Sustainable biomass availability in the EU towards 2050 (RED II Annex IX, Parts A and B)

This article summarises a study undertaken to estimate the potential sustainable biomass availability in the European Union and the UK by 2030 and 2050, and to assess the production of sustainable advanced biofuels for 2030 and 2050 on the basis of this biomass potential.

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Objective

Within the framework of the European Commission's long-term strategy, Concawe's cross-sectoral Low Carbon Pathways project identifies opportunities and challenges for different low-carbon technologies and feedstocks, and their potential to achieve a significant reduction of the CO_2 emissions associated with both the manufacturing and use of refined products in Europe in the medium (2030) and longer-term (2050). Accessibility to sustainable low-carbon biofeedstock is one of the key drivers to achieve a low-carbon EU economy by 2050.

In this context, one of the key questions regarding the role of biofeedstocks in the transport sector is the potential availability of sustainable biomass (included in Annex IX, Parts A and B of RED II[1]) in the EU and UK, and under which conditions and assumptions biomass availability can be improved and biomass potential maximised safely and sustainably by 2050 without any negative impacts (e.g. by preserving natural high-value areas, maintaining and improving biodiversity, and reducing the use of arable land as well as the use of fertilisers and other chemical inputs).

This article summarises a study undertaken by Imperial College Consultants at the request of Concawe, the results of which have been published in a report entitled *Sustainable biomass availability in the EU, to 2050*.[1] The work presented in the report covers only domestic (EU-27 + UK) feedstocks of agricultural, forest and waste origin included in Annex IX of RED II (Parts A and B as shown in Table 1) and imports to the EU. A short overview of the potential for imports to the EU and the potential algae availability, based on other studies, is included as an annex in the Imperial College report.

The biomass feedstocks included in Annex IX (Parts A and B) which have been considered in the Imperial College study are presented in Table 1 on page 5.[2] Food and feed crops, and other sustainable feedstocks accepted by RED II but not included in Annex IX, are not included in the scope of this study.

1 https://ec.europa.eu/jrc/en/jec/renewable-energy-recast-2030-red-ii

2 Feedstocks from (g) to (n) from Annex IX Part A have not been included because there were no consistent statistical datasets available at the time of the study. These include: (g) Palm oil mill effluent and empty palm fruit bunches; (h) Tall oil pitch; (i) Crude glycerine; (j) Bagasse; (k) Grape marcs and wine lees; (l) Nut shells; (m) Husks; and (n) Cobs cleaned of kernels of corn.

Table 1: Biomass feedstocks from RED II Annex IX (Parts A and B) considered in the Imperial College study

RED II Annex IX, Part A	Agricultural feedstocks	Forest feedstocks	Bio-wastes	Algae
(a) Algae if cultivated on land in ponds or photobioreactors				Overview based on recent studies
(b) Biomass fraction of mixed municipal waste, but not separated household waste subject to recycling targets under point (a) of Article 11(2) of Directive 2008/98/EC			Paper, cardboard, wood waste, animal and mixed food waste, vegetal waste, municipal solid waste	
(c) Bio-waste as defined in point (4) of Article 3 of Directive 2008/98/EC from private households subject to separate collection as defined in point (11) of Article 3 of that Directive			Paper, cardboard, wood waste, animal and mixed food waste, vegetal waste, municipal solid waste	
(d) Biomass fraction of industrial waste not fit for use in the food or feed chain, including material from retail and wholesale, and the agro-food and fish and aquaculture industries, and excluding feedstocks listed in Part B of this Annex	Secondary agricultural residues from agro-industries			
(e) Straw	Cerial, straw, maize stover			
(f) Animal manure and sewage sludge	Solid and liquid manure from poultry, pigs, cattle		Sewage sludge	
(o) Biomass fraction of wastes and residues from forestry and forest-based industries, namely bark, branches, pre-commercial thinnings, leaves, needles, treetops, sawdust, cutter shavings, black liquor, brown liquor, fibre sludge, lignin and tall oil		Primary forest residues, secondary forest residues		
(p) Other non-food cellulosic material	Oilseed crop residues, agricultural prunings			
(q) Other lignocellulosic material except saw logs and veneer logs		Stemwood (fuelwood), post-consumer wood		
RED II Annex IX, Part B				
(a) Used cooking oil			Used cooking oil	
(b) Animal fats classified as categories 1 and 2 in accordance with Regulation (EC) No. 1069/2009.			Animal fats categories 1 and 2 are included in Animal and mixed food waste	

Part 1: Sustainable biomass availability for all markets and bioenergy

Methodology

This study capitalises on knowledge and findings from relevant initiatives and studies that have addressed feedstocks across all EU Member States[3] [2,3,4] using harmonised datasets and methodological approaches.[5]

Among these, the authors have focused, in particular, on the following work conducted by the European Commission's Joint Research Centre (JRC) and the Commission's Directorate General for Research and Innovation (DG RTD):

- JRC (2015). 'ENSPRESO - an open data, EU-28 wide, transparent, and coherent database of wind, solar and biomass energy potentials' (website, updated 2019).[6]
- DG RTD (2017). *Research and Innovation perspective of the mid- and long-term Potential for Advanced Biofuels in Europe*.[7]

The study, conducted by Imperial College Consultants at the request of Concawe, considers up-to-date assumptions, that are in line with the European Green Deal, about the sustainable increase of available European biomass, acknowledging the biophysical restrictions of land resources and feedstocks as well as the adverse effects of climate change (e.g. desertification, reduced yields, land marginalisation, etc.).

