WORKING PAPER

Reducing the cost gap for sustainable aviation fuel through policy intervention: A case study of the Netherlands

Gonca Seber, Chelsea Baldino, Nikita Pavlenko

SUMMARY

This working paper examines the role of policy interventions in closing the cost gap between sustainable aviation fuel (SAF) and conventional fossil kerosene through a case study of the Netherlands. Advanced SAF production pathways—including e-kerosene and advanced biofuels made from feedstocks listed in Annex IX, Part A of the Renewable Energy Directive—currently face significant economic barriers, with production costs substantially exceeding those of conventional jet fuel. Our study examines how various European policy instruments and financial support mechanisms could bridge this cost gap, helping accelerate advanced SAF market deployment to meet targets in the ReFuelEU regulation.

We find that capital support covering 40% of the installed equipment cost for a facility with a capacity of 50,000 tonnes of SAF per year, paired with policies currently in place in the Netherlands and the European Union (EU), can reduce the cost gap between e-kerosene and fossil kerosene by 56%. For Fischer-Tropsch fuels from agricultural residues, 40% of capital support for a facility with the same capacity, paired with other policies, can reduce the cost gap by 87%.

National governments could take advantage of relaxed state aid rules and provide additional targeted support, particularly for capital expenses. Member State aid schemes could cover up to 45% of investment costs in e-kerosene projects, with additional bonuses for small- and medium-sized projects. When competitive bidding is used, support of up to 100% of the investment cost can be received. In addition, Member State implementation of the Renewable Energy Directive, such as the Netherland's emission reduction units, can generate credit value for co-products of

www.theicct.org

communications@theicct.org

@theicct.org

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advanced SAF pathways supplied to road or marine sectors. Reducing or removing grid fees for high-voltage electricity used for e-fuel production, where relevant, could also be effective in reducing operational costs.

Although we do not address the impact of revenue certainty mechanisms included in the Sustainable Transport Investment Plan (STIP), the results of our assessment could help determine how much support from a revenue certainty mechanism may be necessary under the STIP.

At present, Hydrogen Bank auction prices are not high enough to provide significant support for e-kerosene, and receipt of Hydrogen Bank support limits a producer's ability to use certain funds, such as Innovation Fund grant financing or state aid. However, the STIP specifies that SAF-specific calls will be added to the Hydrogen Bank, indicating that auction prices may be higher in the future, which would provide more support to e-kerosene producers. We also find that the 20 million free allowances for aviation fuels in the EU Emissions Trading System (ETS) will likely be spent towards commercial hydroprocessed esters and fatty acids fuels by 2030. This mechanism would need to expand beyond 2030, with an increased allocation of reserved allowances, to benefit advanced fuels. Finally, we estimate that the EU ETS's auction revenues from aviation allowances would generate more than €2 billion annually from 2026. A portion of this revenue could be invested in a revenue certainty mechanism to help de-risk advanced SAF investments or be dedicated to capital cost support.

INTRODUCTION

A significant quantity of sustainable aviation fuel (SAF) will be needed to achieve carbon emission reductions in the aviation sector (Graver et al., 2022). This is because aviation will continue to depend on liquid fuels due to their high volumetric energy density and the substantial investment costs associated with overhauling existing engine technology and infrastructure.

Most SAFs available on the market today are hydroprocessed esters and fatty acids (HEFA) fuels produced from waste fats and oils, in addition to vegetable oils (Rosales Calderon et al., 2024). However, the availability of waste oil feedstocks is limited in the European Union (EU), and their import can pose a fraud risk (Kristiana et al., 2022; O'Malley & Baldino, 2024). Thus, advanced SAF pathways (e.g., e-kerosene and cellulosic SAF) will be needed to scale up SAF deployment.

The development of commercial SAF facilities requires significant upfront investment before any fuel production can commence (Pavlenko et al., 2019). Advanced SAF projects are considered high-risk investments due to the limited technological maturity of these pathways and the current absence of commercial-sized facilities. Overcoming economic barriers, such as attracting capital investment, mitigating off-take risk, and recouping costs, is considered vital to the market success of these fuels (Navarrete et al., 2025). Government policies such as incentives and tax benefits can help shape the fuel market and complement demand-side policies such as ReFuelEU mandates, which require aviation fuel suppliers to gradually raise the share of SAF blended into conventional jet fuel they provide at EU airports. The value of these incentives will inform the economic viability of advanced SAF projects.

This paper explores how national and EU SAF finance mechanisms can help fill the cost gap between advanced SAF and fossil kerosene in 2030. Using the Netherlands as a case study, we examine policy support under direct grants and other financial incentives (e.g., via the Innovation Fund, Hydrogen Bank, and national grants, considering the effect of state aid rules), as well as under market-based mechanisms (e.g., the EU

Emissions Trading System [ETS] and Dutch emission reduction units). We also describe potential policies that may indirectly support SAF deployment, such as the Energy Taxation Directive, although these are not included in our quantitative analysis.

The European Commission recently released the Sustainable Transport Investment Plan (STIP), a roadmap to financially support the production of aviation and marine fuels with low greenhouse gas (GHG) emissions (European Commission, 2025a). The STIP includes measures to provide capital support, some of which we assess in this study. The plan also mentions the importance of revenue certainty measures in supporting advanced SAF. In line with the STIP, the European Commission launched the eSAF Early Movers Coalition, bringing together interested Member States to establish a pilot revenue mechanism program, including a pooled double-sided auction with the goal of mobilizing at least €500 million in 2026 to finance a few large-scale e-kerosene projects. The European Commission will continue to assess the feasibility of an EU-wide revenue certainty mechanism and the best approach to set up an EU market intermediary that connects e-kerosene suppliers with consumers, including through long-term contracts to provide revenue certainty to fuel producers.

While revenue certainty measures will be important for bringing advanced SAF production online, we do not assess their role in reducing the per-liter cost of SAF. By providing estimates of the cost of advanced SAF under other policy options, however, our analysis can inform the design of such mechanisms by indicating the remaining cost gap to be bridged between SAF and fossil kerosene. This could help policymakers to optimize the policy mix to minimize the cost gap, which would decrease the required contribution of revenue certainty mechanisms. In return, revenue certainty mechanisms can increase the effectiveness of these incentives by making them more attractive and improving their value proposition for investors (Pavlenko et al., 2016).

ADVANCED SAF PRODUCTION IN THE EUROPEAN UNION AND THE NETHERLANDS

In this paper, advanced SAF pathways include advanced biofuels made from feedstocks listed in Annex IX, Part A of the Renewable Energy Directive (RED) and synthetic aviation fuels, also known as e-kerosene, power-to-liquid, or renewable fuels of non-biological origin (RFNBOs; Baldino et al., 2019).

Cellulosic wastes and residues listed in Annex IX, Part A are available as feedstocks at a greater scale within the EU than waste oils, whereas e-kerosene can theoretically be produced at larger capacities without feedstock availability constraints, while providing higher emissions reduction (O'Malley & Baldino, 2024; Prussi et al., 2020).

E-kerosene production projects are in the early stages of development. Announced projects within the EU are estimated to have a total capacity of around 2.8 million tonnes (Mt) of e-kerosene in 2030 (Transport & Environment, 2025), which can cover the minimum demand from the ReFuelEU subtarget that year. However, it is uncertain whether this capacity will be realized because, as of January 2026, no large-scale e-kerosene plant had reached a final investment decision in the EU (Idrissov, 2026).[1] Meanwhile, advanced biofuel technologies such as gasification and alcohol-to-jet (ATJ) have not yet reached commercial-scale production levels.[2]

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1   A large-scale e-kerosene plant is one with 25 kilotonnes or more of production capacity per year.

