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Research and Innovation

Mobilization of Industrial Capacity Building for Advanced Biofuels

EXECUTIVE SUMMARY

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Mobilization of Industrial Capacity Building for Advanced Biofuels

Executive Summary

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Executive Summary

The objective of the project "**Study on how to mobilize industrial capacity building for advanced biofuels***"* is to identify and propose ways to realize the essential industrial value chains of advanced biofuels including the technical, financial, business and feedstock-related aspects, in order to reach the defined 2030, 2040 and 2050 EU targets. It aims at analysing the actual needs of each Industrial Value Chain (IVC), developing a business model for each IVC, interviewing relevant industrial stakeholders and financial sources to collect inputs to validate the identified business models and proposing a plan for financing and realizing the IVCs, collectively. The project selected the essential industrial value chains of advanced biofuels for the periods of 2025-2030 and 2030-2040 under technological and commercial maturity criteria, with the goal of closing the gap between the biofuels' Levelized Cost of Production (LCoP) and the market price of their fossil fuel counterparts, estimating the financing needs to support building new capacity of industrial units and for mobilizing farmers. The first is proportional to produced quantities of biofuels in the form of Feed-in-Premium (FiP), which accounts for **3,849 – 7,499 mil.€/yr** in 2030, while support to farmers is proportional to produced feedstock amount in the form of FiP or production grant. The estimation of the respective financing support figures for 2040, when new technologies will be mature and penetrate in the market, is **11,586 – 17,852 mil.€/yr** for industrial units and **1,704 – 2,805 mil.€/yr** for farmers' mobilization. The project concluded that there is not one single solution or pathway that will provide 50% or more of the fuels needed to fulfil the targets, but rather a portfolio of essential pathways is necessary.

BOX 1 - Project Activities

Task 1: Record of essential industrial value chains of advanced biofuels and needs, to meet the GHG emission targets in transport for 2030, 2040 and 2050.
Task 2: Business models of industrial value chains of advanced biofuels and needs, to elaborate - and validate with relevant industrial and financial stakeholders - business models feasibility studies and, where necessary, technology-to-market plans.
Task 3: Proposal for a collective financing and realization plan, suggesting possible financial sources.
Task 4: Organization of a consultation workshop with external stakeholders and subject matter thematic experts.

Identification of Industrial Value Chains

A list of essential industrial value chains (i.e. combination of feedstock types and conversion technologies into one or more products) has been elaborated. Value chains considered in this study include the production of liquid and gaseous biofuels from feedstock listed in Part A and part B of Annex IX of Directive 2023/2413, as well as Renewable Fuels of Non-Biological Origin (RFNBOs) in combination with biogenic CO2. The list was based on the value chains assessed in a previous study[1].

This study estimated **2.2 Mtoe of biofuels** production from Annex IX Part A feedstocks in 2025, versus a **need of 18.4 Mtoe** to fulfil the 2030 advanced biofuels target, requiring an **8-fold increase in advanced biofuels** production capacities within just a couple of years. It is important to understand that there is not one single value chain that is capable of providing 50% or more of the sustainable fuels needed to fulfil the targets for 2030 and beyond, enforced by the Renewable Energy Directive, the ReFuelEU Aviation and FuelEU Maritime; rather there is a portfolio of pathways needed to produce these fuels. Technologies such as transesterification, hydrotreatment, anaerobic digestion, pyrolysis, and gasification followed by synthesis to Fischer–Tropsch (FT) liquids, methanol and methane will all need to contribute to the fuel pool. All of these technology pathways and more need to be fully developed and deployed, since only

1 "Study on development of outlook for the necessary means to build industrial capacity for drop-in advanced biofuels" No: CINEA/2022/OP/0004/SI2.884011; https://op.europa.eu/en/publication-detail/-/publication/b1c97235-c4c3-11ee-95d9-01aa75ed71a1/language-en

a diverse set of conversion technologies will be able to make use of the full range of feedstocks from lipids to agricultural and forestry residues to biogenic CO2 and green hydrogen, and enable the production of the full spectrum of renewable fuels needed, including gasoline, diesel, kerosene, and heavy fuel oil.

Identification of essential Industrial Value Chains and Key Performance Indicators

A number of Key Performance Indicators (KPIs) were developed to identify Essential Industrial Value Chains. It was concluded that to be considered essential within the scope of this study, the respective IVC should be able to contribute at industrial scale to a specific sectorial target in the given year, meaning that:

Box 2 - Essential Industrial Value Chain criteria

- It is **eligible** under the Renewable Energy Directive (RED), in particular towards GHG emission reduction (KPI: **GHG saving in %).**
- It must have reached **commercial maturity, i.e., TRL 9** at least 5 years ahead of the considered target year (KPIs: **TRL** (Technology Readiness Level) **and CRL** (Commercial Readiness Level).
- There must be sufficient **feedstock available** to support biofuel production in quantities of at least 10% of the sectorial target, i.e., road, shipping and aviation considered separately (KPI: **feedstock potential to contribute to sectorial target**).
- The expected **technology deployment** allows the production of quantities of at least 10% of the advanced biofuels target as per current EU legislation (RED, ReFuelEU Aviation, FuelEU Maritime; KPI: **expected technology deployment versus advanced biofuels target**).

The TRL of each IVC was assessed for 2024 and placed in the proper timeframe as follows:

- **TRL 9,** the value chain has the potential to be essential in the 2025-2030 timeframe.
- **TRL 7-8**, the value chain will be considered for the 2030-2040 timeframe.
- **TRL 4-5-6**, the value chain will be considered for the 2040-2050 timeframe.

To determine the KPI **feedstock potential to contribute to sectorial target**, data for feedstock availability and for volumes needed to fulfil the targets were drawn from the previous study and displayed as percentage. For the KPI **expected technology deployment**, technically possible production capacities as calculated in the previous study were used and compared to the advanced biofuels targets.

All industrial value chains were assessed against these KPIs. Out of the 20 IVCs identified and assessed, only **4 IVCs** met all selection criteria for the **2025-2030** timeframe, and **13 IVCs** met all selection criteria for the **2030-2040** timeframe. Several essential value chains were clustered, as displayed in Table 1.

It should be noted that this selection of value chains was made to narrow the number of IVCs to be further analysed in Tasks 2 and 3, and the definition of “essential” is based on TRL, feedstock availability and perceived potential for rapid deployment. IVCs not included in the list could still become (or remain) important in the future and should not be excluded from public support measures.