The study integrates the counterbalancing mechanisms of using new machinery, efficient crop management practices (seeding/irrigation systems, crop rotation, cover crops, agroforestry and disease control in the field) as well as precision farming, which will allow the development of plants to be monitored in the field to better target their needs and ease farm management.

A detailed annex is included in the main report, describing the methodologies used for the estimation of sustainable biomass availability.

[3] Studies undertaken before 2020 include data from the UK.

Scenarios for future biomass availability

Key assumptions

This section outlines the key assumptions for the scenarios examined in the study (no double counting has been taken into account in this study). All scenarios were developed in accordance with the following principles:

1. **A strong political will to deliver the European Green Deal targets and increase societal awareness that biomass availability is essential to achieve the transition to a zero-carbon, zero-pollution economy towards 2050**
   The target to cut emissions to at least 55% of 1990 levels by 2030 has been set[8] within the European Green Deal, and the European political system has reacted positively. To achieve carbon neutrality by 2050, the agriculture, forestry and other land use (AFOLU) sector has been targeted with the goal of becoming carbon neutral by 2035.[8] This implies improvements in cropping and forest practices, and a reduction in the amount of arable land in favour of environmental benefits such as carbon storage, biodiversity, etc.

2. **Covid-19 has shifted attention and the funding focus to the transition for achieving zero carbon through economic recovery, social resilience and welfare**
   As the 2020 Covid-19 pandemic spread reapidly, the focus on the European Green Deal diminished and attention shifted to economic recovery and social resilience. The study considers that the pandemic is not having a negative impact on biomass deployment but a positive one, as an effective economic recovery can stimulate the broadening of the biomass feedstock base which, in turn, will result in economic benefits for local producers.[9,10]

3. **RED II and Annex IX set the regulatory framework for advanced biofuels, bioliquids and biomass fuels**
   Within the 14% target of renewables in the transport sector, the RED II Directive establishes a dedicated target for advanced biofuels and biogas produced from the feedstocks listed in Part A of Annex IX. The contribution of advanced biofuels as a share of the final energy consumption in the transport sector shall be at least 0.2% in 2022, at least 1% in 2025 and at least 3.5% in 2030 (double counted). Part B of Annex IX also includes feedstocks for the production of biofuels and biogas for transport, for which the contribution towards the minimum share of 14% shall be subject to a cap. These fuels may also be considered to be twice their energy content, and include (a) used cooking oil and (b) animal fats classified as categories 1 and 2 in accordance with Regulation (EC) No 1069/2009.[4]

   This study assesses the role of biomass in meeting both the 2030 and the 2050 targets as set by RED II and the European Green Deal, taking into consideration the respective ambitions announced by the aviation and maritime sectors.[11,12,13] The focus of the study is on the feedstocks listed in RED II Annex IX Parts A and B.

4 https://www.legislation.gov.uk/eur/2009/1069/introduction

The European Commission is currently undertaking a study[14] to establish a longlist of potential feedstocks which could be added to the feedstocks already listed in Parts A and B of Annex IX. Feedstocks under consideration include: potato/beet pulp; sugars (fructose, dextrose); molasses; vinasses; spent grains; whey permeate; olive pomace; raw methanol; oil, beans and meals derived from rotation crops; biomass from fallow land; biomass from degraded/polluted land; mixture meadow; damaged crops; animal residues (not fat; Categories 2 and 3); animal fats (Category 3); municipal wastewater and derivatives (other than sludge); soapstock and derivatives; brown grease; fatty acid distillates (FADs); various oils from ethanol production; distillers' grain and solubles (DGS); and other bio-waste.

From the above list, the Imperial College study considers biomass from degraded land only where lignocellulosic biomass crops can be grown. The study does not consider the other feedstocks due to insufficient statistical time series data to form a dataset comparable to the ones used for all countries for agriculture, forestry and wastes.

Food and feed crops, and other feedstocks that are currently used in the EU for biofuel production and accepted by the RED but not included in RED II Annex IX, are not included in the study.

4. Low-indirect land-use change (ILUC) risk concept

The RED II Directive introduces the concept of low-ILUC risk biofuels, bioliquids and biomass fuels, which will represent one of the main options for maintaining the current shares of renewables in transport, and for the further development of the market potential for sustainable biofuels in Europe from 2023 onwards, especially in sectors with limited short-term alternatives such as the aviation, heavy-duty road transport and maritime sectors.

The criteria for certification of low-ILUC risk biofuels, bioliquids and biomass fuels have been outlined in Commission Delegated Regulation (EU) 2019/807 of 13 March 2019,[15] supplementing Directive (EU) 2018/2001. This Delegated Regulation defines low-ILUC risk biofuels, bioliquids and biomass fuels as those 'that are produced under circumstances that avoid ILUC effects, by virtue of having been cultivated on unused,[5] abandoned[6] or severely degraded[7,8] land or emanating from crops which benefited from improved agricultural practices.[15,16]

This study includes the low-ILUC risk concept in the scenario assumptions by addressing improved yields and exploitation of unused, abandoned or severely degraded land for biomass production.

[5] 'Unused land' means areas which, for a consecutive period of at least 5 years before the start of cultivation of the feedstock used for the production of biofuels, bioliquids and biomass fuels, were neither used for the cultivation of food and feed crops, other energy crops nor any substantial amount of fodder for grazing animals;

[6] 'Abandoned land' means unused land, which was used in the past for the cultivation of food and feed crops but where the cultivation of food and feed crops was stopped due to biophysical or socioeconomic constraints;

[7] 'Severely degraded land' means land that, for a significant period of time, has either been significantly salinated or presented significantly low organic matter content and has been severely eroded.