2   There is currently one first-of-a-kind commercial-size ATJ facility, located in the United States, that produces biofuels from sugarcane and corn (IEA Technology Collaboration Programme, n.d.; Marsh & Hudson, 2025), and one demo-scale gasification project that produces advanced SAF from lignocellulosic residues in the EU (IEA Technology Collaboration Programme, n.d.).

The ReFuelEU Aviation regulation supports SAF deployment by establishing interim blending targets, with a blend mandate of 6% for SAF in 2030 (Regulation [EU] 2023/2405). This includes a subtarget for synthetic aviation fuels, which have a minimum blending requirement of 0.7% in 2030 and a 1.2% blending average in 2030–2031, increasing to 35% in 2050. To qualify as SAF under ReFuelEU, biofuels must meet specific sustainability criteria and be produced from eligible feedstocks (Baldino, 2023). By setting binding targets, ReFuelEU is intended to create long-term demand that will help accelerate the deployment of SAF.

In 2020, the Dutch government set a national target of 14% SAF blending by 2030 and 100% SAF by 2050 (Ministerie van Infrastructuur en Waterstaat, 2020). Since then, the ReFuelEU mandate of 6% SAF blending for 2030 has been implemented, and Member States are preempted from setting higher binding mandates (SkyNRG, 2023). However, Member States can provide fiscal incentives and establish other supporting policies for more ambitious targets. A SAF roadmap recently developed by the Dutch government (Deloitte, 2025) includes measures to reach the EU blending obligation of 6% in 2030 and the Dutch goal of 14% in the Sustainable Aviation Agreement (Ministerie van Infrastructuur en Waterstaat, 2020). The roadmap also includes information on the barriers to SAF deployment. Thus, while the Netherlands is used as a case study in this analysis, it can also serve as an example for other Member States interested in scaling up advanced SAF.

According to data from the Centre of Competence for Climate, Environment and Noise Protection in Aviation (2025), the number of synthetic fuels projects announced for the Netherlands in 2030 would amount to a total capacity of 195,000 tonnes. If this projected production level for synthetic fuels were realized, the Netherlands would be positioned to meet the EU's synthetic SAF submandate requirements. At the same time, fuel production capacity in 2030 for ATJ fuels is projected to be 30,000 tonnes.

POLICY OPTIONS FOR SUPPORTING ADVANCED SAF

Table 1 summarizes some of the available policy options that could support advanced SAF deployment, along with available EU-wide funding schemes and market-based mechanisms, including those specific to the Netherlands. Policy options targeting renewable hydrogen production, which are described in more detail below, are also included, since e-kerosene is produced from electrolysis hydrogen. We note that given the announcement of the STIP in November 2025, it is possible that the European Commission and Member States may add further financial support options for SAF.[3]

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3   We do not describe the pilot double-sided auction announced in the STIP, given its nascency at the time of writing and this study's focus on financial support options besides revenue certainty mechanisms.

Table 1

Policy options that could support advanced SAF deployment

Policy instruments	Scope	Details
ReFuelEU (Regulation [EU] 2023/2405)	Sets a blending mandate of 6% for SAF in 2030, including a submandate for an average blending share of 1.2% of synthetic aviation fuels from 2030–2031, with a 0.7% minimum annual share of synthetic aviation fuels. Non-compliance penalties will be determined by each Member State but should not be less than 2 times the price gap between SAF and fossil kerosene multiplied by the total yearly non-blended SAF quantity.	SAF produced from feedstocks in Annex IX in the RED are acceptable. The contribution of non-Annex IX feedstocks is capped at 3%. Fuels from food and feed crops do not qualify. Synthetic aviation fuels include drop-in RFNBOs.
Net-Zero Industry Act (Commission Regulation [EU] 2024/1735)	Provides administrative and regulatory support to accelerate the development of clean technologies in the EU. The act provides streamlined permitting processes by setting maximum timeframes for permit granting. It sets a simplified regulatory framework through strategic project designation, which unlocks preferential treatment in permitting and funding for certain net-zero technologies.	Hydrogen technologies, including electrolyzers and fuel cells, are covered.
InvestEU (European Union, n.d.)	A financing program designed to support access to capital for businesses by providing an EU budget guarantee via the European Investment Bank. This guarantee covers part of the losses of riskier investments in projects that contribute to EU policy goals.	InvestEU could provide an additional co-financing opportunity for projects eligible under the Innovation Fund.
Dutch aviation policy memorandum (Ministerie van Infrastructuur en Waterstaat, 2020)	By 2030, carbon emissions from aviation must be equal to 2005 levels. By 2050, they must be halved compared with 2005 levels. By 2070, emissions must be reduced to zero.	Aspirational goal of 14% SAF blending by 2030 and 100% by 2050.
Clean Industrial Deal State Aid Framework (European Commission, 2025b)	The framework sets out how Member States can design aid measures to support their objectives related to the Clean Industrial Deal. RFNBOs are eligible for financial support by Member States under subsection 4.1: *Aid Schemes to Accelerate the Rollout of Renewable Energy*.	Investment aid can provide up to 45% of eligible costs per project when the aid is set administratively (with a 10% bonus for medium-sized projects and a 20% bonus for small-sized projects). If aid is granted via competitive bidding, 100% of the total costs will be awarded. Under direct price support schemes, contracts for difference and feed-in premiums can be used. The aid limit is 100% of the total eligible costs.
Financial support mechanisms	**Scope**	**Details**
Innovation Fund: Regular grant (European Commission, n.d.-a)	530 million ETS allowances (around €40 billion) are available for funding from 2020 to 2030 to support highly innovative projects that could bring emissions reductions.	The grant could cover up to 60% of capital and operational costs, excluding revenues, over the first 10 years of operation. Projects can receive up to 40% of their total funding before full project implementation upon reaching predefined milestones.
Innovation Fund: Hydrogen Bank auctions (European Commission, 2023a)	Awards a fixed subsidy per kilogram of hydrogen produced, through bidding.	Awarded up to 10 years upon verification and certification as RFNBO. Cannot be cumulated with state aid.
Emissions Trading System: Aviation auction revenues (Directive (EU) 2003/87/EC)	The EU's ETS regulates greenhouse gas emissions through an emissions cap that declines each year. Airlines are required to buy allowances at auction for emissions in excess of the allowed emissions, or they can use SAF to reduce their emissions. The percentage of free allowances for aviation decline by 50% in 2025 before fully phasing out in 2026. The revenue from auction sales could be used to support SAF production.	A linear reduction factor establishes the annual rate at which the total number of emission allowances decrease. This is set to be 4.3% between 2024 and 2027 and 4.4% from 2028.
Emissions Trading System: 20 million free allowances (DG CLIMA B.4 & European Commission, 2023)	The reinvestment clause within the ETS sets aside 20 million allowances for aircraft operators to offset the higher cost of SAF use. A formula to calculate the cost gap is provided in a delegated act.	Aircraft operators will receive varying support for the cost differential between SAF and fossil fuels: 95% for RFNBOs, 70% for advanced biofuels defined under Annex IX, Part A in the RED, and 50% for all other SAF covered under the ReFuelEU mandate, with calculations based on fossil jet fuel costs including applicable taxes.
Energy Taxation Directive (European Commission, 2021a)	Establishes minimum taxation levels for energy products and electricity. Aviation fuel is currently exempt from taxation but, as of February 2026, a revision to this directive is undergoing trilogue discussions.	According to the amended European Commission proposal, fossil aviation fuels used for intra-EU air transport would be taxed according to their energy content under this scheme, reaching the full tax rate over a transitional period of 10 years. SAF (including sustainable biofuels and biogas, low-carbon fuels, advanced sustainable biofuels and biogas, and RFNBOs) would have a minimum rate of zero for 10 years.
Dutch national emission reduction units (Dutch Emissions Authority, n.d.)	Emissions reduction units (Emissiereductie-eenheden [EREs]) were established for the Netherlands' national implementation of the RED. Starting from January 1, 2026, the Netherlands switched from compliance based on renewable energy share supplied to transport to greenhouse gas savings. Fuel suppliers are required to meet specific emissions reduction targets in the transportation sector.	Each ERE represents 1 kg of CO_2-equivalent (CO_2e) emission reduction compared with the fossil fuel reference (94 g CO_2e/MJ). Fuel suppliers can generate, buy, or sell these units to meet emission reduction obligations. The new system introduces a subgoal for RFNBOs. Aviation is no longer included in this new system and fuels supplied to aviation cannot produce EREs.

