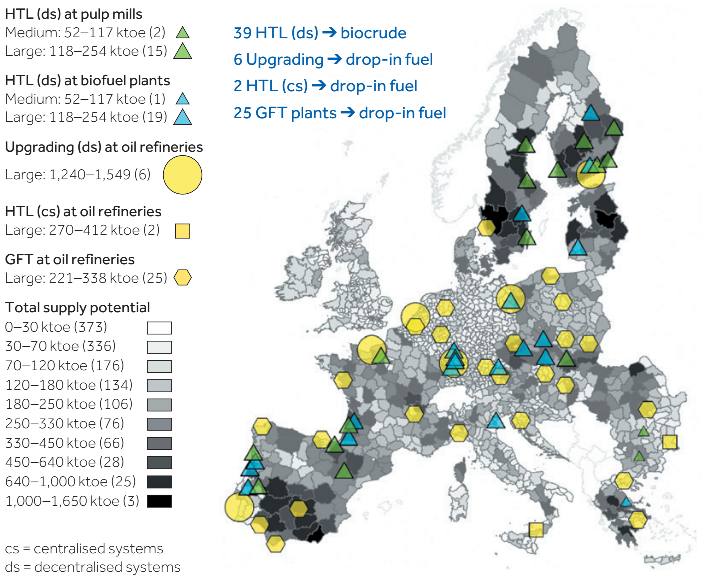
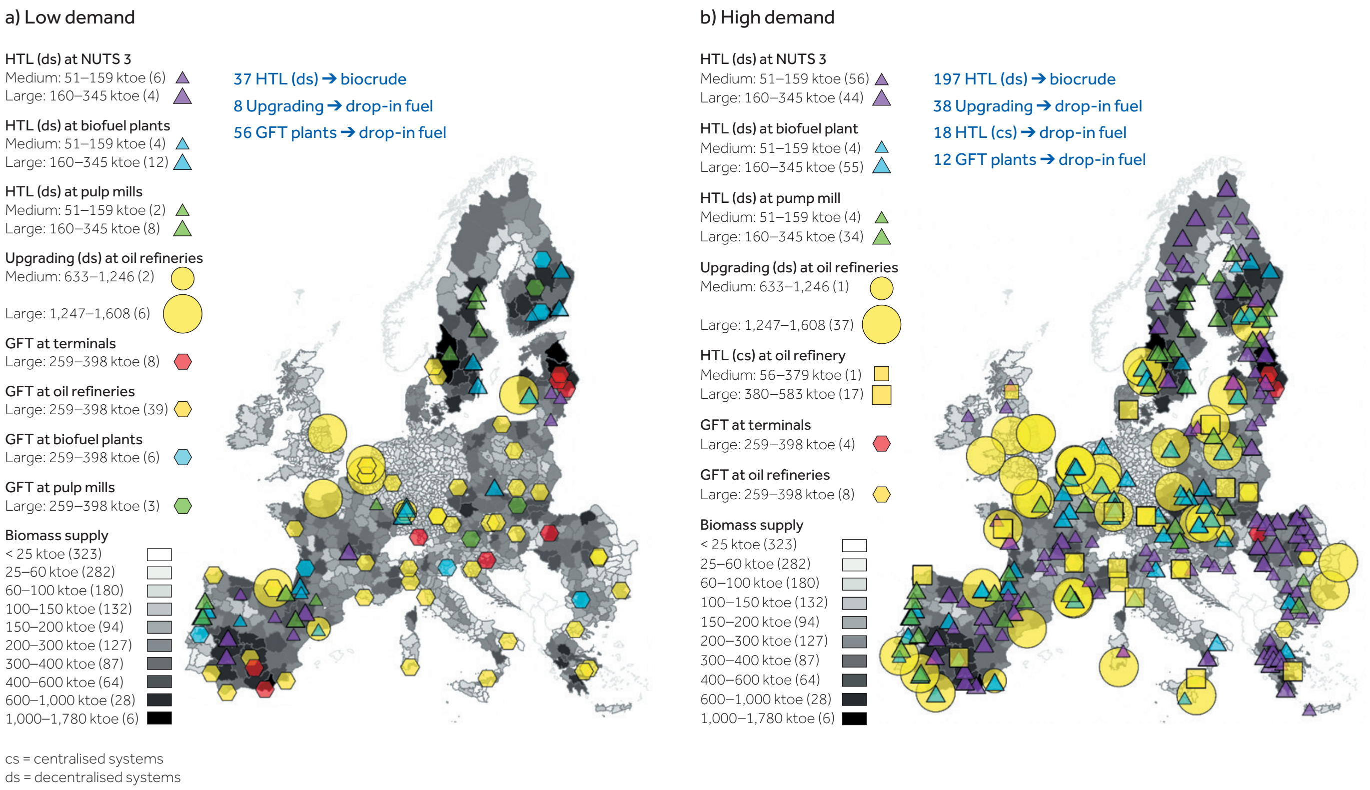