[8] The definition for marginal land has not yet been clearly defined.

5. **Biomass for bio-based products**

   The allocation of raw biomass materials to biobased products (bioplastics, biopharmaceuticals, construction materials, biochemicals, etc.) in this study has been performed by estimating the baseline sustainable potentials for all uses (i.e. bioenergy and bio-based products) and deducting the demand for each feedstock category and sector based on the projections of the CAPRI model[9] and statistics from the JRC.[10] The remaining potential is then considered as being available for all bioenergy applications (transport, heat, power, industry, agriculture, service and buildings).

6. **Biodiversity**

   The study accounts for biodiversity risks as defined in the RED II Directive. Biomass availability increases in all three scenarios evaluated (explained below) without including biomass from:

   - conservation of land with significant biodiversity values (such as areas of High Nature Value (HNV), NATURA 2000 areas, etc.) which usually includes protected sites — no such land is considered as being available for biomass feedstocks in this study; and
   - land management that has negative effects on biodiversity — the study accounts for cultivation practices which are based on the following principles: use of domestic species and local varieties; avoiding monocultures and invasive species; preferring perennial crops and intercropping; use of methods causing low erosion and machinery use; low fertilizer and pesticide use; and avoiding active irrigation.

7. **Imports**

   Imported lignocellulosic biomass (pellets from agricultural residues, wood pellets and used cooking oil) for bioenergy is addressed in this study (detailed in Annex II of the Imperial College report) based on recent statistics and projections from recent relevant literature.[17,18,19]

Scenarios

Three scenarios have been analysed in the study:

1. Low biomass mobilisation.
2. Improved mobilisation in selected countries due to improvements in cropping and forest management practices.
3. Enhanced availability through research and innovation (R&I) measures as well as improved mobilisation due to improvements in cropping and forest management practices.

[9] https://www.capri-model.org/dokuwiki/doku.php

[10] Data-Modelling platform of agro-economics research (European Commission) https://datam.jrc.ec.europa.eu/datam/public/pages/index.xhtml

1. **Scenario 1: Low mobilisation (Low)**

This scenario assumes low mobilisation of biomass for both 2030 and 2050. Key assumptions include:

- farming and forest practices at 2020 levels;
- a small proportion (25%) of unused, abandoned and degraded land is used for biomass crops; and
- emphasis is placed on the use of residues and wastes in the energy and non-energy bio-based sectors.

2. **Scenario 2: Improved mobilisation in selected countries (Medium)**

This scenario focuses on the improved mobilisation of biomass resulting from enhanced cropping and forest management practices. These practices take place in countries with:

i) high biomass availability (total estimated biomass potential ≥20 million tonnes per year) and in combination with either good institutional framework, established policies/targets for bioenergy or advanced biofuels, strong infrastructure and strong innovation profiles (Germany, France, Sweden, Finland, Italy, United Kingdom, Austria, Spain); or
ii) low biomass supply costs (Poland, Romania, Czech Republic, Hungary, Bulgaria).

Key assumptions include:

- improved management practices in (i) agriculture, such as crop rotation, cover crops, agroforestry, etc., which can improve soil and increase biomass productivity, and (ii) forestry, such as improved harvesting techniques, fertilisation (where possible), storage and transport optimisation, etc.;
- a significant proportion (50%) of unused, abandoned and degraded land is used for biomass crops; and
- emphasis remains on the use of residues and wastes in the energy and non-energy bio-based sectors.

3. **Scenario 3: Enhanced availability through R&I and improved biomass mobilisation (High)**

This scenario applies the highest rates for assumptions on increased mobilisation, as well as increased improvements in management practices, which can maximise the availability of sustainable biomass across all feedstocks.

Key assumptions include:

- improved management practices in (i) agriculture, such as crop rotation, cover crops, agroforestry, etc., which can improve soil and increase biomass productivity, and (ii) forestry, such as improved harvesting techniques, fertilisation (where possible), storage and transport optimisation, etc.;
- a significant proportion (75%) of unused, abandoned and degraded land is used for biomass crops;
- improved R&I; and
- emphasis remains on the use of residues and wastes in the energy and non-energy bio-based sectors.

In the three scenarios, biodiversity is included in the estimated potentials, accounting for:

i) conservation of land with significant biodiversity values (direct and indirect); and
ii) land management without negative effects on biodiversity.

Table 2 on page 11 shows the main assumptions for the three scenarios examined.

