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Environmental Science for European Fuel Manufacturing

Sustainable biomass availability in the EU for the production of advanced biofuels

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Abinash Ramasary, Science Executive, Renewable Fuels Manufacturing

Concawe: Environmental Science for EU Fuel Manufacturing

Concawe Membership

Concawe represents 40 Member Companies (≈95% of EU Refining), in the EU, UK, Switzerland and Norway

Concawe Mission

Concawe's mission is to develop scientific research and technical studies on industry's products and operations, and their impact, often in association with external research institutes, in order to:

- ✓ Increase the understanding of the impact of our industry and use of our product through advanced scientific developments
- ✓ Develop with scientific rigour technically feasible and cost-effective pathways to achieve the EU's health, environmental and climate goals
- ✓ Contribute to an informed legislative decision and facilitate the industry's regulatory compliance
- ✓ Evaluate, for future scenarios, the potential role and contribution of our industry and its evolution.

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Agenda

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03 Fuel demand outlook up to 2050

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Overview of Study on **Sustainable Biomass Availability in Europe towards 2050** *(Imperial College, 2021)*

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Sustainable biomass availability towards 2050

Basis for the analysis

- Focus on biofeedstocks in **RED II Annex IX (Part A and B)**:
  - Traditional biofuel crops (1st generation) and wastes & residues beyond Annex IX not included.
- Granularity at EU **country level** **(EU-27+UK)**, by **2030 & 2050**
- **Imports** potential (up to 50-60 Mtoe/y in 2030/2050).
- Allocation of biomass to **bio-based products** and **bio-energy** (Power, Industry, Buildings, & Transport)

Report: "Sustainable biomass availability in the EU towards 2050

Scenarios Considered

1. **LOW. Low mobilization:**
   - Farming and forest practices at 2020 levels.
2. **MEDIUM. Improved mobilisation in selected countries:**
   - Improved mobilisation in **countries with high biomass availability:**
     - Germany, France, Sweden, Finland, Italy, United Kingdom, Austria, Spain, Poland, Romania, Czech Republic, Hungary, Bulgaria.
3. **HIGH. Enhanced availability through R&I and improved mobilisation in all EU countries:**
   - Pushed to high technical sustainable potential through R&I.

Feedstocks evaluated

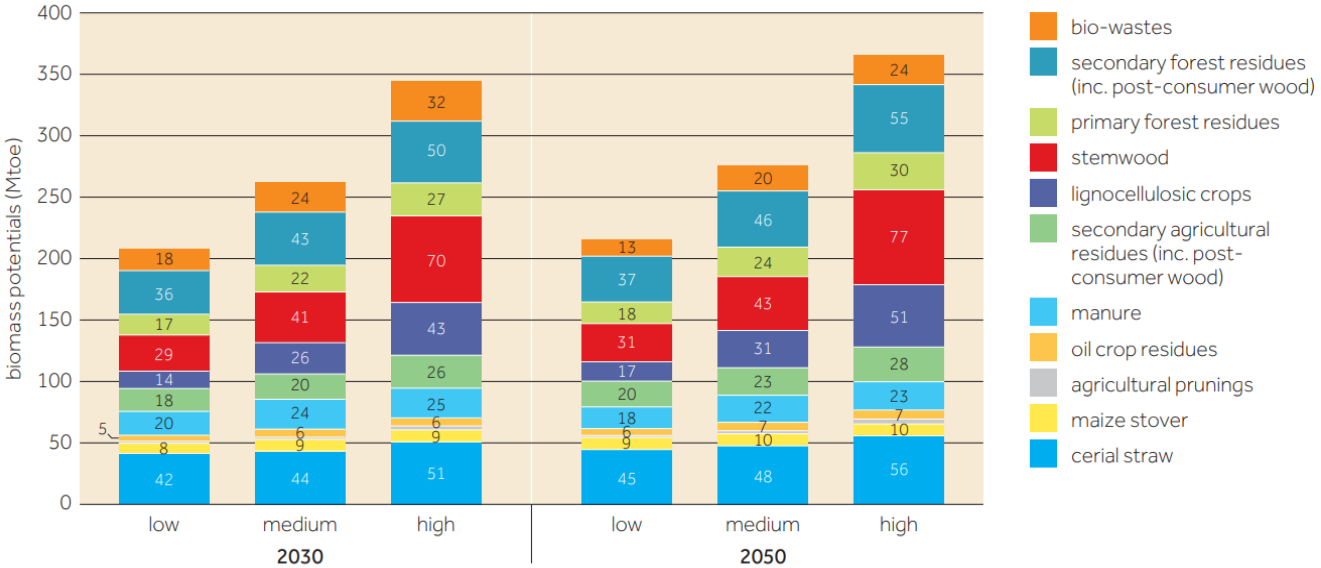
REDII (Annex IX – Part A)