2025-2030	2030-2040
IVC1 - Transesterification for the production of FAME (Fatty Acid Methyl Ester) for the road or shipping sector	
IVC2 - **Hydrotreatment of Lipids** (either through co-processing or in stand-alone facilities) for the production of HVO (Hydrotreated Vegetable Oil) for the road sector and HEFA (Hydroprocessed Esters and Fatty Acids) for the aviation sector	**IVC2 - Hydrotreatment of Lipids** for the production of HVO for the road sector and HEFA for the aviation sector
	IVC5+12+6 - Production of advanced ethanol for the road sector or for further processing into Alcohol-to-Jet Synthetic Paraffinic Kerosene (AtJ-SPK) for the aviation sector
IVC7 - Biomethane from Anaerobic Digestion (AD) for the production of biomethane for the road and shipping sectors	**IVC7+9a+9b - Biomethane from AD, and Gasification and Methanation, and Methanation from CO2 and H2**, for the production of bio- or e-methane for selling into the road and shipping sectors
	IVC8a+8b+8c - Gasification and Methanol Synthesis, Biomethane (from AD) reforming to methanol, and Methanol Synthesis from biogenic CO2 and H2 for the production of bio- or e-methanol for the shipping sector
	IVC11a - Gasification and FT-Synthesis for the production of FT-SPK for the aviation sector
IVC13a - Pyrolysis and Co-processing in Refinery for the production of fuels with biogenic content for the road sector	**IVC13a+13b - Pyrolysis and Co-processing in Refinery or Upgrading** for the production of fuels with biogenic content for the aviation and shipping sectors

Table 1. List of selected (and clustered) essential Industrial Value Chains

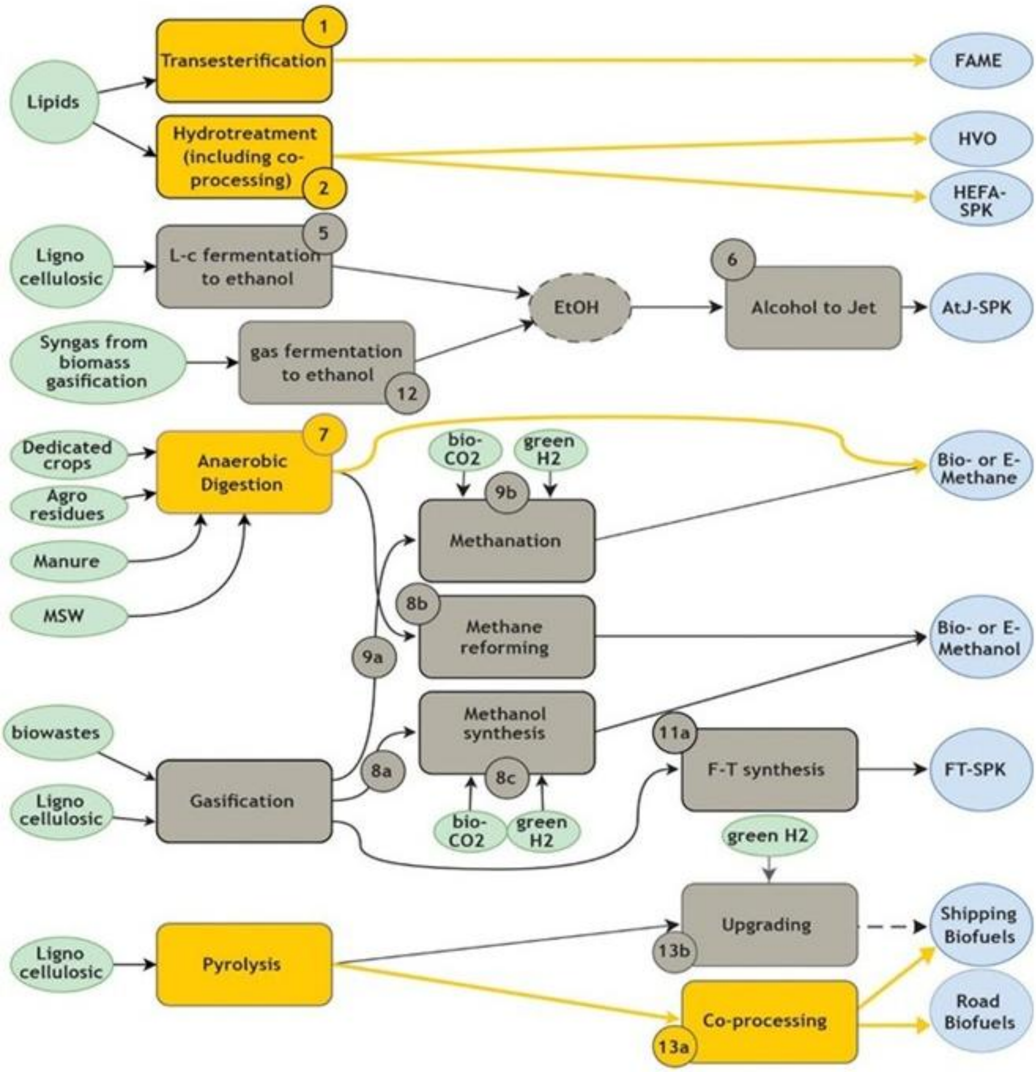

Figure 1. Simplified flowchart of the essential IVCs. 2025-2030 essential IVCs are colored in yellow and 2030-2040 essential IVCs in grey)

Value chains at lower Technology Readiness Level

Further value chains at lower TRL were identified, which could become important in the 2040-2050 timeframe. This was done through scanning the technologies investigated in recent and ongoing Horizon Europe research projects on renewable fuels, and through discussing a draft list with the experts of ETIP Bioenergy Working Group (WG) 2. The identified technologies and their estimated TRL are listed in Table 2.

IVC at TRL 4-6 / Variation of IVC at lower TRL	Estimated TRL
Hydrotreatment of lipids, produced from algal lipids	3-5
Hydrotreatment of lipids, produced without additional hydrogen	3-5
Lignin boost of fatty acids and Co-processing in Refinery	6
Lignin depolymerisation	5
AtJ combination of ethanol and methanol and including production of aromatics	3
AtJ technology, based on methanol	4-5
AtJ technology, consolidated alcohol deoxygenation and oligomerization (CADO)	7-9[2]
Biomethane from AD - methanation from upgrading of biogas to biomethane	6-7
Biomethane from AD, providing energy to microbes through electrodes	5
Methanolysis from CO2 and H2	3-7
Gasification and Methanation, heat integration to minimize auxiliary fuel needs	5-7
Gasification to Hydrogen, multiple process variations	5-7
FT Synthesis from CO2 and H2	4-5
Gas fermentation, producing lipids instead of ethanol	4-6
Pyrolysis, providing energy through microwaves	5
Pyrolysis, providing energy through concentrated solar power	3-7
Hydrothermal treatment - higher temperature and pressure increasing gaseous phase	4
Hydrothermal treatment, using ethanol or methanol as solvent instead of water	5
Gasification and chemical looping	5
Thermo-catalytic reforming	5
Dark fermentation to hydrogen	4-5
Dark fermentation to single cell oils	4-5
Aqueous phase reforming	5
READi Reactive Distillation Technology	4-5
Condensation of C5 sugars and hydrodeoxygenation	3-4
Sugar to lipid conversion	4-5