SUPPORT THROUGH DIRECT GRANTS AND SUBSIDIES

Governments and institutions can de-risk the substantial capital investments required for advanced SAF facilities by providing targeted subsidies, tax incentives, and low-interest financing options (Navarrete et al., 2025). This assistance can help bridge the price gap and encourage additional private sector investment. Here, we explain some options available to advanced SAF producers.

THE INNOVATION FUND AND THE HYDROGEN BANK AUCTION

The Innovation Fund is financed by the monetization of EU ETS allowances, which is described in more detail below. From 2020 to 2030, 530 million ETS allowances, equal to around €40 billion, are available to support highly innovative projects that could reduce carbon emissions (European Commission, n.d.-a). The grants can cover up to 60% of capital and operational costs, excluding revenues, over the first 10 years of operation. For regular grants, projects can receive up to 40% of their total financing upon reaching pre-defined milestones before full project implementation. Since 2020, only a few e-kerosene projects have received Innovation Fund grants, with amounts ranging between €40 million and €167 million (Transport & Environment, 2025). The recent STIP announcement noted that €153 million was awarded in November 2025 to four e-kerosene projects (European Commission, 2025a). Innovation Fund grants can be combined with Member State aid, but the amount of financial support a project is permitted to receive from a Member State is limited by the cumulative maximum amounts set in state aid rules. If the state aid covers the same eligible costs as the Innovation Fund grant, the total amount of funding cannot exceed the most favorable funding rate in the applicable rules. State aid rules are discussed in more detail in the following section.

The Innovation Fund also supports hydrogen projects categorized as RFNBOs through competitive bidding via the European Hydrogen Bank. The Hydrogen Bank organizes auctions and awards a fixed subsidy per kilogram of hydrogen produced for up to 10 years upon verification and certification as an RFNBO project (European Commission, 2023a). After signing the grant agreement, the selected projects must start producing renewable hydrogen within 5 years. Hydrogen Bank auction grants cannot be cumulated with state aid.

The pilot auction took place in the first quarter of 2024, with €720 million in funds awarded, and was followed by a second auction that opened in December 2024. The second auction, which had a higher budget of €1.2 billion, resulted in slightly higher bidding ranges (between €0.2/kg and €0.6/kg of hydrogen) than the first auction (European Commission, n.d.-b). Of the €1.2 billion, €200 million was dedicated to marine fuels and supported three projects with bid prices ranging between €0.45/kg and €1.88/kg of hydrogen. As announced within the STIP, the third Hydrogen Bank auction opened in December 2025 with a dedicated budget of €300 million for hydrogen off-takers in the maritime and aviation sectors (European Commission, 2025a).

NATIONAL GRANTS AND SUBSIDIES AND THE EFFECT OF STATE AID RULES

Although Member State governments may be eager to provide support for SAF projects, these activities must be in line with the state aid rules of the European Commission (n.d.-c). These rules, which regulate how Member States can provide financial assistance to companies or specific sectors, are intended to prevent distorted competition that would affect trade between Member States. Financial aid in the form of direct grants, tax advantages, and other mechanisms generally needs to be approved by the European Commission (European Commission, 2008).

The General Block Exemption Regulation (Commission Regulation [EU] 651/2014) identifies specific categories of state aid that could be exempt from the notification obligation if the aid amount does not exceed €30 million per undertaking. A limitation of the regulation is that thresholds are relatively low, and aid intensity is capped. A revised version of the regulation was released in March 2023 and will apply until the end of 2026 (Commission Regulation (EU) 2023/1315).

The Important Projects of Common European Interest (IPCEI) provisions (European Commission, 2021b) and Climate, Energy and Environmental Aid Guidelines (European Commission, 2022) could also provide opportunities for funding biofuels. RFNBOs could be eligible for state aid under Section 4.1.2.1 of the guidelines (*Aid for the Promotion of Renewable Energy*), and this framework could support RFNBOs if hydrogen projects are designated as an IPCEI, for instance. As part of the STIP, the Joint European Forum for IPCEI will consider a potential IPCEI designation for SAF in 2026 (European Commission, 2025a).

The European Commission introduced the Green Deal Industrial Plan in 2023 to strengthen Europe's clean technology manufacturing capabilities (European Commission, 2023b). Central to this initiative was the loosening of EU state aid regulations to help accelerate the rollout of renewable energy (von der Leyen, 2024).

A revision to the state aid rules, the Clean Industrial Deal State Aid Framework (CISAF), was finalized in June 2025 (European Commission, 2025b). Built on experience from the Temporary Crisis and Transition Framework (European Commission, 2024), the rules are designed to fast-track the rollout of renewable energy and low-carbon fuels in the EU via simplified procedures for financial support, to avoid relocation of renewable energy projects overseas due to alternate funding opportunities.

Under the CISAF, aid by Member States for RFNBO projects is supported, along with aid for biofuels and biogas projects. There are multiple aid schemes, but production of RFNBOs could be supported via Section 4.1 (*Aid Schemes to Accelerate the Rollout of Renewable Energy*). Aid may be granted via a competitive bidding process (up to 100% of eligible costs) or administratively (up to 45% of the eligible costs, with bonuses for small- and medium-sized projects).[4] Direct price support schemes could also be used to cover the eligible costs of investments, whereby Member States may use instruments such as contracts for difference and feed-in premiums.[5]

Aid under the CISAF can be combined with other state aid or EU funds (e.g., the Innovation Fund) when those measures concern different identifiable eligible costs. If the aid would be used in relation to the same eligible costs, the funds can still be combined; however, such cumulation must not result in the aid exceeding the highest support intensity or amount applicable under any of the relevant conditions.

The Dutch government has several programs to support renewable fuels, such as the Demonstration Energy and Climate Innovation scheme allocated by the Netherlands Enterprise Agency (RVO; RVO, n.d.). E-kerosene can be supported under this scheme because it incorporates electrolysis hydrogen production. As many projects with substantial support needs apply, and the funding is limited, the budget is quickly exhausted. To prevent this, in late 2024, the RVO announced that it was considering including specific funding for advanced fuel pathways such as power-to-liquids and ATJ under this scheme (Ministerie van Infrastructuur en Waterstaat, Ministerie van Klimaat

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4   Aid intensities can be increased by 20 and 10 percentage points for small- and medium-sized enterprises, respectively.