Agricultural biomass	Energy crops	Primary crop residues (e.g. wheat straw, prunnings, etc.)	Secondary crop residues (processing residues)	Manure
Forest biomass	Low-quality stemwood (fuelwood)	Primary forest residues	Secondary forest residues (processing residues)	
Waste and recycling	Wood waste	Vegetal waste	Animal and mixed food waste	
	Paper and cardboard	Household biowaste	Sewage sludge	

RED II (Annex IX – Part B)

UCO Animal fats

Distribution of sustainable biomass potentials for bioenergy across feedstocks



Estimated sustainable biomass potentials for bioenergy in 2030 and 2050 (in Mtoe)

Agricultural and **forestry** biomass serve as the primary drivers for the total biomass potential.

Biowastes contribute marginally to the total availability.

Biomass for bio-energy ranges:

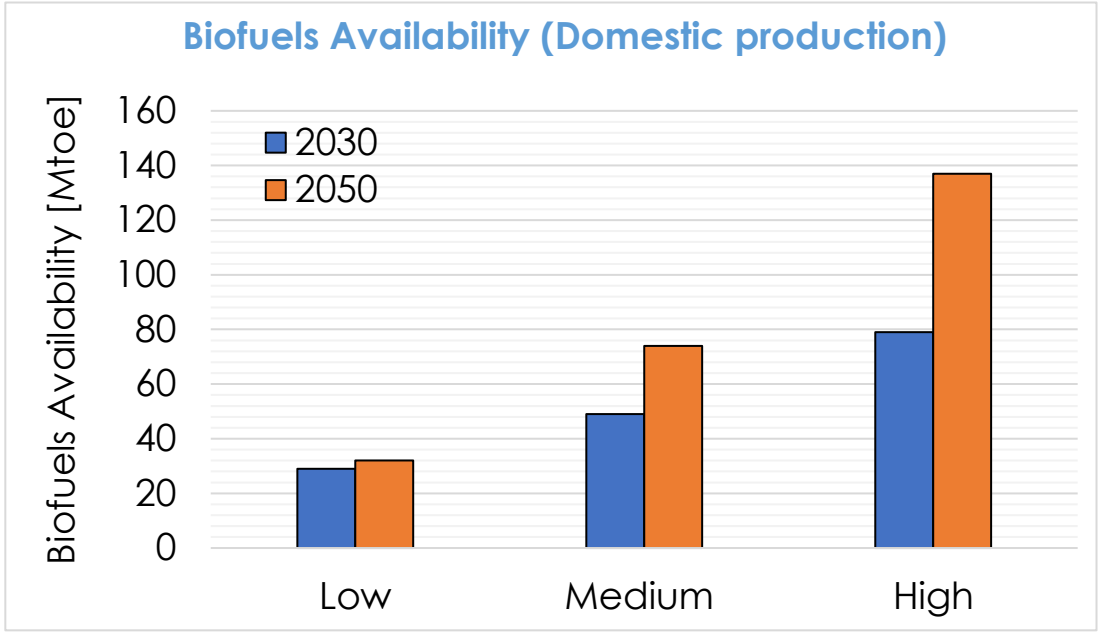
2030: 520- 860 million dry tonnes (**208-344 Mtoe**);

2050: 539 -915 million dry tonnes (**215-366 Mtoe**)

Estimating EU advanced biofuels availability potential for transport sector

Competition with other sectors

The EU Commission (ACP4A & IA) allocates ~170 Mtoe/y of biomass to power + industry + residential sectors in 2050 -> Subtracted to estimate the remaining biomass availability for transport sector



The remaining biomass potentially available for transport results in advanced biofuels availability potential of 29-79 Mtoe (2030) & 32-137 Mtoe (2050).