Table 2. List of value chains at lower Technology Readiness Level

A literature survey complemented by an online survey (16 experts from 11 companies) confirmed that European technology providers **have the knowledge and the personnel needed** to build the advanced biofuels industry. The industry **does not anticipate a lack of**

[2] Not yet demonstrated at scale with RED Annex IX feedstocks

suitable equipment to build advanced biofuel production facilities. However, several industrial stakeholders noted that, although the supply of equipment is available within Europe, it might be cheaper to purchase globally. Components usually sourced from outside Europe include catalysts and pressure equipment. A future supply gap—both from within and outside Europe—is expected in biomass pre-treatment (steam explosion), gasification and FT reactors, and equipment for upgrading biogas to biomethane.

Processing materials are generally available in Europe; only catalysts, reactor internals, and instrumentation are usually imported, and it could be challenging to purchase catalysts from within Europe. In addition, low-cost renewable electricity is only available in specific locations in Europe.

Although sufficient feedstock can be made available in EU to support the production of advanced biofuels, ensuring sufficient (RED Annex IX) feedstock supply is key, in particular as regards sourcing waste lipids for hydrotreating. For the Alcohol-to-jet and all gasification-based pathways, the main challenge is to organize at large scale the production and collection of biomass residues from agriculture and forestry. Finally, for RFNBOs the lack of maturity of biogenic CO2 and of green hydrogen markets are critical.

Engineering, Procurement, and Construction (EPC) companies capable of building production facilities are available in Europe. The most important gap identified is the **lack of project developers** for advanced biofuels.

Refiners seem to focus their efforts on HVO/HEFA production, there is no strong wide action for other technologies in place in the EU. Project developers for biomethane from anaerobic digestion often aim to sell projects to third parties: moreover, industry appears reluctant to invest in gasification technologies.

The most important identified bottlenecks are: (a) lack of project developers for advanced biofuels, (b) reluctance to invest in CAPEX-heavy pathways, and (c) if indeed all these facilities were decided to be built in the next years, experienced EPC companies exist, but with low availability due to present commitments in projects.

Business Models of industrial value chains of advanced biofuels

A set of **Business Models** of the **essential Industrial Value Chains** (IVCs) was developed (see Table 1. List of selected (and clustered) essential Industrial Value Chains

). Business Models provide the basis for the evaluation of additional support that could be required to improve the techno-economic performance of the IVCs.

Each **Business Model** briefly outline an essential IVC in terms of main products and coproducts, feedstock(s) used, target market(s), techno-economical parameters of the conversion process, overall Value Chain structure and economics. It includes a qualitative section with assessments on environmental performance, market and technology perspective and expected risks and barriers. An additional **Technology-to-Market (T2M) Plan** was produced for the 2030-2040 IVCs, whenever their TRL was deemed lower enough than commercial level; the T2M plan describes the IVC features that should be further developed in order to reach commercial maturity.

A **quantitative Financial Analysis** is integrated in each Business Model, using a discounted cashflow model and analysing a 100% equity-based case, provides a consistent baseline for the comparison of the results between different IVCs, as well as for Task 3 activities. The main outputs of the Financial Analysis comprise:

- **The Levelized Cost of Production (LCoP)** of the main biofuel product, defined as the minimum selling price that allows to reach a Net Present Value of zero at the end of the considered plant lifetime; it takes into consideration also (possible) additional revenues from co-product sales.

- **The expected profitability** when considering counterfactual fossil market prices, calculated under current market and regulatory framework conditions, including EU Allowances cost (as per EU Emissions Trading System -ETS-) as well as penalties for non-compliance with existing regulations, when applicable.
- **A sensitivity analysis** assessing the impact of CAPEX, OPEX and feedstock prices variation on the Levelized Cost of Production of the main product.

The qualitative information and the quantitative input data used for the definition of the Business Models were gathered from multiple publicly available sources; they were processed using a coherent methodology to provide the basis for the definition of representative IVCs, on which the Business Models were based upon. All the main assumptions used in the Business Models, in terms of techno-economical parameters of processes and IVCs, as well as the general outcomes, have been **checked against industrial stakeholders' opinion** by collecting answers to tailored questionnaires.

Outcomes from the EIVCs Business Model development activity

An overall positive evaluation of the Business Models dataset and outcomes was reported by the industrial stakeholder's consultation, with average scores ranging 2.9–3.9/5 (in a 1 to 5 range, where 5 is the maximum). Slight revisions of specific process schemes and output yields were requested, together with refinements on specific product slates and feedstock compositions.

Research on existing sector literature and databases (I.e., the IEA Bioenergy Task 39[3]) has been carried out, complemented by experts' evaluations, in order to define a plausible **average commercial scale of the conversion plants** for the considered IVCs. Figure 2 reports on the lowest side of the range, the biomethane production through AD (IVC7) and synthesis (IVC9b), with **5 MW** output. Many IVCs are in the range of **75-150 MW**, such as all the ones in the AtJ cluster and in the Pyrolysis cluster (IVC13a and IVC13b), as well as the methane and methanol production from syngas from gasification (respectively IVC9a and IVC8a) and from biomethane reforming (IVC 8b). Increasing the size, gasification + F-T (IVC11a) and FAME (IVC1) are positioned around the **200 MW** size, while HVO/HEFA (IVC2) so far is on the highest side of the range with more than **700 MW**.

Figure 2 provides an overview of the considered average commercial size (light blue bars: total ranges from public literature; blue dots: value used in Financial Analysis; orange dots: suggested values from Stakeholders consultation) for all the essential IVCs. Figure 3 provides an overview of the specific CAPEX for all the essential IVCs (light purple bars: total ranges from public literature; blue dots: value used in Financial Analysis; orange dots: suggested values from Stakeholders consultation, used in updated Financial Analyses calculations).The **lowest average specific CAPEX** is attributed to the most mature IVCs, such as FAME (IVC1 – 570 €/kW) and HVO/HEFA (IVC2 – 1,050 €/kW). On the opposite side of the range the AtJ IVCs (IVC6 and IVC6a), with significantly higher CAPEX values of 5,500 – 8,200 €/kW, which could seriously hinder business viability. All the other IVCs' specific CAPEX are considered as within the 2,500 – 3,500 €/kW range. Stakeholders' consultation results reported how the specific CAPEX for lignocellulosic ethanol, AtJ and gasification and F-T synthesis plants could still have been underestimated; this would in turn lead to a further increase in the already high LCoP for the related biofuels.