Figure 6: Optimal spatial distribution of modelled biocrude and biofuel plants required for advanced biofuels in the EU-27 + UK; Base scenarios, 2050



Advanced biofuel production costs

The average supply chain costs for all simulated scenarios, along with the breakdown by cost components, are presented in Figure 7.

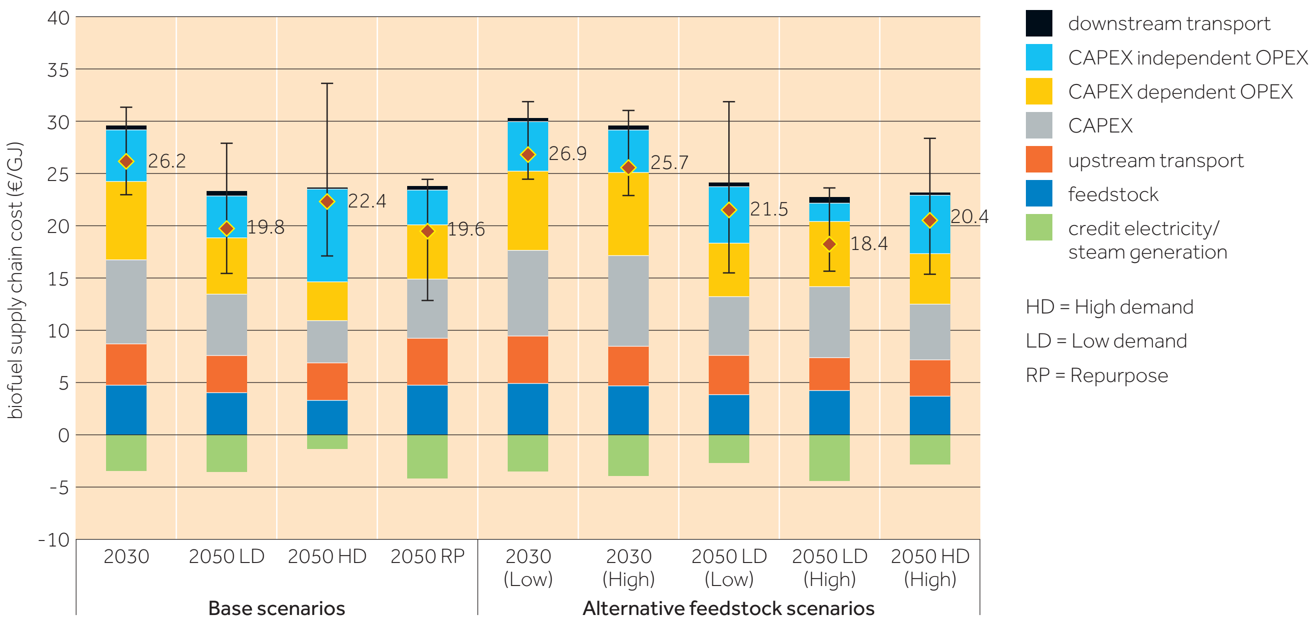
For 2030, the average cost for the base case is 26.2 EUR/GJ$_{biofuel}$. When alternative biomass availability scenarios are applied, only minor cost variations are observed, consistent with the limited structural changes in the optimal supply chain described earlier. The cost range across supply chains in 2030 remains narrow due to the relatively similar cost levels of a mature GFT and HTL process. However, as HTL is currently at a lower TRL, achieving such scales in the short term may be challenging, making GFT a more immediately deployable option.