5   Direct price support schemes provide beneficiaries a fixed or variable monetary payment that depends directly on the quantity of energy produced and/or stored, which can be set based on the actual or reference output. Aid must be granted through a competitive bidding process.

en Groene Groei, n.d.). Applicants could receive €25 million for pilot projects and €30 million for demonstration projects. At the time of writing, no project announcements had been made. There are also multiple tax reduction programs in the Netherlands designed to encourage investments in environmentally friendly technologies from the country's environmental list (RVO, 2025a, 2025b). However, currently, these do not apply to SAF.

SUPPORT THROUGH MARKET-BASED MEASURES

EU EMISSIONS TRADING SYSTEM

The ETS is a market-based measure that requires companies in regulated industries to buy or trade allowances for their GHG emissions to comply with a declining emissions cap (Directive [EU] 2003/87/EC). The ETS penalty for using fossil kerosene is calculated by multiplying the emissions factor from fossil kerosene and the price of ETS emissions allowances (i.e., the carbon price). The ETS carbon price depends on the supply of allowances, the level of the emissions cap, and the wholesale price of fossil fuels. A portion of the revenues from the ETS is used to fund renewable energy projects, such as SAF production, through the Innovation Fund (European Commission, n.d.-a). In addition, the reinvestment clause within the revised ETS sets aside a pool of 20 million allowances for aircraft operators to offset the higher cost of SAF production (O'Malley, 2024).

ETS auction revenues

The ETS regulates GHG emissions through an emissions cap for intra-EU flights that is reduced each year. The total number of emission allowances decreases by a linear reduction factor of 4.3% annually between 2024 and 2027 and 4.4% from 2028. In the past, airlines in Europe received about 85% of their ETS aviation allowances (EUAA) for free, amounting to 21.5 Mt CO_2e in 2023 (European Environment Agency, 2025). However, under the revised ETS, the free allowances decreased in 2024 and will be phased out in 2026 (Directive [EU] 2023/958), meaning airlines will have to buy allowances for emissions from intra-EU flights at auction.

To estimate the amount of revenue from the auctioned EUAA for the Netherlands and the EU up to 2030, we used the allocated aviation allowances from 2023 (European Environment Agency, 2025) and adjusted the number of allowances using the ETS linear reduction factor (Table A1). The percentage of free allowances was estimated to be 64% for 2024 and 43% for 2025, in line with the revised ETS; starting from 2026, all allowances will have to be auctioned. Then, we assigned a carbon price to each year between 2025 and 2030, assuming a linear increase. The ETS carbon price in 2024 averaged around €65/t, and we assumed a 2030 carbon price of €146/t based on projections from BloombergNEF (2024).

Using the assumed ETS prices and the number of auctioned allowances, we estimated the cumulative ETS auction revenue that would be generated from the EUAA under the aviation cap between 2025 and 2030 to be around €723 million for the Netherlands (Table 2). The estimated EU-wide revenue starting in 2026 is more than €2 billion each year, with a cumulative revenue of €13.8 billion between 2025 and 2030.

Table 2
Estimated auction revenues from the ETS aviation allowances for the Netherlands and the EU

Estimated auction revenues from EUAA	2025	2026	2027	2028	2029	2030	Cumulative
	(million €)						(billion €)
Netherlands	57	113	124	134	143	151	0.72
EU	1,095	2,159	2,372	2,564	2,732	2,880	13.8

Note: See Table A1 in the appendix for more details.

At present, it is unclear what these funds are used for in the Netherlands. Some part of this auction revenue would be set aside for the ETS reinvestment mechanism, which is described in the following section. Given these factors, we did not include the EUAA auction revenues as a funding resource for our analysis of the cost gap, but it could represent a significant source of funding for advanced SAF.

ETS reinvestment mechanism

The reinvestment clause in the ETS sets aside a pool of 20 million allowances for aircraft operators to offset the higher cost of SAF use (Directive [EU] 2023/958). These allowances are available to claim from 2024 until 2030 and must be drawn from the pool of allowances allocated for aviation (i.e., EUAA). The Commission will consider extending this funding mechanism as part of its upcoming review in 2026 (European Commission, 2025a).

Aircraft operators receive varying support for the cost differential between SAF and fossil fuels: 95% for RFNBOs like e-kerosene and renewable hydrogen, 70% for advanced biofuels defined under Annex IX, Part A in the RED, and 50% for all other SAF covered under the ReFuelEU mandate (e.g., biofuels from feedstocks under Annex IX, Part B in the RED). The level of support increases to 100% for all types of SAF when the fuel is uplifted at an airport in small islands, small airports, and outermost regions. The methodology for calculating the price differential for these SAF types was recently adopted by the European Commission, along with price information on SAF (Commission Delegated Regulation [EU] 2025/723).

We explored whether these allowances, worth €2 billion with an average ETS price of €100/t CO_2e, could help close the price gap for advanced fuels by 2030. An average ETS price was used instead of annual predictions because it is unknown when the fuel would be used or when the allowances would be requested. First, we estimated the fossil kerosene demand between 2025 and 2030 within the EU using the baseline scenario from the ICCT's *Vision 2050* report (Graver et al., 2022). That scenario assumes a 2.1% passenger traffic growth rate and a 0.8% annual technical efficiency improvement. We find that the amount of SAF that the aircraft operators would be required to blend to be ReFuelEU-compliant is around 15.3 billion liters (11.6 Mt) cumulatively between 2025 and 2030 (see Table A2). A minimum of 0.46 billion liters (0.35 Mt) must come from synthetic fuels in 2030, corresponding to 0.7% of the demand by volume as mandated in the ReFuelEU regulation. We assumed that the rest of the demand (around 14.8 billion liters or 11.2 Mt of SAF) would be fully supplied by commercially available HEFA fuels and, as a result, expect them to use all or most of the 20 million allowances.

To estimate the cost gap, we used the following formula from the delegated act that established rules on price difference calculations by the Commission (Commission Delegated Regulation [EU] 2025/723):

Price gap = [price of SAF – (price of fossil kerosene + ETS price)] × % coverage × SAF supply

We used an average market price of fossil kerosene of €734/t (€0.6/L), based on a recent report on the state of the EU SAF market by the European Union Aviation Safety Agency (EASA, 2025). Fossil kerosene would have an ETS price of €0.25/L assuming an average price of €100/t CO_2e.[6] We used a production cost estimate from EASA of €1.11/L as the price of HEFA fuels from waste oils (EASA, 2025).[7] For this type of fuel, 50% of the price gap would be covered, as previously explained.[8]

Under these assumptions, our analysis indicates that roughly €1.9 billion in allowances will be required to bridge the cumulative price gap for HEFA fuels through 2030 (see Table A3). Considering the higher level of support (100% of price gap) for small islands, small airports, and outermost regions, the funds from the reinvestment mechanism are likely to run out by 2030, even if all the SAFs produced are HEFA fuels, which are cheaper than advanced SAF. Consequently, the investment mechanism will have little to no funds available for supporting fuels derived from advanced technologies. Sanford and Malins (2025) conclude similarly that these funds will be spent on HEFA fuels and predicted that the allowances would be exhausted by 2028. The reinvestment mechanism for supporting next-generation fuel technologies would need to be extended to support advanced SAF.