Table 2: The main assumptions of the three scenarios analysed in the study

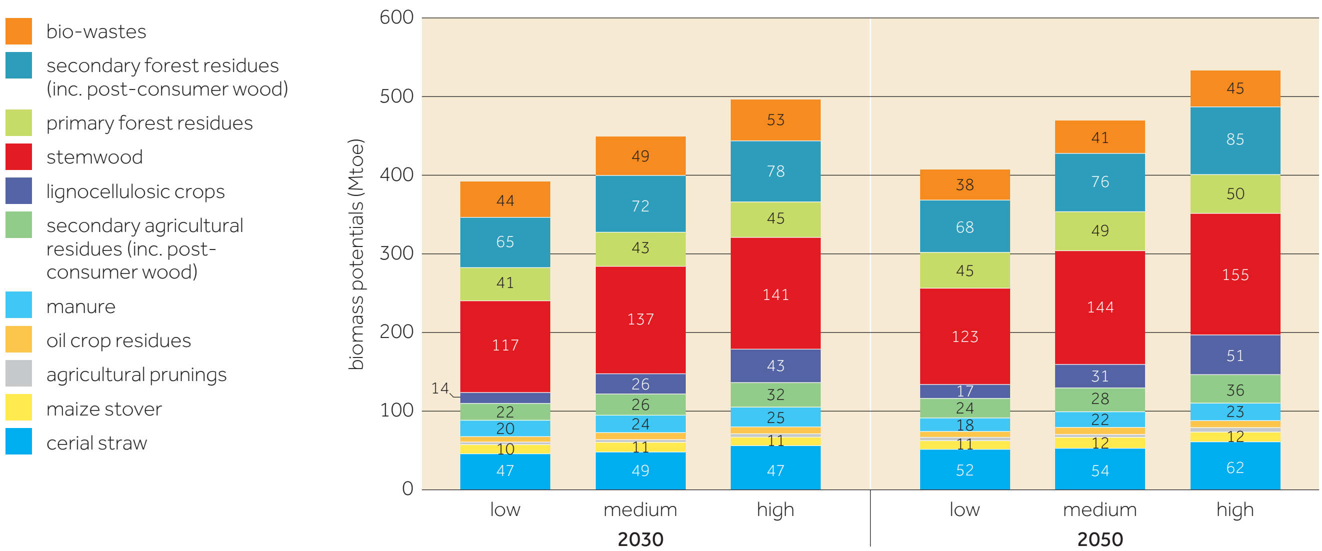
		Scenario 1 (Low)	Scenario 2 (Medium)	Scenario 3 (High)
Agriculture	Removal rate of field residues	40%	45%	50%
	Use of prunings	5%	20%	50%
	Moderate yield increases in perennial lignocellulosic crops in unused, degraded and abandoned land	1%	1%	2%
	Share of unused, degraded and abandoned land for dedicated crops, excluding biodiversity-rich land and land with high carbon stocks (current share of unused, degraded and abandoned land for dedicated crops: there are no official statistics — only at experimental and demonstration scale)	25%	50%	75%
Forestry	Stemwood used for energy purposes (current stemwood for energy: 45%)	25%	30%	50%
	Primary forestry residues availability for energy production	40%	50%	60%
	Secondary forestry residues and post-consumer wood availability for energy	55%	60%	65%
Wastes	Bio-waste used for energy production (current collection for bioenergy: 40–45%)	60% in 2030 (65% in 2050) of bio-waste is recycled and 40% in 2030 (35% in 2050) is separately collected and available for bioenergy	50% in 2030 (55% in 2050) of bio-waste is recycled and 50% in 2030 (45% in 2050) is separately collected and available for anaerobic digestion	40% in 2030 (45% in 2050) of bio-waste is recycled and 60% in 2030 (55% in 2050) is separately collected and available for anaerobic digestion

Results

Biomass availability for all markets in the EU & UK in 2030 and 2050

This section provides an overview of the estimated sustainable biomass potential from agriculture, forestry and bio-wastes that can be available for all markets (i.e. energy and non-energy markets). The estimated figures for 2030 range from 0.98 to 1.2 billion dry tonnes (392 to 498 Mtoe). The respective numbers for 2050 remain similar and range from 1 to 1.3 billion tonnes (408 to 533 Mtoe).

Figure 1: Estimated total sustainable biomass potentials (RED II Annex IX, Parts A and B) in 2030 and 2050 for all markets



Biomass availability excluding potential demand for non-energy uses (biomass for bioenergy) in the EU and UK in 2030 and 2050

This section presents the estimated biomass potentials for bioenergy (transport, heat and power) (excluding demand for non-energy uses (plastics, pharmaceuticals, etc.). The estimated figures for 2030 range from 520–860 million dry tonnes (208–344 Mtoe) for 2030. The respective numbers for 2050 remain similar and range from 539–915 million dry tonnes (215–366 Mtoe).

The reasons why potentials remain unchanged between 2030 and 2050 despite improvements in biomass mobilisation and increased innovation for higher yields are mostly related to:

- strong pressure for the sustainable use of land and water resources, including a 30% reduction in arable land by 2050;
- the fact that improvements in forest management are slow due to the long growing cycles of forests that prohibit fast changes in growth of potentials; and
- increased awareness of the need for waste reduction and strong commitments to recycling.

Figure 2: Estimated sustainable biomass potentials (RED II Annex IX, Parts A and B) than can be available for bioenergy in 2030 and 2050