By 2050, a considerable cost reduction is observed, with average production costs ranging between 19.8 EUR/GJ and 22.4 EUR/GJ. This decline mainly results from technological learning and the associated reduction in capital costs. Unlike 2030, however, larger cost differences appear across scenarios reflecting the need for structural adjustments in the supply chain under higher demand or lower biomass availability conditions.

Across all scenarios, process-related costs (CAPEX and OPEX) remain the dominant cost drivers and thus the most critical area for further cost reductions. Nevertheless, biomass production and transport costs are also non-negligible, as they strongly influence the optimal supply chain configuration, particularly the balance between centralised and decentralised systems under varying demand and biomass availability conditions.

Figure 7: Average biofuel production cost in the base and alternative scenarios

The error bars show the ranges between the minimum and maximum biofuel production costs calculated for each scenario.



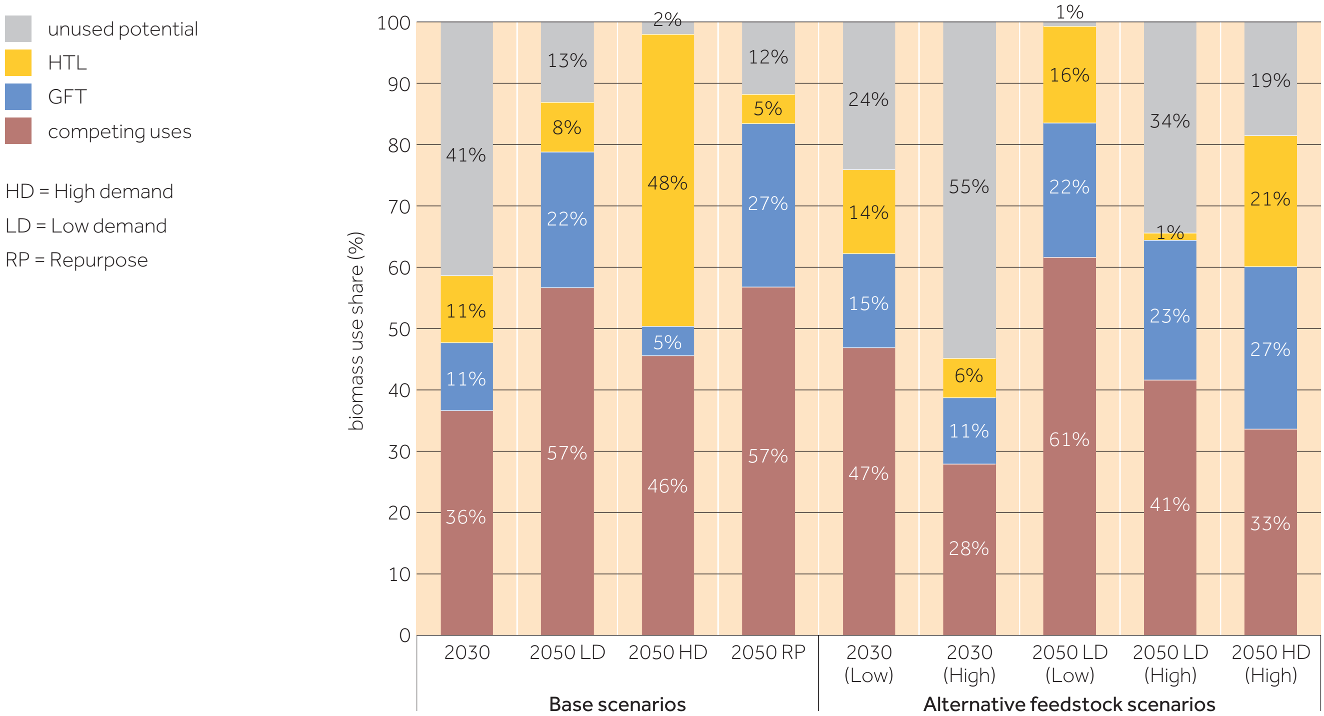
At this point, it should be noted that the calculated process costs are consistent with the values reported in the scientific literature. However, in industrial practice, total project costs are typically higher due to the early commercialisation stage of these technologies and additional factors such as site infrastructure, owner's costs, and financing during construction. Therefore, the results are presented on a comparative basis to assess the impact of different scenarios on supply chain costs and drivers rather than as an absolute cost assessment.