DUTCH EMISSION REDUCTION UNITS

A market-based mechanism called renewable energy units (*hernieuwbare brandstof eenheden* [HBEs]) was used to help reach renewable energy targets in the transport sector for the Netherlands' national implementation of the RED (Dutch Emissions Authority, n.d.). This system will transition into emissions reduction units (*emissiereductie-eenheden* [EREs]) from January 2026 pending approval of the Dutch Senate (Dutch Emissions Authority, n.d.). This aligns with the most recent version of the RED, whereby Member States may demonstrate compliance with a GHG reduction target for transport (Baldino, 2023). Producers of renewable fuel or renewable energy generate EREs, and fuel suppliers can comply with their annual emission reduction obligations by blending renewable fuels into traditional fossil fuels or by purchasing ERE credits from other parties that have produced or imported renewable fuels. In the HBE system, aviation was included as opt-in, and fuels provided to the aviation sector were able to generate credits. Aviation is not included in the new ERE system, as ReFuelEU Aviation covers the aviation sector, and the RED should not create any additional obligations or compliance mechanisms (C. Sikow-Magny & F. Cornelis, personal communication, June 19, 2024).

Here, we assume ERE credits will be generated per kilogram of CO_2e emission reduction, and we estimate the amount of credits generated from RFNBOs based on a minimum 70% emission reduction for this type of fuel, as required by the RED. Although aviation is not included, an e-kerosene producer would still be able to generate credits for RFNBO fuels, such as e-diesel, that are produced as co-products and supplied to the marine or road sector.

The price of the EREs is unknown. However, the Dutch Emissions Authority has established an HBE-to-ERE ratio of 1:46, which could serve as a benchmark for the price of ERE credits (Dutch Emissions Authority, n.d.). The price of HBEs was 4–5 cents per kilowatt-hour (€11–€14 per gigajoule [GJ]) of renewable fuel in the first quarter of 2024 (ChargeUp Europe, 2024). We assume an ERE price of 30 cents per kg CO_2e reduced using the high-end HBE price of €14 and dividing by the conversion factor.

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6   Emissions are determined based on fuel consumed; 3.16 kg CO_2e is assumed to be released per kilogram of jet fuel combusted. This would result in 0.0025 t CO_2e/L jet fuel.

7   The market price of aviation biofuels in 2023 was €2,768/t (€2.10/L), whereas in 2024 it was €2,085/t (€1.58/L; EASA, 2025). Because we look for an average representative price between 2024 and 2030 to calculate the price gap, we used the production cost estimation from the same report for 2024 at €1,461/t (€1.11/L) to reflect the probable price decrease between 2024 and 2030.

8   Price gap = [1.11-(0.6+0.25)]*0.5*(14.8*10^6).

ENERGY TAXATION DIRECTIVE

In 2021, the European Commission proposed a revision of the Energy Taxation Directive, but this proposal had not been approved at the time of writing (European Commission, 2021a). The proposed revisions would restructure tax rates based on energy content and environmental performance, transitioning from a volume-based to an energy-based system. Notably, the proposed amendment includes a phase out of tax exemptions for fossil kerosene used on domestic and intra-EU flights. Currently, jet fuel is largely untaxed due to international agreements, but the proposal seeks to gradually introduce a tax to encourage decarbonization of the air transport sector. The proposed minimum tax rate for low-emitting energy sources like electricity and advanced SAF is €0.15/GJ, while it is a minimum of €10.75/GJ for higher-emitting fuels, including fossil fuels and non-sustainable biofuels (e.g., those derived from vegetable oils). The proposed tax rate for SAF is between €0.15/GJ and €5.38/GJ following a 10-year transition period (European Commission, 2021a).

If the amendment is approved, the revenue from taxing jet kerosene would be available to Member States, including the Netherlands, to close the gap between SAF production costs and jet kerosene.

COST OF PRODUCING E-KEROSENE AND ADVANCED BIOFUELS IN THE NETHERLANDS

This section presents details of the techno-economic assessment (TEA) we used to estimate the cost of e-kerosene and Fischer-Tropsch (FT) fuels from agricultural residues, along with a sensitivity analysis for e-kerosene.[9] In this work, we employed a publicly available FT-synthesis TEA model (Brandt et al., 2021) and adapted it to conditions in the Netherlands by changing economic parameters and processes. The model calculates the minimum selling price (MSP) needed for an investment in advanced SAF to achieve a specified rate of return. A more detailed description of this model is included in the appendix.

Both of the advanced fuels we assessed rely on the FT reaction for fuel synthesis, but they use different feedstocks. The e-kerosene pathway starts with renewable hydrogen from water electrolysis using renewable electricity and combines it with captured CO_2 to create syngas. Gasification-FT begins by thermally converting agricultural residues directly into syngas. In both cases, syngas must be cleaned and conditioned before entering the FT process. The product slate for fuel synthesis is assumed to maximize jet fuel production with an energy distribution of 40% jet fuel, 40% diesel, and 10% each of naphtha and propane (Zhou et al., 2022). An annual production capacity of around 50,000 tonnes of advanced SAF is assumed for both cases.

E-KEROSENE

We modified the TEA model to include processes related to renewable hydrogen production from electrolysis and determine the MSP of e-kerosene. Key economic parameters for the Netherlands, listed in Table A4, were extracted from a recent report from the Netherlands Organisation for Applied Scientific Research (TNO) evaluating the levelized cost of renewable hydrogen in 2024 based on proposed electrolyzer projects in the Netherlands (Eblé & Weeda, 2024). Inputs regarding the renewable hydrogen production were adapted from Soler et al. (2022). The average costs of the electrolyzer system, renewable electricity, and grid fees in the Netherlands were taken from the TNO study and are listed in Table A5, along with other operational costs.

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9   Numerous TEAs have been conducted on advanced biofuels and synthetic SAF using methods adapted from the power and chemical industries (Pavlenko et al., 2019; Soler et al., 2022; Zhou et al., 2022).

We assumed a proton exchange membrane electrolyzer with 68% efficiency, in line with Soler et al. (2022), with a 400 MW capacity producing 50,000 tonnes of e-kerosene per year, assuming grid connection with a 90% capacity factor and an electrolyzer price of €1,525/kW adopted from the TNO study (see Table A5). Electrolyzer costs in the EU have increased in recent years and are currently in the range of €2,000–€2,500/kW (Project SkyPower, 2024). To capture the effect of electrolyzer cost fluctuations (Parkes, 2024) on the e-kerosene MSP, we included a sensitivity analysis, varying the electrolyzer cost accordingly.

A power purchase agreement supplying offshore wind electricity at a fixed cost of €75/MWh was assumed for the renewable electricity, in line with the TNO report. In the Netherlands, a grid tariff for extra-high voltage is applied to large-scale electrolyzers. These grid fees have increased significantly over the years and are expected to continue to rise (E-Bridge, 2024). We used a grid fee of €18/MWh, reflecting current fees from the TNO study. This brings the electricity cost to €93/MWh. Concentrated CO_2 supplied from a point source was assumed to cost €100/t CO_2 (International Energy Agency, 2019).

In our analysis, we did not assess the impact of complying with the EU's rules on additionality and temporal and geographic correlation, which may add around €1/kg to the price of hydrogen (Ricks et al., 2023). However, even without including this cost factor, our analysis can illustrate the impact of different policy support options for closing the cost gap between fossil kerosene and e-kerosene.