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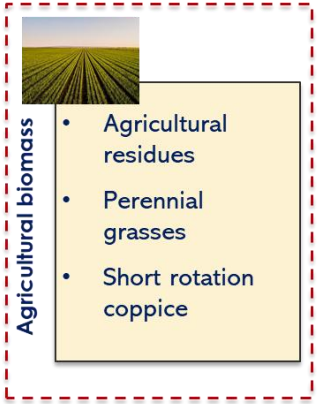
2 Comparison of sustainable biomass availability studies

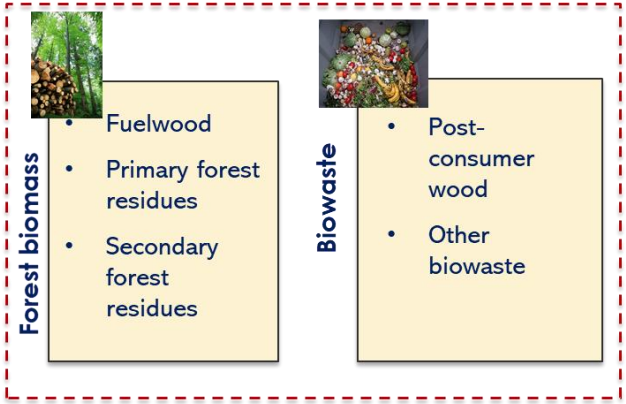
Sustainable biomass supply chains study

- Concawe commissioned with **Utrecht University and TNO** the study: "***Sustainable biomass feedstock supply chains for advanced biofuels***" **(ongoing)**.
- The **objective** of this work is to **determine at high granularity the economically optimal biomass to advanced biofuel supply chains across Europe** to meet the future demand
- To determine detailed supply chain costs, it is necessary to understand biomass availability potential at **high granularity**.
- Rather than the statistical based models used in the IC study at national level, in this study the agricultural biomass potentials were assessed using a **spatial based model** at a high granularity. For forestry and biowastes, availability potentials were scaled from a national to small regional (NUTS 3) level



Mapping model

For agricultural biomass, the results were calculated at small regional scale (1 km^2) across Europe



Systemic review – the results of Imperial College & Concawe study were used as a basis and were scaled from a country to regional level

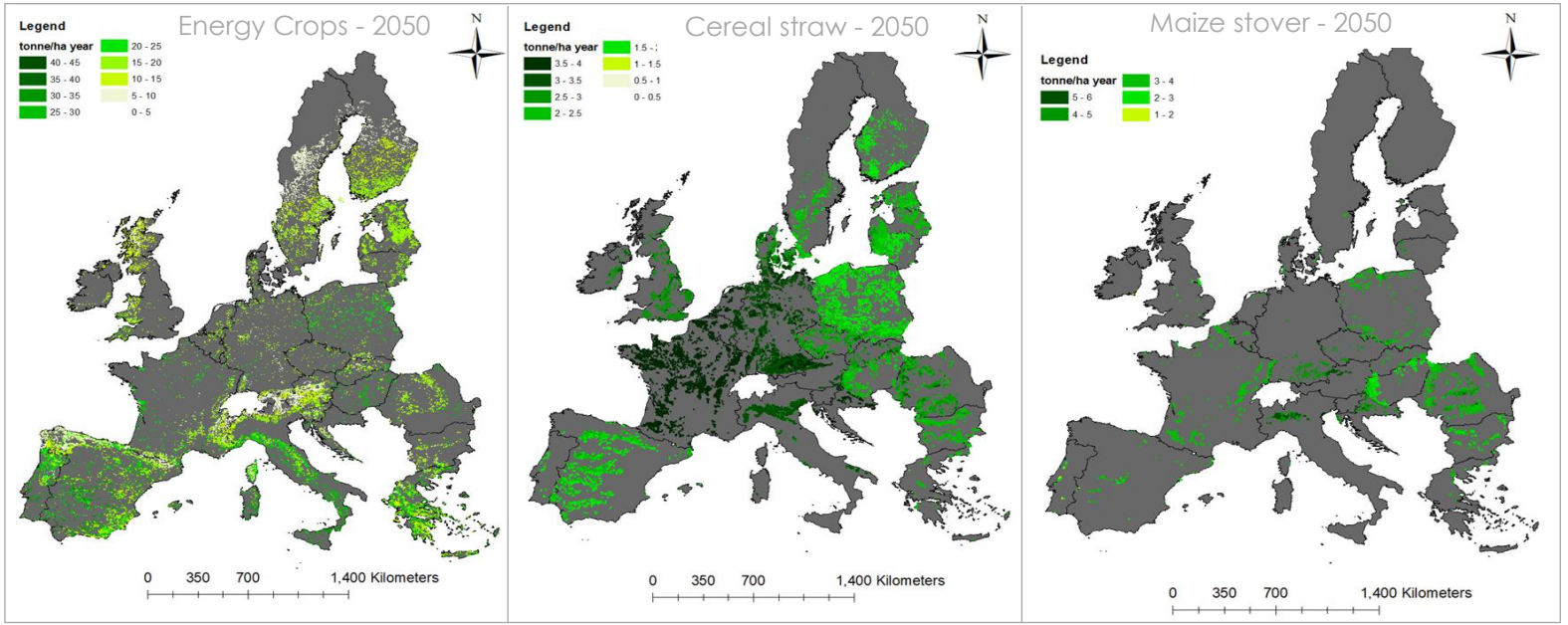
Energy crops
Share of potential available marginal land that meets RED II/III sustainability criteria
Annual yield increase due to improved crop management practices
Agricultural residues
Annual yield increase due to improved crop management practices and R&I
Removal rates limited by sustainability considerations
Forest biomass
Stemwood used for energy purposes
Primary residues used for energy purposes