3 https://demoplants.best-research.eu/

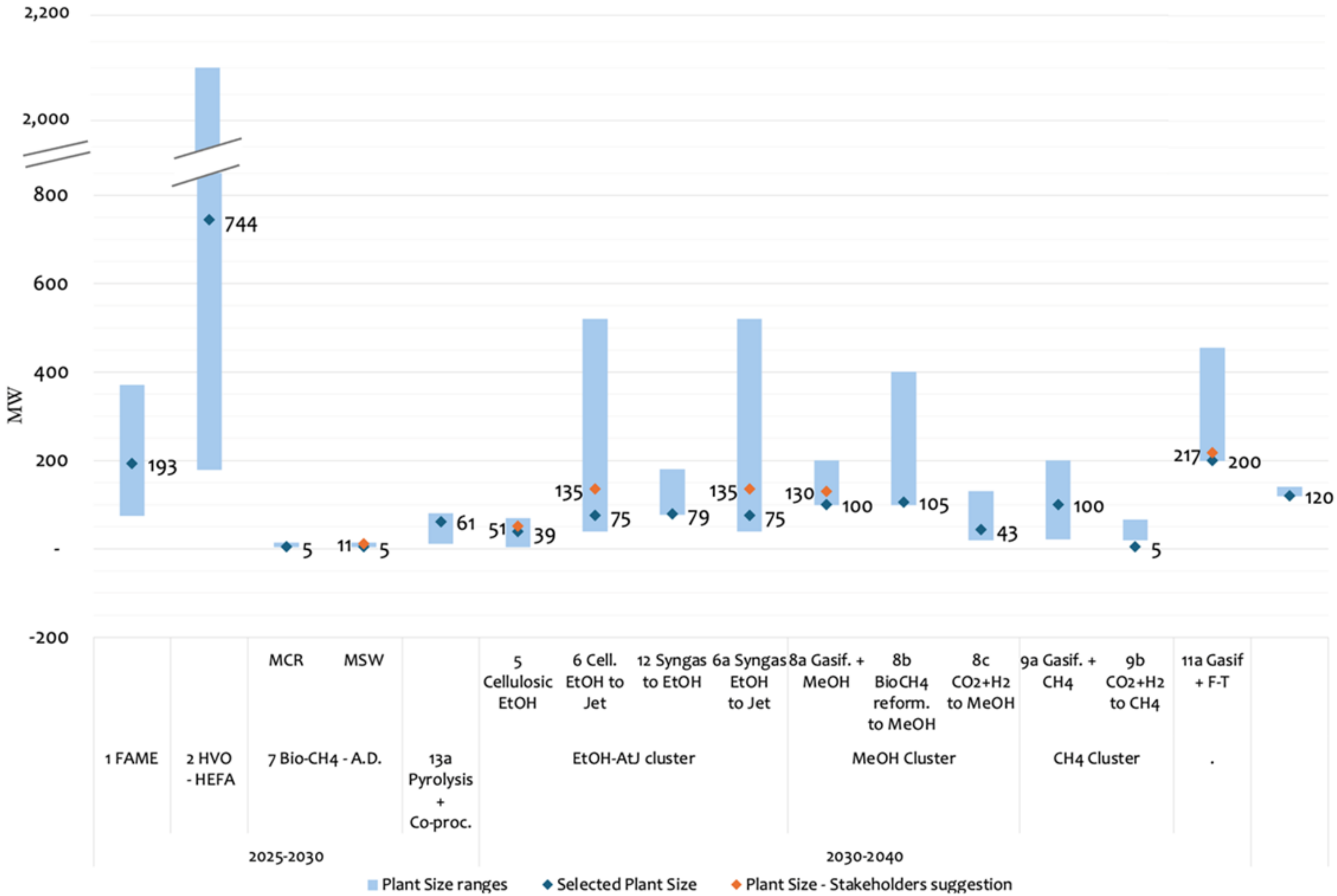

Figure 2. Overview of the average commercial size considered for all the essential IVCs