ADVANCED BIOFUELS: FT FUELS FROM AGRICULTURAL RESIDUES

As a second advanced fuel pathway, we assessed the MSP for FT fuels from agricultural residues, such as cereal straw. We used the TEA model described above to determine the MSP for this fuel. Key economic parameters for the Netherlands are extracted from the same TNO report described above and are listed in Table A4 (Eblé & Weeda, 2024). Price assumptions for operational costs are listed in Table A7. The price of agricultural residues was estimated to be €76.8/t.[10] A more detailed description of this model is included in the appendix section.
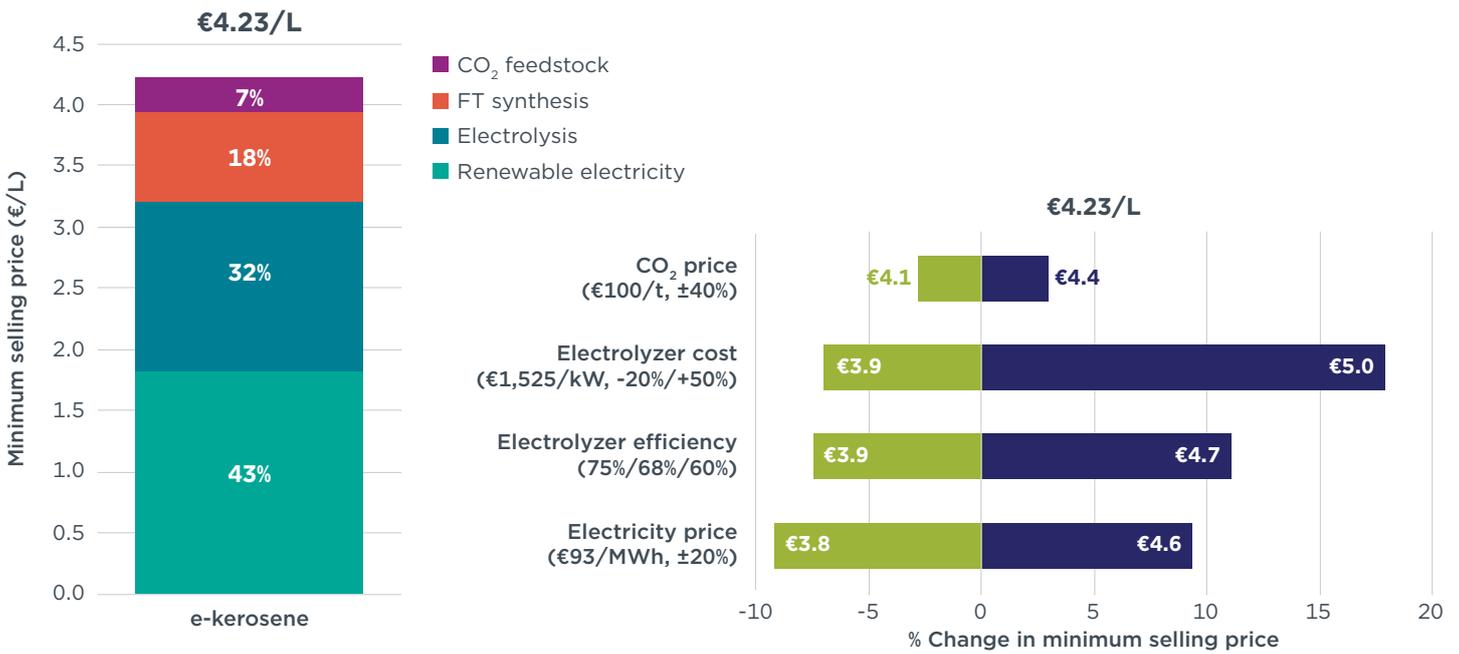
RESULTS

MINIMUM SELLING PRICE OF E-KEROSENE AND AGRICULTURAL RESIDUES-FT FUELS

We estimated the MSP of e-kerosene in the Netherlands to be €4.23/L (€5,588/t). Figure 1 illustrates the contribution of cost components to the overall MSP, and Table A6 lists the overall capital expenses (CapEx) associated with the facility, with a total fixed capital investment of around €1.6 billion. We find that renewable electricity, along with grid fees, is the largest contributor to our estimated MSP, making up 43%. This finding is in line with other recent studies (Project SkyPower, 2024; Soler et al., 2022). Electrolysis (cost of electrolyzer) and FT synthesis (cost of FT equipment and related utilities) comprise 32% and 18% of the MSP, respectively, while CO_2 feedstock contributes 7%.

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10 A price of €3.7/GJ in 2010 euros was used for primary agricultural residues in the Netherlands from the JRC-EU Times Model for 2030 (Ruiz Castello et al., 2015). A lower heating value of 14.6 MJ/kg was used for straw from cereals from the same publication. The resulting price was adjusted to 2024 euros using the consumer price index (Trading Economics, n.d.).

Figure 1

**Minimum selling price for e-kerosene in the Netherlands with sensitivities to various parameters**

We assessed the sensitivity of our results to various parameters, focusing on variables related to electrolysis for hydrogen production because renewable electricity and the electrolyzer comprise a large part of the fuel production costs. Increasing the cost of the electrolyzer by 50% brings the electrolyzer cost to €2,288/kW and increases the MSP by 17.9% to €5.0/L. We find that decreasing the electrolyzer efficiency to 60% would increase the MSP of e-kerosene by 11.1% to €4.7/L, while increasing the efficiency to 75% decreases the MSP by 7.4% to €3.9/L. Varying the price of renewable electricity by 20% changes the MSP by around 9%. Finally, varying the CO_2 price by 40% changes the MSP by about 3%. In a case where direct air capture is used for CO_2 supply at €400/t CO_2, the price increase is estimated to be 22% to an MSP of €5.2/L.

Figure 2 displays the MSP for FT fuels from agricultural residues, estimated at €2.12/L (€2,806/t), and the cost components of the overall price. Table A8 presents the CapEx associated with the facility with a total fixed capital investment of around €1 billion. Expenses from gasification and FT synthesis constitute 25.9% and 41.8% of the MSP, respectively. Feedstock costs make up around 21.6% of the MSP, and other operating costs make up 10.8% of the total. Changing the feedstock cost by ±20% changes the MSP by 4.2%.

Figure 2

Minimum selling price for FT fuels from agricultural residues in the Netherlands
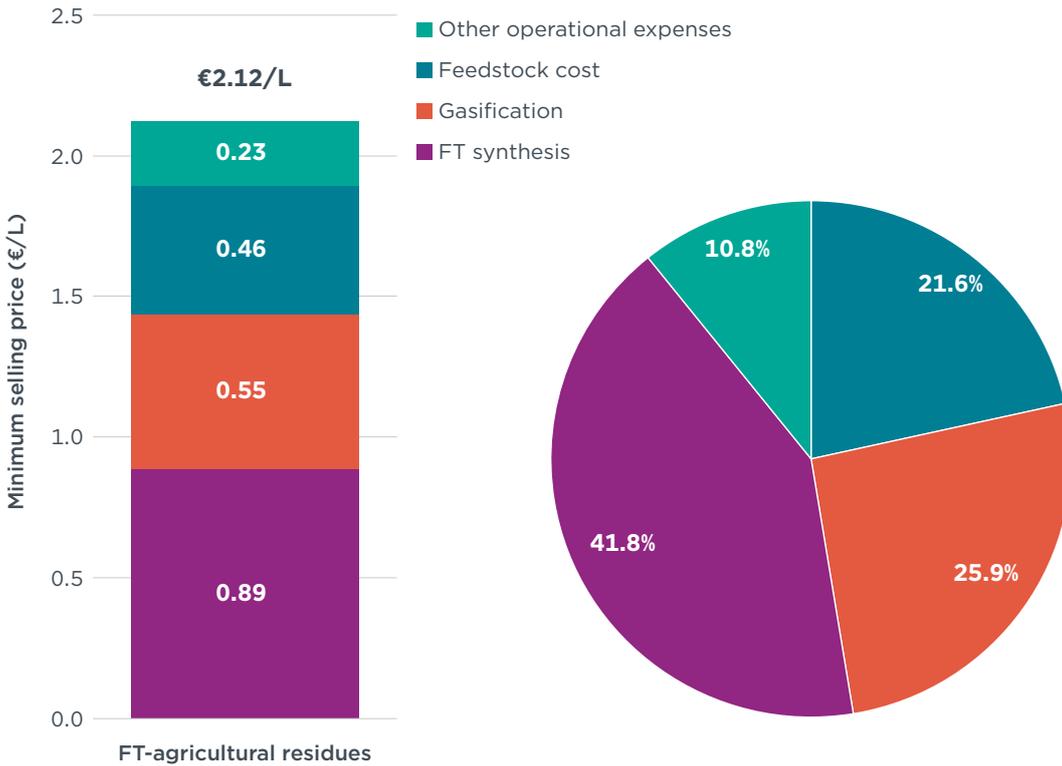
Note: Gasification includes the CapEx related to syngas production, while FT synthesis includes expenses from syngas cleaning and fuel synthesis through Fischer-Tropsch reaction, including hydroprocessing and separation. Other operational expenses do not include feedstock cost.