A **low, medium and high scenario** were developed to capture the uncertainty of different parameters:

Biomass Availability Distribution and Mapping in 2050

The example of agricultural biomass (high scenario) – EU-27 + UK

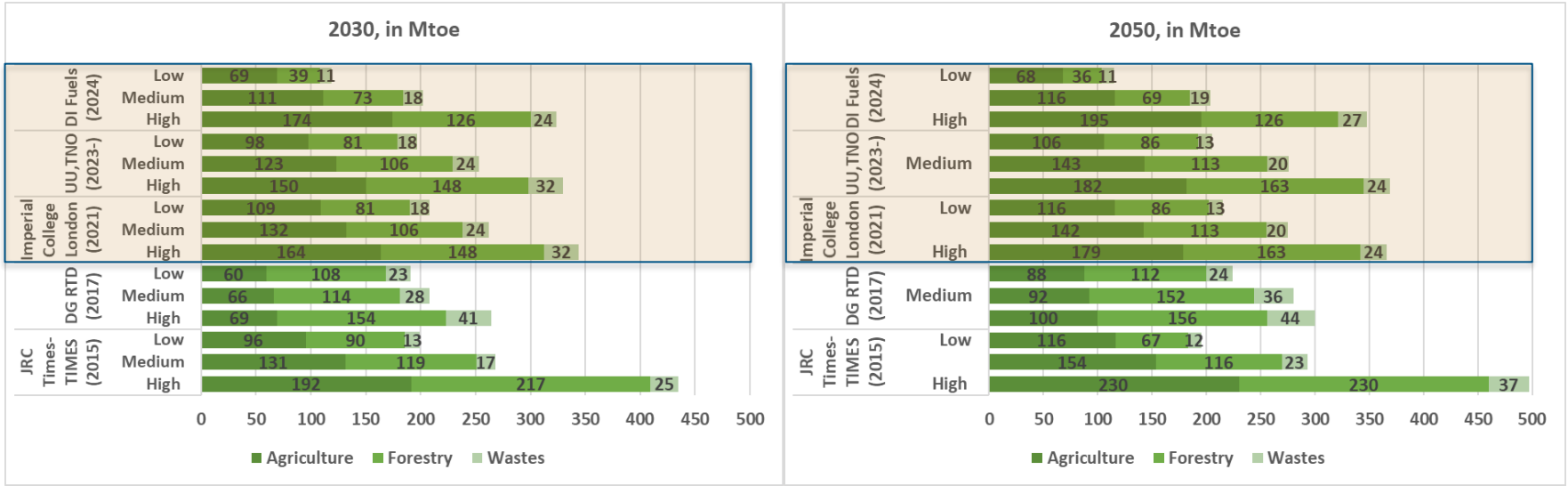
Potential for lignocellulosic energy crops is primarily in southern Europe, where climate conditions will lead to land marginalization and favour crop yields. Achieving this energy crop potential requires irrigation and solutions to increase water availability should be investigated further.