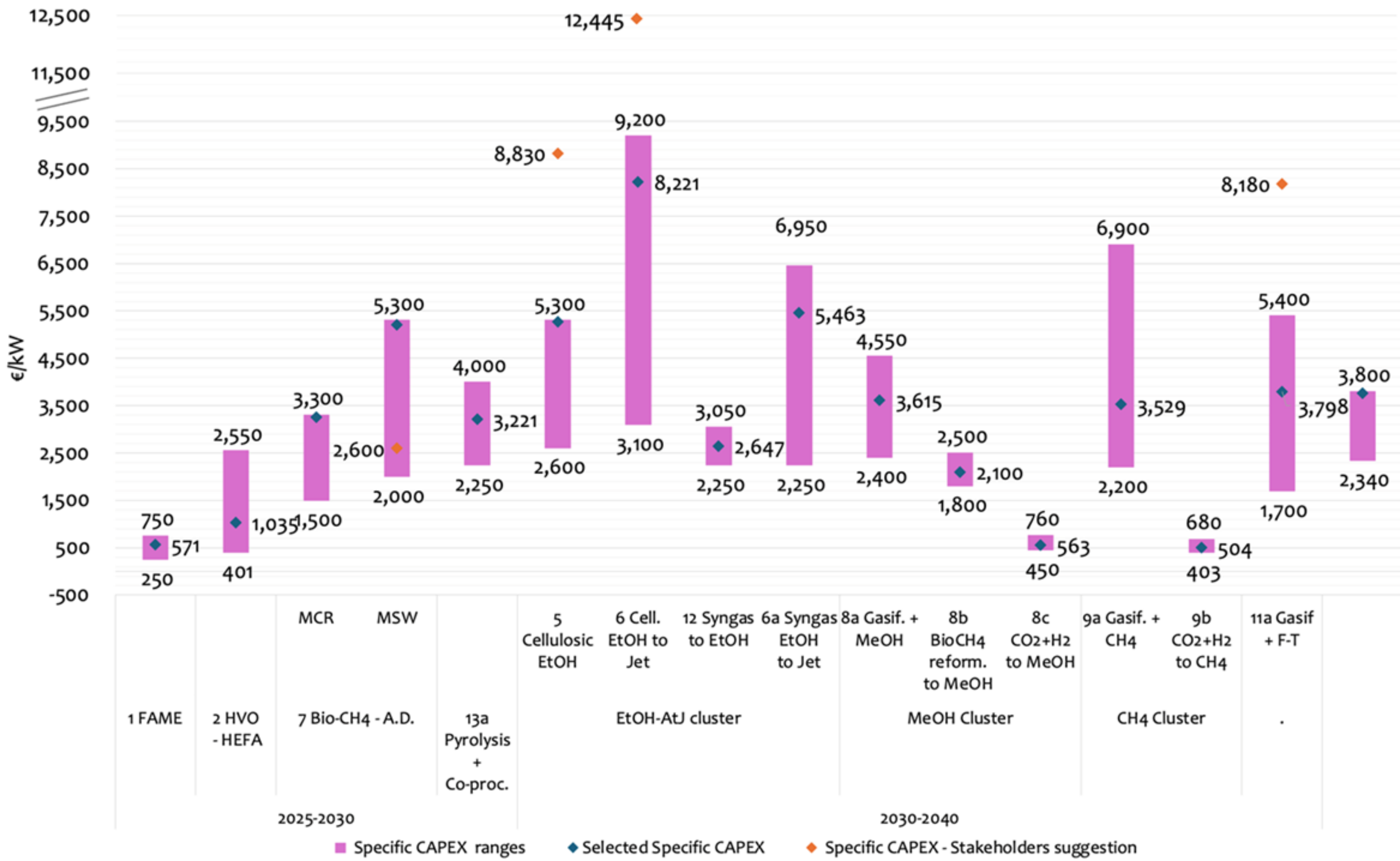

Figure 3. Overview of the specific CAPEX for all the essential IVCs

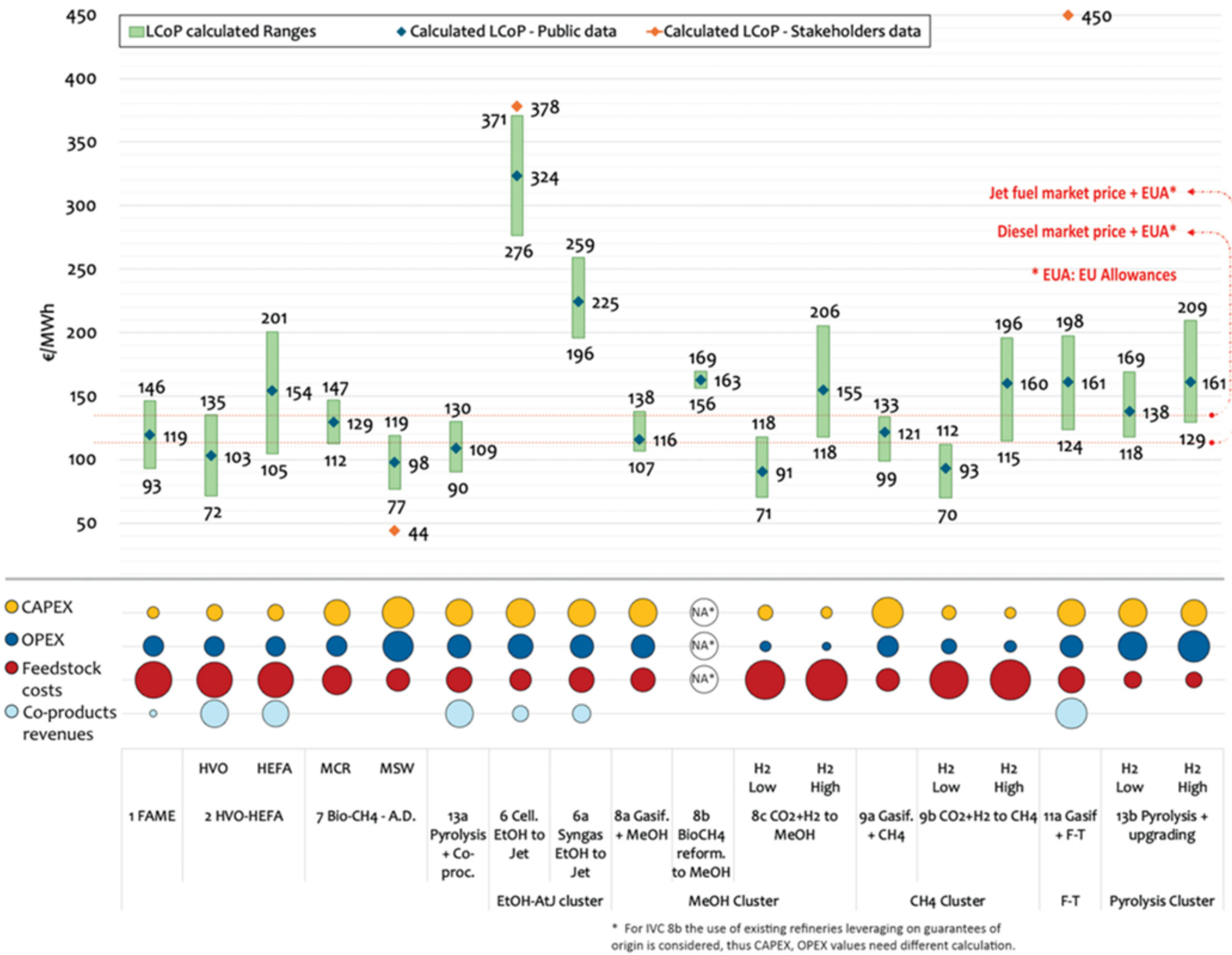

Figure 4. Overview of the composition and range of the LCoP for all the essential IVCs

An overview on the Levelized Cost of Production (LCoP) of the main biofuel output for all the essential IVC, together with its composition in terms of contribution from CAPEX, OPEX, feedstock costs and co-products revenues is presented in Figure 4. The upper part of the graph shows the calculated value from publicly available data (blue dot), the one from alternative data provided by industrial stakeholders (orange dot) and LCoP ranges from sensitivity analysis results (green bars). The lower section qualitatively reports the influence of CAPEX, OPEX, feedstock prices and coproduct revenues on the final LCoP values. The following H2 prices are considered in the analysis “H2 Low”: 2.3 €/kg, “H2 High”: 4.2 €/kg.

The LCoP for the diesel-like biofuels ranges between the 103€/MWh of HVO and the 119€/MWh of FAME. Biomethane LCoP ranges between 98€/MWh of MSW Anaerobic Digestion (IVC7) and 155€/MWh of synthesis from biogenic CO2 and green H2 (IVC9b). The lower end of the range can be achieved when MSW is used as feedstock or in larger plant sizes. This conclusion is supported by industrial stakeholder’s feedback: a LCoP calculated by using the provided inputs would reach 44 €/MWh – for a bigger plant (more than twice the size) processing MSW.

SAF LCoP has a wide range, depending on the technology and the period: from 155€/MWh of HEFA (IVC2), to the 225-320€/MWh of the AtJ (IVC6 and IVC6a) and to the 160€/MWh of gasification + F-T (IVC11a), both considered as available only after 2030. Multiple feedback from stakeholders’ consultation suggested increasing both CAPEX and OPEX for the AtJ and the gasification + F-T IVCs. The impact on LCoP was consistent, especially for the gasification + F-T IVC, which new LCoP raised to 450 €/MWh; instead, the recalculated LCoP for AtJ increased to almost 380 €/MWh.