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POLICY LEVERS AND THEIR EFFECT ON THE COST OF SAF

Based on the policy overview and production cost estimates above, in this section we evaluate the impacts of the fiscal policies on the MSP of e-kerosene and FT fuels from agricultural residues under different scenarios.

SCENARIO ANALYSIS FOR E-KEROSENE

To explore the effect of different policy options on closing the cost gap between fossil kerosene and e-kerosene, we assessed two scenarios to demonstrate how the SAF support elements could pair (Table 3).

Table 3

Variation of parameters concerning different policy elements and scenarios

Assumption	Baseline[a]	Scenario 1	Scenario 2
Discount rate[b]	12%	9.4%	9.4%
Interest rate[b]	6%	4.8%	4.8%
Hydrogen Bank auction price (€/kg)[c]	N/A	N/A	0.68
Capital grant (million €)[d]	N/A	340	96
Electricity grid fee (€/MWh)[e]	18	0	18
EREs (€/kg CO_2e)[f]	N/A	0.34	0.34
EU ETS price (€/t CO_2)[g]	N/A	146	146

[a] Assumptions for the baseline minimum selling price calculation.
[b] We explored the sensitivity of the minimum selling price to decreasing discount rate (i.e., rate of return) and interest rate.
[c] We used the Hydrogen Bank bid value for a selected project in the Netherlands in 2025 (€0.6/kg hydrogen with a 560 MW capacity) and estimated the bid value for 2030, applying a 2% yearly inflation rate.
[d] A capital grant covering 40% of the equipment cost for the whole system (hydrogen production + fuel synthesis) was assumed for Scenario 1. For Scenario 2, 40% of the equipment cost for the fuel synthesis portion was assumed since the Hydrogen Bank auction value is utilized for hydrogen production.
[e] This is a grid tariff for extra-high voltage applied to large-scale electrolyzers by the transmission system operator of €144/kW-yr (€18/MWh; Eblé & Weeda, 2024).
[f] ERE credit price in 2030 was estimated to be €0.34/kg CO_2e, using the HBE-to-ERE conversion factor of 46 and the price of HBEs in 2030, calculated based on a yearly 2% inflation rate from 2024 prices at €13.9/GJ.
[g] We assumed a 2030 carbon price of €146/t based on projections from BloombergNEF (2024).

For Scenario 1, we considered the cost reductions from decreasing the cost of finance, the Innovation Fund, or a similar grant providing upfront support for capital expenses, electricity grid fee waivers, and EREs. For Scenario 2, we included the Hydrogen Bank auction in addition to the Scenario 1 options, excluding the grid fee waivers, which could be considered state aid in some cases and may not be compatible with the use of Hydrogen Bank subsidies (CLIMA C.2, 2024). Using the Hydrogen Bank auction would also result in a change in the amount of support from a capital grant when compared with Scenario 1, because Hydrogen Bank support is allowed to be paired if the two projects (i.e., hydrogen production and FT fuel synthesis) have distinct project boundaries and cost and revenue structures. For both scenarios, we considered that the avoided EU ETS allowances act as an incentive for emitters to use e-kerosene in lieu of fossil kerosene, reducing the cost gap between conventional fossil fuel and SAF.

As explained above, advanced SAF projects require higher amounts of upfront capital with lower certainty on revenues in the short term. Measures such as offtake agreements or loan guarantees can help secure capital and de-risk these projects. Consequently, the improved access to finance would reduce the investment costs through lower discount rates or lower interest rates for loans. To see the influence of reducing the cost of financing on the MSP, we decreased the discount rate (i.e., rate of return) to 9.4% and the interest rate to 4.8% in both scenarios, based on data for the Netherlands in Gautam et al. (2023). We assumed a very slight decrease in these rates consistent with financing conditions in the Netherlands.

In addition to the decrease in the cost of financing, Scenario 1 assumed a capital grant of around €340 million is received to cover 40% of the total equipment costs for hydrogen production and fuel synthesis. This is much higher than the average level of funding provided by the Innovation Fund grant. We assumed other means of capital support (e.g., national grants) could be paired with the Innovation Fund grant to show the impact of this amount of support on closing the cost gap. We also included a grid fee waiver in Scenario 1, as network charge reductions or exemptions apply for electrolyzers in some neighboring Member States, specifically Germany and France (E-Bridge, 2024).

Scenario 2 assumes the Hydrogen Bank auction grant and a capital grant are received simultaneously. The Hydrogen Bank auction grant could be received for hydrogen production for the first 10 years of the project. At the same time, a capital grant could support the costs of the fuel production element of the project. The auction price for the Hydrogen Bank is expected to drop as the technology improves. However, the hydrogen producer could still factor in the effect of inflation on the bid price. As a result, assuming a bid price for the Netherlands of €0.60/kg of hydrogen and 2% yearly inflation, we estimated that the producer would receive €0.68/kg of hydrogen produced in 2030.[11]

We assumed the Innovation Fund grant would cover 40% of the equipment cost for fuel synthesis for Scenario 2. Considering the fuel production costs of this facility, 40% would entail a grant amount of around €96 million.

Both scenarios assess the effect of EREs and the ETS price. E-kerosene cannot produce any EREs because the aviation sector is not included; however, e-diesel, which is also an RFNBO, supplied to the road or marine sector would receive EREs. Because the price of EREs is unknown, we used the HBE price from 2024 of €13.9/GJ and assumed 2% yearly inflation to calculate the price in 2030 as €15.6/GJ fuel. Then, using the ERE-to-HBE conversion factor of 46:1, we estimated the price of an ERE credit to be €0.34.

E-kerosene is zero-rated under the EU ETS, meaning it meets the defined sustainability and emissions savings criteria from Directive 2003/87/EC and no emission allowance is required for its combustion. Consequently, the avoided ETS allowances can be considered an incentive that would reduce the cost gap between conventional fossil fuel and SAF. Using an ETS price of €146/t CO_2 for 2030 (BloombergNEF, 2024), we estimated this incentive would be €0.37/L.[12] As the ETS price changes, the incentive amount will vary.

Figures 3 and 4 illustrate the stepwise decrease in the MSP for e-kerosene in relation to the applied policy options with waterfall charts.