Results are presented at a coarser spatial resolution (original calculation: 1 km^2) for better visualization

Comparison of Biomass for Bio-energy Availability Studies

- **TNO/UU vs IC:** Two studies report **close values**. Agricultural biomass was calculated at a higher granularity, with similar results at EU level.
- **DI Fuels – 2024 (DG-RTD):** A new study which included the new feedstocks in the Annex IX (e.g., intermediate crops). Task 2 of the study calculated biomass availability potential with the methodology built upon existing studies with updates and modifications in assumptions.
- **Important variability across scenarios**: i.e. IC biomass availability range of 208-344 Mtoe (2030) & 215-366 Mtoe (2050)
- Biomass availability figures are **generally close between the studies for the different scenarios.** Agricultural and forestry sectors are the primary biomass availability drivers. Minor contribution from biowastes
- Variability exceptions are observed for certain cases such as the low scenario of the DI fuel study due to very conservative assumptions regarding the **utilisation extent of biomass for bioenergy and crop yields**



3 Fuel demand outlook up to 2050

S&P-Concawe study : 2050 net-zero theoretical scenarios for transport

Working with Concawe, S&P Global developed 2 new scenarios which both meet EU 2050 net-zero GHG emissions objective :

Max Electron

- *Unprecedented electrification across all transport*
- *Fulfils all Fit-for-55 policies while exceeding HDV CO2 standards legislation (0 ICE sales after 2035)*
- *Relies on the widespread and very rapid adoption of electric vehicles (*PC, LCV and HDV)
- *Important transfer of passenger and freight, from road and aviation to rail*
- *Envisions some electrification of Aviation and Maritime*

More Molecule

- *Derived from Max Electron*
- *Assumes moderate relaxation of the road vehicle standards (some ICE sales after 2035)*
- *Partial electrification of Aviation and Maritime postponed to after 2050*
- *Complements electrification with increased use of low carbon fuels*

This study evaluates the impact on the refining and fuel manufacturing industrial assets of two hypothetical scenarios which both meet the net zero GHG emission objective by 2050 in EU27 + 3 European countries (NO, CH, UK). Both scenarios share a common basis for the transition of most economic sectors but differ on the decarbonization pathway of the transport sector.

Neither scenario is intended as a validation of the probability or feasibility of realisation of the various assumptions in the study, such as the rate of electrification, availability of renewable energy and green hydrogen for the transport sector, nor do they assess the impact on competitiveness of Europe economy or the affordability for consumers or industries. These scenarios are 2 theoretical cases to meet the EU 2050 objective.

The choice of these 2 theoretical scenarios should not be considered as exhaustive to meet the 2050 net zero emission objective, as this study does not include other scenarios which could potentially achieve the objective by modifying further other key decarbonisation opportunities, such as, for example, even greater uptake of carbon capture and storage (CCS), additional bioenergy carbon capture and storage (BECCS), blue hydrogen or other technology advancements in other sectors than transport.

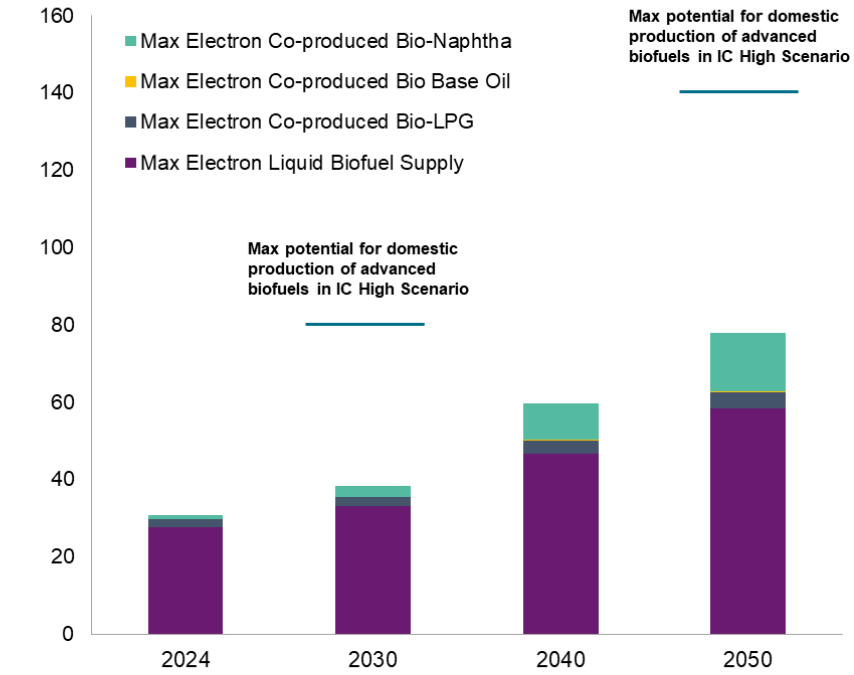
Furthermore, the economic modelling behind the scenarios did not take into account refinery specific parameters, such as petrochemical integration, individual refinery energy efficiency, etc. The conclusions regarding the necessary reduction of refining capacity should therefore not be interpreted as indication at the level of any specific European refinery.