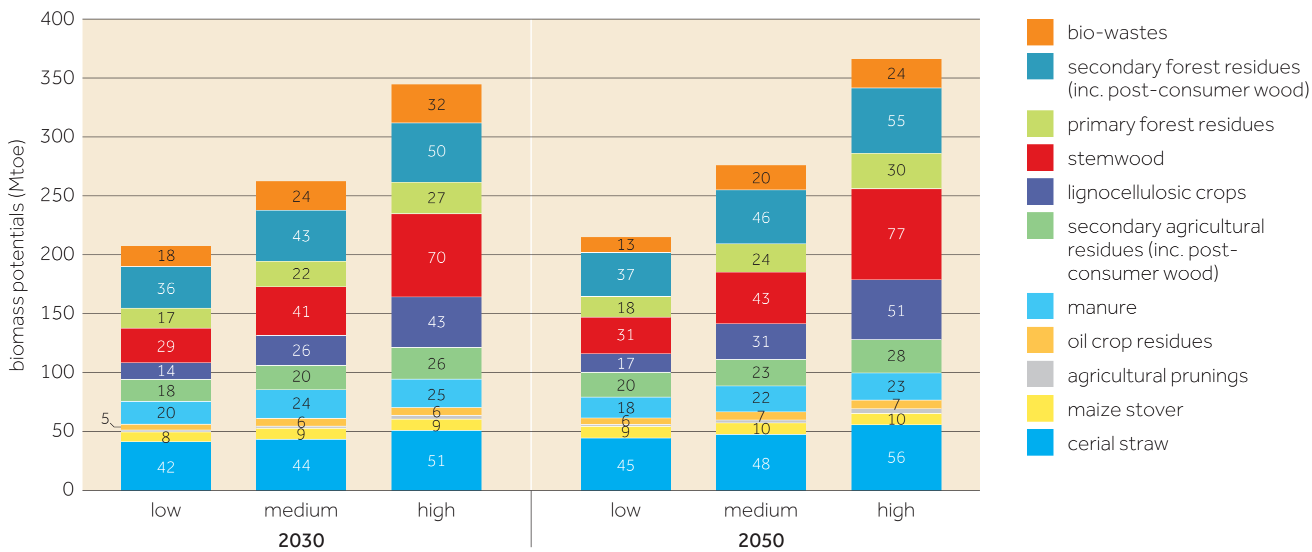
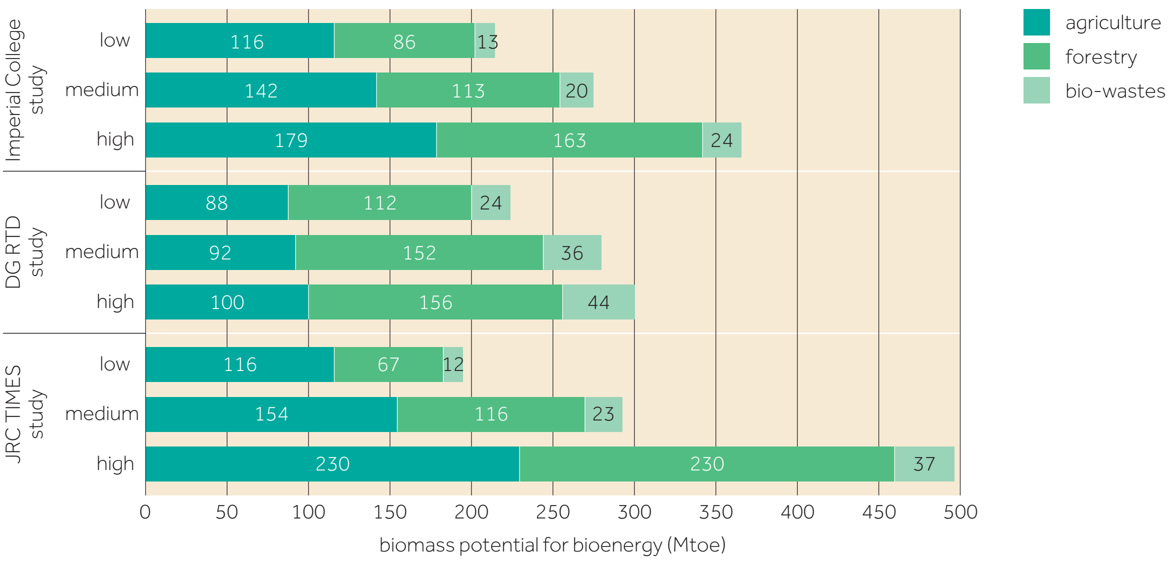


Figure 3 presents comparative estimates of the biomass potentials for bioenergy in the Imperial College, DG RTD and JRC (ENSPRESO database) studies based on feedstocks from Annex IX, Parts A & B (as detailed in Table 1). The potential longlist of feedstocks that are under consideration by the European Commission for inclusion in Annex IX is not included in the figures below.

Figure 3: Comparative estimates for biomass potentials (Mtoe) for bioenergy in the Imperial College, DG RTD and JRC TIMES (ENSPRESO database) studies for 2050



Imperial College's estimation of biomass availability in the High scenario is 22% higher than in the DG RTD high scenario, and 26% lower than JRC TIMES high scenario. The JRC TIMES high scenario gives the technical maximum that can be achieved, without sustainability criteria, allowing dedicated cropping in high biodiversity lands and including first-generation biofuel crops. It cannot be considered for future projections within the EU Green Deal targets.