In the shipping sector, Methanol LCoP projections range between 121€/MWh of the gasification-based process (IVC8a) and 160€/MWh of the synthesis from biogenic CO2 and green H2 (IVC9b) and biomethane reforming (IVC8b). All the LCoP projections here provided do not include taxes and do not consider the effects of inflation over the lifetime period of the plant. The green hydrogen production prices considered in the financial analyses range between 2.3 €/kg for the “H2 Low” scenarios and the 4.2 €/kg of the “H2 High” ones.

When considering a market scenario in which the biofuel products and co-products are sold at the same price of their fossil alternative plus the price of the required EU Allowances, IVC2-HVO is the only IVC among the ones considered for the first period that come close to not needing additional financial support in order to reach a calculated NPV higher than zero at the end of plant lifetime. In the second period, the modelling results show that IVC9b-Methanation from biogenic CO_2 and green H_2 would not require additional support, but only in the case of the extremely low electrolysis-based H_2 costs of 2.3 €/kgH_2. It should be noticed that such value was included in the analysis because it can indeed be found in available literature for 2030 and beyond, but it is still considered as overly optimistic by many experts. On top of all the earlier considerations, it should then be pointed out that adequate margins for the industry should also be added to the evaluation. Internal expertise suggests that usually margins range between 10 and 30%; a high degree of uncertainty is associated to this parameter, due to obvious commercial sensitivity of these industrial data.

Furthermore, several IVCs that emerged as requiring additional economic support from the model evaluation in the *EUA* case (where biofuel products and co-products are considered as sold at the same price of their fossil alternative plus the price of EUA) are however rather close to economic viability. As an example, the variability range attributed to the LCoP by the sensitivity analysis carried out on the following IVCs could intersect with the fossil fuel counterpart market price: IVC1 – FAME, IVC2 – HVO, IVC7 – Biomethane from AD (both cases), IVC13 – Pyrolysis and co-processing and IVC9a – Gasification to CH4. Thus, a +/- 30% variation (or less) in one or more among CAPEX, OPEX or feedstock price, could allow these IVCs to be profitable without additional financial support.

Review of available funding programs and schemes

Regarding the **financial support of commercial projects** in the field of advanced biofuels, the main conclusions drawn from the assessment of current EU and Member State (MS) programs are as follows:

- **EU-level funding opportunities** play a crucial role in the deployment of advanced biofuel supply chains. These initiatives are essential to bridge the gap between pilot-scale technology demonstrations and full commercial operations, particularly by addressing market risks and financing barriers.
- **Existing EU and MS financial instruments**—such as grants, loans, interest-rate subsidies, credit support, and institutional equity capital—are useful for kick-starting CAPEX-intensive investments on the refining and processing side.
- For **project sponsors** developing advanced biofuel processing or refining facilities, EU programs such as **InvestEU**, the **Modernisation Fund**, the **Connecting Europe Facility (CEF)**, and the **European Regional Development Fund (ERDF)** can provide substantial financial support.
- Since the challenges faced by advanced biofuel projects involve both **capital and operational risks**, both types of support are essential. Therefore, **price support mechanisms** for feedstocks and products—such as Feed-in Tariffs (FiT), Feed-in Premiums (FiP), Contracts for Difference (CfD), and tax incentives—are necessary to improve the economic and risk profile at the operational stage and ensure a sustainable and predictable feedstock supply.
- From the **feedstock suppliers' perspective**—particularly agricultural and forestry operators supplying lignocellulosic biomass—the **Common Agriculture Policy (CAP) Pillar I** (Eco-schemes, Voluntary Coupled Support) and **Pillar II** (EAFRD) provide significant potential support. These instruments incentivize sustainable agricultural practices, the cultivation of energy crops, and feedstock supply chain integration.
- Among the 27 Member States, approximately **one-third** have effectively integrated tangible and concrete measures in support of the advanced biofuels sector into their respective national energy and transport strategies.
- Regarding the **types of biofuels and stages of the value chain** targeted by MS support schemes, these may focus on maritime and aviation biofuels, biomethane, e-fuels, or more broadly on commercial-scale advanced biofuels technologies.

From a **geographical perspective**, the review can be grouped into four regional clusters:

Box 3 – Geographical grouping of EU countries regarding biofuel industry

- **Western Europe:** France, Germany, and the Netherlands lead efforts to decarbonize transport through accelerated biofuel industry development.
- **Northern Europe:** Finland, Sweden, and Denmark are at the forefront of advanced biofuel deployment, with national climate goals that often exceed EU targets.
- **Central–Southern Europe:** Austria and Italy rank highest in supporting the industrialization of biofuels.
- **Eastern Europe:** Romania, Poland, and Lithuania are emerging as regional leaders in advanced biofuel industrialization.

Determination of integrated projects of common interest

To address the support needs of the four main **value chain actors**—farmers or biomass residue collectors, aggregators, industrial units, and marketers—the concept of **integrated projects** could be introduced. This concept would encompass the entire IVC and provide combined financial support across all stages of the value chain. Such integrated projects would require dedicated financing schemes.

The development of new **collective financing plans** for aggregated industrial value chain projects within the EU is guided by core principles aimed at strengthening industrial capacity to meet the 2030 and 2040 climate targets. These plans seek to mobilize both EU and MS support tailored to the specific needs of investors and producers across different segments of the value chain and to promote cooperation among EU countries. A key focus is on **de-risking the entire value chain**—considering geographic dispersion and project size—through targeted financial instruments and support mechanisms.

Regarding **farmers**, the analysis highlights a set of administrative and regulatory challenges, including the need to align CAP with RED provisions on supported crops, registries, and sustainability certification. The development of **standardized contract templates** between farmers and aggregators—with built-in compliance safeguards for harvest windows, minimum residue retention, and cover crop re-establishment—would be beneficial. Such contracts should be developed in consultation with local authorities and auditors to reduce risks for farmers.

Financial support should be targeted directly to farmers and collectors in the form of EU or MS **feed-in premiums** to increase their participation in feedstock production.

The role of **aggregators**—regardless of the value chain—is critical. Aggregators collect biomass, pre-process it into standardized feedstock, manage warehousing and logistics, ensure sustainability certification up to the factory gate, and provide training and agronomic support to farmers. Aggregators are often organized as **cooperatives or joint ventures** with farmers or industrial units to reduce supply-side, logistics, and market risks. The existing EU and international financing frameworks, including those involving the **EIB** and **EBRD**, as well as development and commercial banks, appear adequate to support aggregators financially.