Biomass consumption dynamics

The breakdown of biomass consumption across the different pathways for each scenario, along with the share of domestically available biomass that is not mobilised, is presented in Figure 8.

The results indicate that, in all cases, there is sufficient biomass to meet the advanced biofuel demand. However, under certain combinations of high demand and low biomass availability, such as the High Demand 2050 base scenario, the share of unutilised biomass becomes very small. This highlights the increasing challenges of meeting ambitious future demand levels, as doing so requires near-complete mobilisation of available biomass resources.

Figure 8: Biomass utilisation as a fraction of the total domestic availability potential in the base and alternative scenarios in the EU-27 + UK



However, it should be noted that not all feedstocks listed in Annex IX, Part A were included in this study (see *Biomass availability and production costs* on pages 6–7). Furthermore, the integration of green hydrogen in conversion plants, such as GFT, could significantly increase biofuel yields and reduce biomass consumption, thereby lowering the overall biomass footprint. However, this integration of RFNBOs[11] and biofuel pathways was beyond the scope of the present work.

Conclusions

This study analysed the economically optimal supply chain configurations for advanced biofuel production from lignocellulosic biomass across the EU-27 + UK under varying future scenarios of biomass availability and advanced transport biofuel demand. Using a spatially explicit optimisation model, the analysis accounted for biomass supply and costs, transport networks, conversion technologies (gasification and Fischer-Tropsch—GFT; hydrothermal liquefaction—HTL) and economies of scale.

Centralised vs decentralised systems

Large-scale, centralised GFT plants integrated with industrial assets (especially refineries) are generally more cost-effective when biomass availability is sufficient. However, under high-demand or low-availability conditions, decentralised HTL systems become more efficient, enabling the use of dispersed or remote biomass. The optimal system depends on biofuel demand, local resource availability, and geographic factors such as inland versus port access.

Geographic patterns and trade

Geography decisively determines the optimal supply chain selection. Western European countries with limited biomass, such as the UK, Belgium and the Netherlands, emerge as import and upgrading hubs thanks to their port and refinery networks. Scandinavia and the Iberian Peninsula act as biocrude exporters, while Germany and France require hybrid systems combining both strategies. As biomass availability tightens relative to demand, cross-border trade intensifies, favouring biocrude and drop-in fuels over solid biomass for their higher energy density and transport efficiency.

Biomass demand vs availability

Europe's domestic biomass is sufficient to meet demand through 2030 and 2050, but by 2050 the availability-to-demand ratio narrows considerably in scenarios of high biofuel demand or low biomass availability. This strains the supply chain, requiring wider deployment of decentralised HTL plants to reach scattered resources. Future targets will rely on better biomass management practices and innovations.

[11] Renewable fuels of non-biological origin

Advanced biofuel supply chain costs

In 2030, cost differences between scenarios are small (< 10%), suggesting that early deployment will depend more on commercial readiness than intrinsic cost advantages. By 2050, learning effects reduce process costs substantially and GFT becomes more favourable when biomass availability is high or demand is low, while HTL gains ground when resources are limited and decentralised collection is required.

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