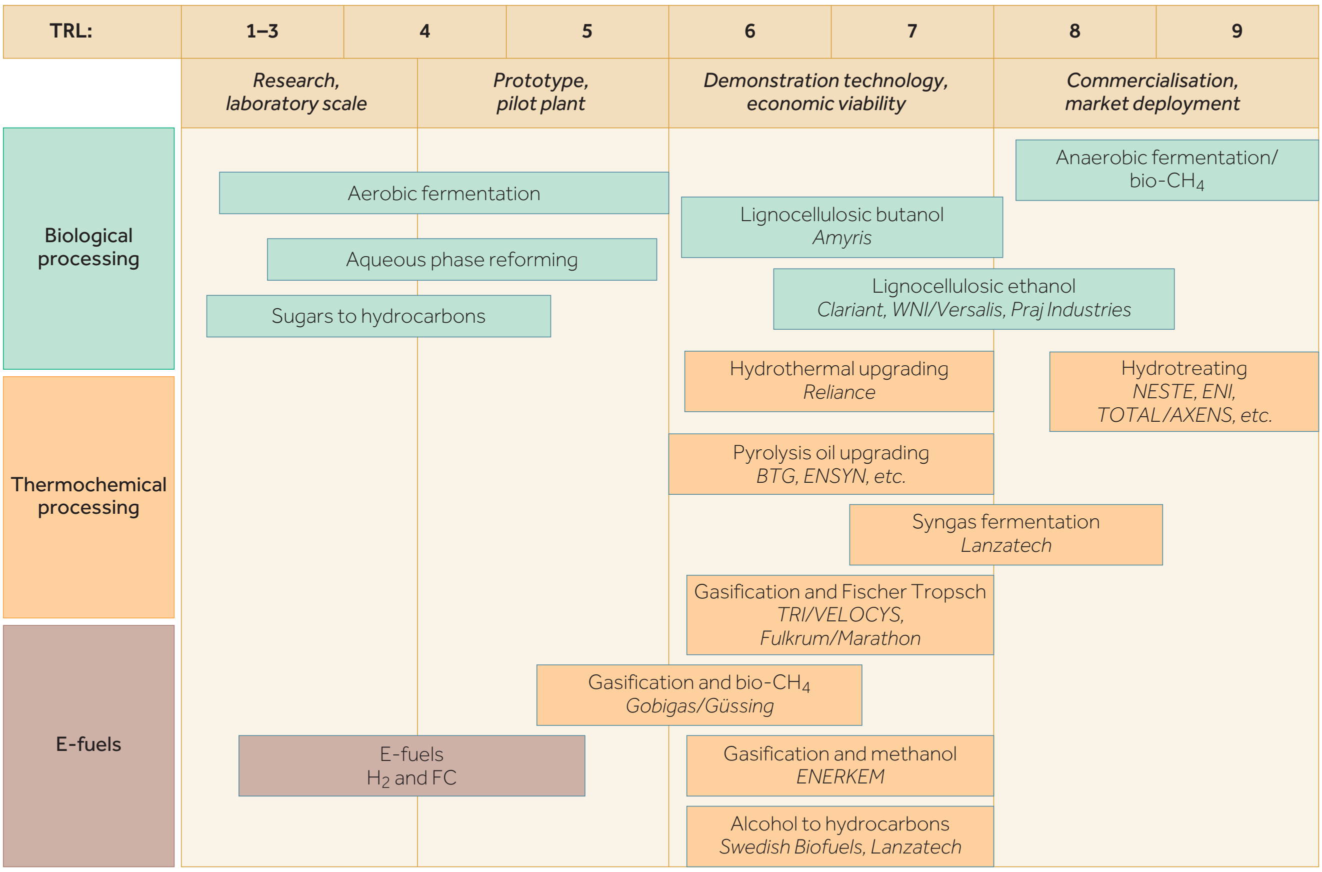
Part 2: Potential biofuel production

Part 2 of the study presents the status of the various technologies and value chains based on their maturity for market deployment, and assesses the potential production of sustainable advanced biofuels for 2030 and 2050 on the basis of the biomass potentials calculated in Part 1.

Biofuel technologies and technology readiness level

A summary of advanced biofuel technologies and their technology readiness levels is presented in Figure 4.

Figure 4: Simplified presentation of technologies and value chains for advanced biofuels



Methodology

A maximum biofuel potential scenario has been estimated considering:

- the sustainable biomass availability per type of feedstock for all bioenergy sectors (2030/2050 Low/High scenarios);
- the available technologies for advanced biofuels per type of feedstock, and the TRL in a given time frame; and
- the maximum conversion yields per type of biomass and feedstock (including conversion efficiency maximization due to H_2 enhancement).

Results

Table 3 summarises the potential advanced biofuel production per feedstock in 2030 and 2050, considering the maximum yields per pathway and the total sustainable biomass for bioenergy calculated in Part 1.

Table 3: High technology scenario: potential advanced biofuel production per feedstock in 2030 and 2050, taking into account the maximum yields per pathway and the total sustainable biomass for bioenergy

Biofuel	Feedstock	2030 estimated advanced biofuel quantity (Mtoe)	2050 estimated advanced biofuel quantity (Mtoe)
Hydrotreated vegetable oil/ renewable diesel	Waste oils and fats	1.9	1.9
	Used cooking oil	2.6	6.5
Biomethane	Sewage sludge	0.1–0.2	1.0–1.2
	Manure (solid and liquid)	1.1–1.3	0.4–0.4
	Agricultural residues (high moisture, sugar beet leaves, etc.)	0.1	0.1
Ethanol and hydrocarbons from enzymatic hydrolysis and fermentation	Agricultural residues (straw-like)	21.0–25.3	N/A
	Lignocellulosic crops (grassy)	5.5–16.6	6.5–19.6
	Biowaste	9.2–16.8	13.2–24.4
Fischer Tropsch from gasification + catalytic synthesis	Solid industrial waste (secondary agricultural and forest industries)	27.9–40.1	56.8–84.0
	Agricultural residues (straw-like)	N/A	54.4–62.4
	Agricultural (woody) and forestry residues	1–1.5	2.4–3.2
	Lignocellulosic crops (woody)	7.6–22.7	16.8–50.8
	Totals	**78.0–129.1**	**160.0–254.5**
	Total liquid advanced biofuels taking into account the total sustainable biomass for bioenergy	**76.7–127.5**	**158.5–252.8**
	Average conversion yield on an energy basis	**37%**	**70%**
	Average conversion yield on a dry mass basis	**15%**	**29%**

A look into demand versus availability

It should be noted that a part of the total sustainable biomass available for bioenergy could potentially be used for power, industry, services and agriculture, and residential heat demand in 2030 and 2050; this will decrease the amount of feedstock available for advanced biofuel production.