Regulatory support for industrial units should focus on enforcing **Renewable Energy Directive** (**RED) III**, **FuelEU Maritime**, and **ReFuelEU Aviation**, ensuring that fuel buyers actively seek advanced biofuels and that mandated demand ramp-ups are scheduled for 2030 and 2040. Several EU and MS mechanisms—such as **InvestEU**, **Important Project of Common European Interest (IPCEI)**, **Connecting Europe Facility (CEF)**, and **Just Transition Fund (JTF)**—can provide or enable CAPEX support, ideally through direct funding and financial de-risking.

As seen in earlier stages of renewable energy market development, there is a need for **final price support policies**, such as Feed-in Premiums or similar financial mechanisms, to close the price gap between fossil fuels and advanced biofuels—a gap that remains significant even for the lower-cost biofuels.

For **marketers**, administrative and regulatory measures aimed at harmonizing operations across Member States are necessary. This would allow companies to focus on innovation and efficiency rather than navigating regulatory fragmentation, thereby accelerating decarbonization across aviation, maritime, and road transport sectors. **Financing for marketers** can be mobilized through targeted support measures within national policy frameworks, leveraging direct and indirect incentives, grants, and public–private partnerships, particularly under the **Alternative Fuels Infrastructure Regulation (AFIR).**

Formulation of collective plans for advanced biofuels value chain

The formulation of collective plans for advanced biofuels value chains addresses the **whole EU as an area**, including the critical regional characteristics and efficient sizes at each value chain stage, for intervention and opening/ mobilization of the relevant markets of biomass feedstocks and advanced biofuels as final drop-in products for the three main transport sectors: road, aviation and maritime. The main points are presented below.

Experience and analysis across the EU and internationally confirm that **the persistent cost gap with fossil fuels are critical deterrents that hinder the sector's** growth from pilots and isolated investments to meaningful industrial deployment.

The project's intervention area is **intentionally set as additional to existing programme channels**, avoiding overlap with their activities. Instead, it aims to test an **innovative, integrated approach** designed to address the specific market barriers hindering the commercial rollout of advanced biofuels.

Two main financing supports are considered: (a) **Financing farmers to mobilize them** to cultivate the necessary oil or lignocellulosic feedstock crops (i.e. from RED Annex IX feedstocks), or to incentivize them to shift their current cultivation to crops eligible for production of advanced biofuels and (b) Needed overall support that is determined by considering what would be the required reduction in the LCoP so as the particular **biofuel to reach close to a parity with its relevant fossil fuel comparator**.

Industrial units based on **hydrotreatment of oil from crops** can be found in several regions across Europe, particularly in Italy, France, Spain, Sweden, the Netherlands, Finland, Austria, i.e. in countries with significant refining capacity, and are planned in other countries. These regions have leading roles in hydrotreatment technology deployment for biofuel production from crops and waste oils, and their facilities are either operational or in advanced planning stages.

Industrial units converting **lignocellulosic crops and agricultural residues** are distributed across several regions in Europe, notably Austria, Norway, France, Sweden, Denmark, Finland, and the Netherlands. **Forestry residues** are specifically considered and prioritized in Finland, Sweden, Austria, Norway, and the Netherlands, where several commercial and demonstration-scale facilities process forest-derived biomass, indicating these countries as key areas of focus for forestry-based biorefineries.

Table 3 presents indicative collective support expressed in million EUR for the distinct essential IVCs in 2030. The aggregated quantities of the distinct four IVCs account for the 60% (14.4 Mtoe) of the foreseen quantities of advanced biofuels needed in 2030. This support should be considered that is implemented as: (a) **minimum financing support to industrial units** that is proportional to produced quantities of biofuels in the form of FiP, which accounts for **3,849 – 7,499 mil.€/yr** in 2030 and (b) **minimum financing support mobilizing farmers** that is proportional to produced feedstock quantities in the form of FiP or production, which accounts for **700 – 1,245 mil.€/yr** in 2030 and is absorbed at the stage of agricultural production not influencing the final price.

The support to farmers, which accounts for **approximately 15% of the total financing** needs in the biofuel value chains in 2030, must be provided through the generation of additional financing streams, as these funds do not currently exist. This upstream support is essential to mobilize feedstock production and is typically delivered as feed-in premiums or production subsidies.

The support to industrial units, which represents about 85% of the total financing needs in 2030, **primarily constitutes a redistribution of existing financing flows**. Instead of consumers facing increased prices for the final biofuel product, this support—potentially funded through mechanisms such as carbon pricing revenues—helps maintain price parity between biofuels and fossil fuels at the point of sale. This ensures market competitiveness and consumer acceptance while enabling industry development.

In 2040, the needed quantities of advanced biofuels to meet the respective targets are almost 50% higher than the needs in 2030. These increased needs naturally bring more IVCs at the spotlight in the 2030 – 2040 period. Table 4 presents estimated collective support expressed in million EUR for the selected essential IVCs in 2040. The aggregated sum of the quantities stemming from the IVCs of Table 4, accounts for approximately 70% of the needed quantities of advanced biofuels for the target year 2040. The estimation of the respective financing support figures for 2040, when new technologies will be mature and penetrate in the market, is **11,586 – 17,852 mil.€/yr** for industrial units and **1,704 – 2,805 mil.€/yr** for farmers' mobilization.

Industrial Value Chain (IVC)	IVC level			Collective plan		
	Support to farmers (€/t)	Support to farmers (€/MWh)	Operational support to the industrial unit (€/MWh)	Support for securing the mobilization of the upstream part (mln.€/yr)	Support for industrial units development (mln.€/yr)	Total support for operation of the entire IVC (mln.€/yr)
IVC2 Hydrotreatment (HVO/HEFA) of oil, eligible oil crops	25 – 40	3.2 – 7.9	min. 7 - 75	ca. 157 – 357	from 343 (slate 1) to 3,672 (slate 2)	ca. 499 - 4,029
IVC8a Biomass gasification and methanol synthesis	11 – 18	4.0 – 6.5	min. 36	ca. 63 – 103	580	ca. 643 - 683
IVC7 production of advanced Biomethane eligible crops	11 – 18	4.8 – 7.9	min. 21	ca. 442 - 724	1,954	ca. 2,396 – 2,678
IVC13b Pyrolysis and upgrading for maritime sector	11 – 18	3.4 – 5.6	min. 88 – 117	ca. 38 - 62	from 972 to 1,293	ca. 1,010 – 1,354
TOTAL	-	-	-	**700 – 1,245**	**3,849 – 7,499**	**4,548 – 8,744**

Table 3. Estimated collective support in million €/yr for the selected distinct IVCs, 2030