Max Electron and More Molecule both meet net-zero emission target in 2050 for the EU+ countries (EU + Norway, Switzerland and UK).

Source: S&P Global Commodity Insights

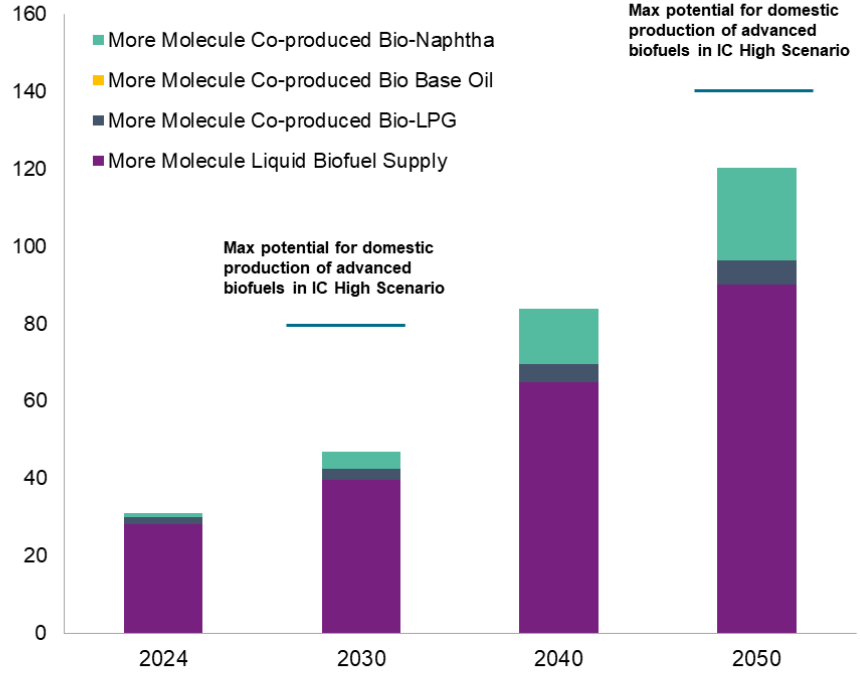
Study biofuel demands fits within the range of biofuel potentially available from EU domestic production according previous Concawe/Imperial College report

Biofuel Availability: Max Electron (mmtoe)



Source: CONCAWE & Imperial College London, S&P Global

Biofuel Availability: More Molecule (mmtoe)



Source: CONCAWE & Imperial College London, S&P Global

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4 Key Takeaways

Key Takeaways

Demand vs. Supply Potential

- Sustainable biomass potential availability for bio-energy in EU (without imports) is estimated at up to 344 Mtoe (2030) & 366 Mtoe in 2050.
- After considering the needs of other energy uses, the remaining biomass potentially available for transport results in advanced biofuels availability potential of up to 79 Mtoe (2030) & 137 Mtoe (2050).
- This is sufficient to supply the estimated biofuel demand for 2030 and 2050.

Key Biofeedstocks

- Low-grade stemwood, forestry residues, energy crops, and agricultural residues are the most important feedstocks contributing to future biofuel potential.
- Mobilization and organisation of supply chain needs to be developed to unlock biomass resources.

Consistent Biomass Availability Estimates

- Sustainable Biomass availability potential estimates are coherent across recent scientific studies, with studies differing in mobilisation hypotheses.

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Thank you

Email: abinash.ramasary@concawe.eu