No allocation to transport has been developed in this study due to the absence of an economic model. Reference was made to the use of bioenergy estimated by the European Commission in the recently published Impact Assessment[20] (allocation of about 130 Mtoe for 2030 and 170 Mtoe for 2050), as shown in Figure 5.

Figure 5: Use of bioenergy estimated by the European Commission in the recently published Impact Assessment[20]

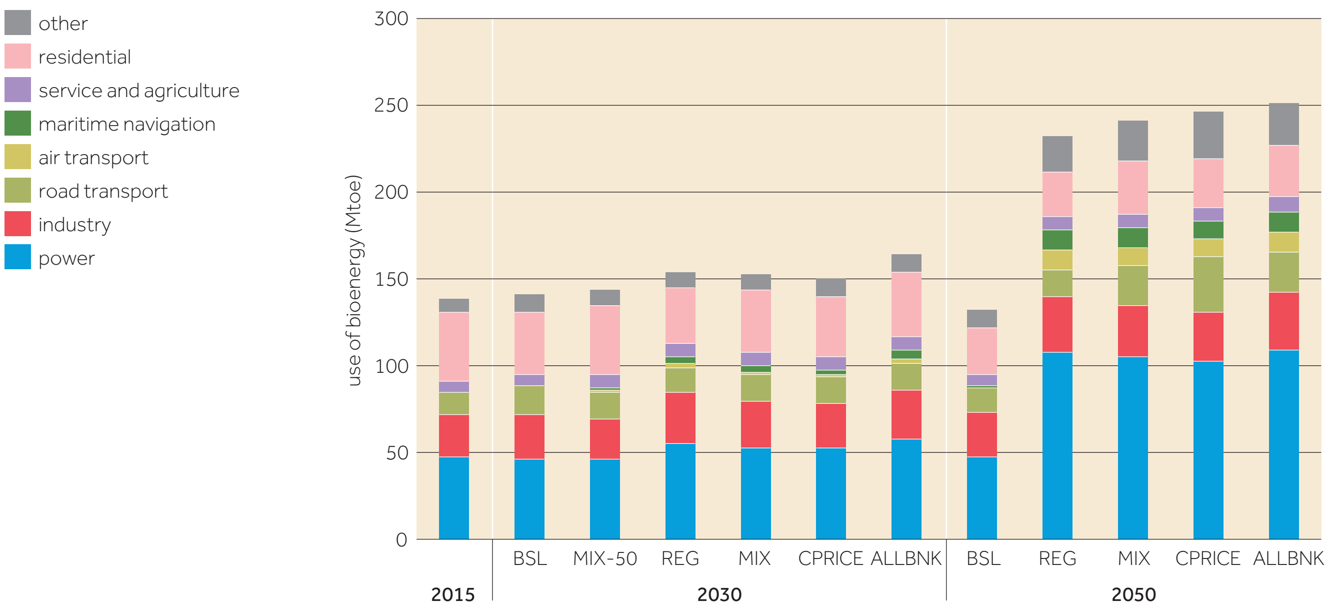


Table 4 on page 17 shows the amount of biomass available for bioenergy according to the Imperial College study, together with with an estimate of biomass imports. The allocation of biomass to non-transport-related uses according to the European Commission's model is also shown, and its impact on the total estimated amounts of biomass available for biofuels in transport is shown both with and without biomass imports.

Table 4: The estimated amount of biomass available for biofuels in transport after accounting for the PRIMES allocation to other, non-transport sectors (both with and without biomass imports)

	2030	2050
Estimated biomass available for bioenergy, excluding imports, in the Imperial College study	208–344*	215–366*
Estimated biomass imports in the Imperial College study — Annex 2 in the full report	48	56
Estimated use of biomass for other non-transport related uses according to the European Commission's PRIMES model	130	170
Estimated biomass available for advanced biofuels, i.e. the balance of biomass available for biofuel, excluding imports, after accounting for the demand for other uses estimated by the PRIMES model	**78–214***	**45–196***
Total estimated biomass left for biofuels in transport, including imports	**126–262***	**101–252***

* The ranges shown correspond to the lowest and highest biomass availability scenarios.

It can be seen from Table 4 that the total estimated net biomass available for biofuel production, after including imports (amounting to 48 Mtoe in 2030 and 56 Mtoe in 2050) and allowing for the use of biomass for other non-transport-related uses (power, industry, service, agriculture and residential, amounting to a total of 130 Mtoe in 2030 and 170 Mtoe in 2050 according to the European Commission's Impact Assessment[20]) is estimated between 126–262 Mtoe for 2030 and 101–252 Mtoe for 2050.

Table 5 summarises the potential sustainable biofuel availability for the production of advanced and waste-based biofuels as defined in the first part of the study (ranges correspond to low/high availability in the High technology conversion scenario, and are shown both with and without the bioenergy sectors and imports considered).