IVC #	Industrial Value Chain	IVC level			Collective plan		
		Support to farmers (€/t feedstock)	Support to farmers (€/MWh fuel)	Operational support to the industrial unit (€/MWh fuel)	Support for securing the mobilization of the upstream part (mln.€/yr)	Support for industrial units development (mln.€/yr)	Total support for the operation of the entire IVC (mln.€/yr)
IVC2	**Hydrotreatment of lipids**	25 – 40	3.2 – 7.3	7 - 75	27 - 61	59 - 628	85 - 689
IVC5+ IVC6	**SAF production from Cellulosic Ethanol (EtOH-to-Jet)**	11 – 18	9.4 – 15.4	102 – 281[4]	251 - 410	2,717-7,484[5]	2,967 – 7,894[6]
IVC12+ IVC6a	**SAF production from Syngas fermentation Ethanol (EtOH-to-Jet)**	11 – 18	6.8 – 11.1	81 - 172	23 - 37	273 - 580	296 - 617
IVC7	**Advanced biomethane from anaerobic digestion**	11 – 18	4.8 – 7.9	21	591 - 966	2,608	3,199 – 3,575
IVC9a	**Biomass Gasification and Methanation**	11 – 18	3.3 – 5.4	19	189 - 309	1,078	1,267 – 1,387
IVC9b	**Methanation from biogenic CO2 and H2**	N.A.[7]	N.A.	16	N.A.	128	128
IVC8a	**Biomass Gasification and Methanol Synthesis**	11 – 18	4.0 – 6.5	36	153 - 251	1,405	1,559 – 1,656
IVC8b	**Biomethane reforming into Methanol**	N.A.[8]	N.A.	1	N.A.	36	36
IVC8c	**Methanol Synthesis from biogenic CO2 and H2**	N.A.[9]	N.A.	31 – 49	N.A.	184 - 291	184 - 291

[4] Increased to 349 mln. EUR considering the higher LCOP value provided by the stakeholders.
[5] Increased to 9,281 mln. EUR considering the higher LCOP value provided by the stakeholders.
[6] Increased to 9,692 mln. EUR considering the higher LCOP value provided by the stakeholders.
[7] This specific technology exploits a flow of biogenic CO2 and clean hydrogen to produce (bio)methane.
[8] Feedstock for Methane Reforming: While traditionally natural gas is the primary feedstock for methanol production, renewable methane sources such as biomethane (from anaerobic digestion of organic resources like agricultural waste, animal excrement, sewage sludge, and organic waste) and biogas can also be used.
[9] In IVC8c, biomethanol is produced through the methanol synthesis of a flow of biogenic CO2 coupled with a flow of H2.

IVC #	Industrial Value Chain	IVC level			Collective plan		
		Support to farmers (€/t feedstock)	Support to farmers (€/MWh fuel)	Operational support to the industrial unit (€/MWh fuel)	Support for securing the mobilization of the upstream part (mln.€/yr)	Support for industrial units development (mln.€/yr)	Total support for the operation of the entire IVC (mln.€/yr)
IVC11a	**Gasification and F-T synthesis**	11 – 18	11.9 – 19.5	74	207 - 338	1,282	1,489
IVC13a	**Pyrolysis and co-processing for road sector**	11 – 18	11.4 – 18.7	14	203 - 333	249	452 - 582
IVC13b	**Pyrolysis and upgrading for road and maritime sector**	11 – 18	3.4 – 5.6	88 – 117	61 - 99	1,566 – 2,082	1,626 – 2,181
TOTAL		-	-	-	**1,704 – 2,805**	**11,586 – 17,852**[10]	**13,290 – 20,526**[11]

Table 4. Estimated financial support needed in 2040 for the essential IVCs of advanced biofuels

[10] Increased to 19,650 mln. EUR considering the higher LCOP value provided by the stakeholders in IVC5+IVC6 pathway.
[11] Increased to 22,324 mln. EUR considering the higher LCOP value provided by the stakeholders in IVC5+IVC6 pathway.

Concluding Remarks

A large increase in biofuels production capacities based on Annex IX feedstocks is required between now and 2030 – and/or a continuous update of the REDII Annex IX list, or a further revision of the RED framework, impacting on eligible feedstocks and sustainable agroforestry value chains for sustainable biofuel production to fulfil the targets of the RED. There is no single value chain that could provide 50% or more of the sustainable fuels; instead, a portfolio of solutions will be needed, complementary to the other decarbonization routes for transport (as electrification, hydrogen, ammonia, etc.). Only a variety of technologies will allow drawing on the full range of feedstocks currently eligible and producing the full spectrum of transport fuels needed.

The results of the Business Model analyses for the essential IVCs indicate that financial support will be required to close the gap between the biofuels' Levelized Cost of Production (LCoP) and the market price of their fossil fuel counterparts, even when considering the impact of EU Allowances' additional costs.

Renewable hydrogen can become an enabler for several benefits, such as higher process yields (e.g., in gasification) and additional emission reductions (e.g., when substituting grey hydrogen in a biorefinery). However, its **production cost remains a major hindrance** – and potentially a showstopper.

The current **R&I funding opportunities**, both at EU and national levels, are considered appropriate to support the development needs of advanced biofuels and should continue to enable the deployment of the future essential IVCs by providing the necessary preconditions for their timely scale-up.

The **required level of financial support** is expected to vary between different essential IVCs. As an example, IVC2 (Hydrotreatment of Lipids) is expected to have a relatively lower financial support requirement compared with other IVCs. Nevertheless, this strongly depends on feedstock eligibility and price evolution, which in turn depend on EU policies.

Two main financing supports are considered as necessary: (a) **financing support to industrial units,** which accounts for **3,849 – 7,499 mil €/yr for 2030** that is proportional to produced quantities of biofuels in the form of FiP and influences significantly the final price to consumers and (b) **financing support to mobilize farmers,** which accounts for **700 – 1,245 mil €/yr** that is proportional to produced feedstock quantities in the form of FiP or production subsidy in €/tn and is absorbed at the stage of agricultural production not influencing the final price.

The estimation of the respective **financing support figures for 2040**, when new technologies will be mature and penetrate in the market, is **11,586 – 17,852 mil €/yr for industrial units** and **1,704 – 2,805 mil €/yr for farmers' mobilization**.

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Biofuels have a vital role to play in reducing emissions in transport if an EU coordinated approach for capacity development of essential industrial value chains of advanced biofuels, needed to achieve the EU targets for 2030,2040, and 2050, is employed. Two main categories of financing support are identified as necessary: (a) for industrial production development, linked to the volumes of biofuels produced and (b) for feedstock supply mobilization, linked to feedstock supply volumes. For 2030, the corresponding financing needs are estimated at €3,849 – 7,499 million per year for industrial installations and €700 – 1,245 million per year for farmers/collectors.

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