Table 5: Summary of potential biofuel availability (Mtoe)

	Potential biofuel availability — all bioenergy		**Potential biofuel availability — allocation to transport based on the PRIMES model**	
2030	Potential advanced and waste-based biofuels (EU domestic production)[a]	Potential advanced and waste-based biofuels (EU + imports)[a]	Potential advanced and waste-based biofuels adjusted according to the PRIMES allocation to the non-transport sector (EU domestic production)	Total potential advanced and waste-based biofuels (EU + imports)
	76.7–127.5	94.5–145.3	28.9–79.2	46.7–97.0
2050	Potential advanced and waste/based biofuels (this study)[a]	Potential advanced biofuels, estimated due to imports (this study)	Potential advanced biofuels, adjusted according to the PRIMES allocation to the non-transport sector	Total potential advanced biofuels (EU + imports)
	158.5–252.8	197.7–292	31.5–137.2[b]	70.7–176.4

[a] Potential advanced biofuels taking into account that all the bioenergy estimated in the Low and High scenarios of the Imperial College study were allocated to advanced biofuels for the transport sector. The ranges include the Low and the High biomass availability scenarios, taking into account the maximum conversion yields for the different pathways per type of feedstock.

[b] The potential for advanced biofuels is based on the estimated balance of biomass available for biofuels, and is an approximate estimation considering the same average conversion efficiency as in this study.

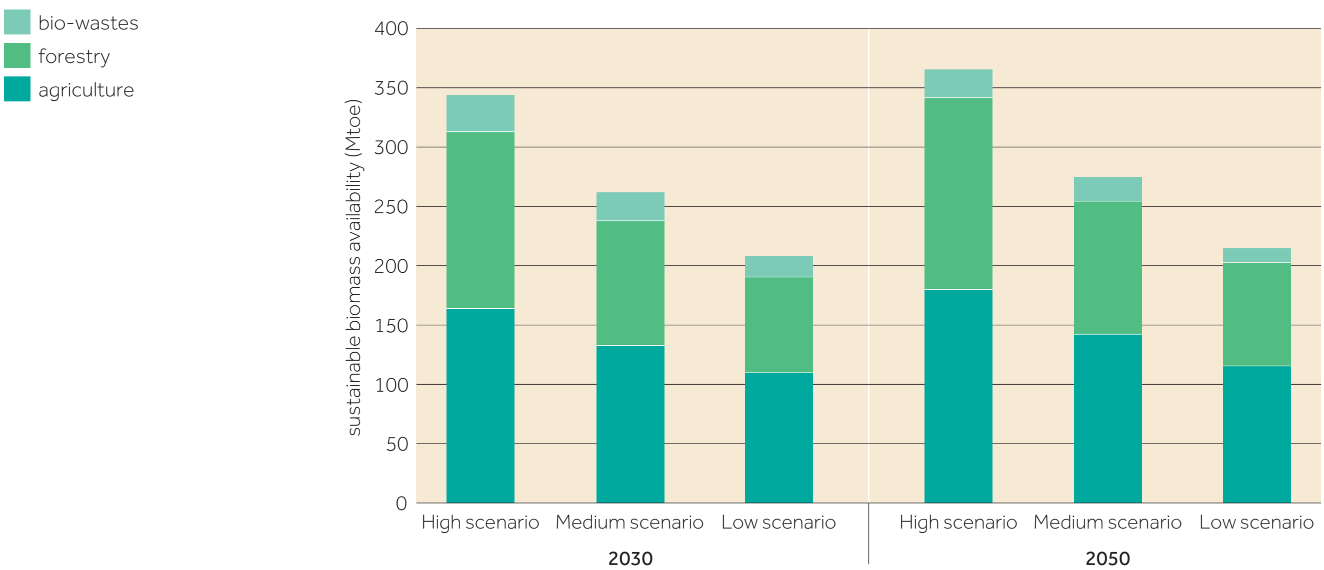
Conclusions

The estimation of the potential availability of sustainable biomass in the EU and the UK by 2030 and 2050 is focused only on the domestic feedstocks of agricultural, forest and waste origin included in Annex IX of RED II (Parts A and B); this is considered a conservative hypothesis assuming that more potential newcomers to Annex IX are currently being analysed by the EU Commission, and is summarised as follows:

- Sustainable biomass availability for all markets: 0.98–1.2 billion dry tonnes (392–498 Mtoe) in 2030, and 1–1.3 billion tonnes (408–533 Mtoe) in 2050.
- From these amounts, the estimated net amount of biomass available for bioenergy ranges from 520–860 million dry tonnes (208–344 Mtoe) in 2030, and 539–915 million dry tonnes (215–366 Mtoe) in 2050 (see Figure 6).

Important R&D developments and implementation of improved management practices are required to achieve this potential availability of biomass. Even if the potential is there, the supply chain would need to be developed to mobilise these resources.

Figure 6: Sustainable biomass availability (feedstocks included in RED II Annex IX, Parts A and B) for bioenergy in 2030 and 2050 as estimated in the Imperial College study



The total estimated net biomass available for biofuel production, after including imports (amounting to 48 Mtoe in 2030 and 56 Mtoe in 2050) and allowing for the use of biomass for other non-transport-related uses such as power, industry, service, agriculture and residential (amounting to 130 Mtoe in 2030 and 170 Mtoe in 2050 according to the European Commission's Impact Assessment[20]) is estimated at between 126–262 Mtoe for 2030 and 101–252 Mtoe for 2050. (Note that the ranges correspond to the lowest and highest biomass availability scenarios.)

Taking into account biomass transformation technologies in the higher TRLs, this could correspond to advanced and waste-based biofuel production of 46–97 Mtoe in 2030 and 71–176 Mtoe in 2050.

Tha fact that a lower availability of biomass in 2050 compared to 2030 leads to a higher production of biofuels in 2050 compared to 2030 is due to the increase in yields that could be achieved in 2050. By then, technologies such as gasification and Fischer-Tropsch could achieve higher conversion yields (from 21% wt in 2030 up to 40% wt in 2050) due to the use of renewable hydrogen.

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