The impact of Scenario 1 on the cost of e-kerosene is visualized in Figure 3. Starting from the initial MSP of producing e-kerosene of €4.23/L, lower discount and interest rates reduce the MSP by €0.21/L (a 5% decrease). A capital grant covering 40% of the total equipment cost (€340 million) could reduce the MSP by €0.76/L (18%). Waiving the electricity grid fee provides a further reduction of €0.38/L (9%). Next, the ERE is applied as a subsidy per amount of emissions reduction from diesel fuel delivered to the transport sector,[13] reducing the cost of e-kerosene by €0.32/L (7%). Finally, considering a penalty under the ETS for fossil kerosene of €0.37/L brings down the MSP of e-kerosene to €2.21/L.

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11 We assumed a conservative increase in the Hydrogen Bank auction price, whereas in other studies, higher prices were assumed (e.g., €1.1/kg in Project SkyPower [2024]).

12 Emissions are determined based on fuel consumed; 3.16 kg CO_2e is assumed to be released per kilogram of jet fuel combusted.

13 The number of EREs (expressed in kg CO_2e) is calculated from the GJ of booked fuel * (94 kg CO_2e/GJ fuel * 70%), in which 70% is the minimum emission reduction for this type of fuel as required by the RED.
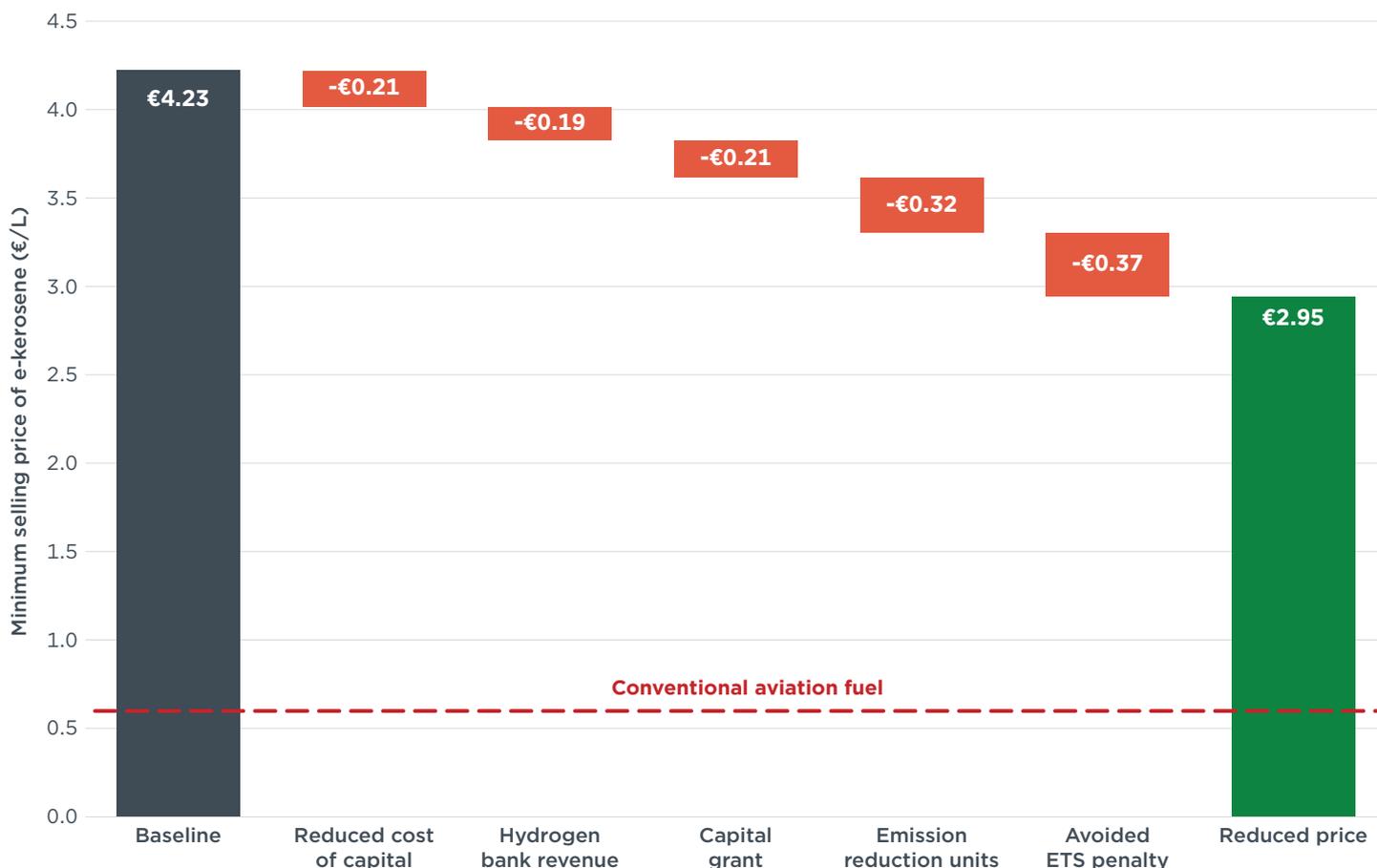
Figure 3
Effect of policy options on the minimum selling price of e-kerosene for Scenario 1

Note: The average conventional aviation fuel market price (€0.6/L) from EASA (2025) is used in comparison to the minimum selling price estimate of e-kerosene.

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Figure 4 illustrates the cost impact of Scenario 2, where we again start by reducing the cost of borrowing capital, resulting in a reduction of €0.21/L (a 5% decrease). Then, the Hydrogen Bank auction grant is applied according to the amount of hydrogen produced at €0.68/kg. The Hydrogen Bank auction grant decreases the MSP of e-kerosene by €0.19/L (4%) at this auction price. A capital grant to cover the CAPEX expenses of the FT fuel production decreases the MSP by €0.21/L (5%). This is lower than in Scenario 1 because the grant amount is smaller at €96 million (corresponding to 40% of the equipment cost for the FT fuel production portion). Next, the ERE is applied based on the amount of emissions reduction from e-diesel delivered to the transport sector. A reduction of €0.32/L (7%) is achieved. Finally, considering a penalty under the ETS for fossil kerosene of €0.37/L brings down the MSP of e-kerosene to €2.95/L.

Figure 4
Effect of policy options on the minimum selling price of e-kerosene for Scenario 2

Note: The average conventional aviation fuel market price (€0.6/L) from the EASA report (EASA, 2025) is used in comparison to the minimum selling price estimate of e-kerosene.

The results indicate that a large upfront capital grant of €340 million for Scenario 1 could be effective in decreasing the MSP by around 18%, reflecting the fact that CapEx is the largest contributor to cost. A market-based instrument, such as EREs, could also be effective in reducing the MSP of e-kerosene, yielding a 7% decrease in both scenarios. However, because aviation is no longer included in the ERE system, this effect is limited by the volume of co-products produced during SAF production.

Because renewable electricity is a significant contributor to the MSP (Figure 1), a waived grid fee could greatly impact the MSP, as shown here. Likewise, if the price of renewable electricity were to be brought down, the MSP would decrease considerably.

In Scenario 2, the Hydrogen Bank auction price of €0.68/kg (assumed for 2030) could reduce the MSP by 5%. The Hydrogen Bank could have a higher impact in the future, depending on the auction prices. Previous auction results may have shown lower bid prices due to competing smaller-scale or lower-cost projects. To benefit e-kerosene projects, a dedicated e-kerosene auction could be established by allocating specific funding, allowing bids to fall within an appropriate price range.

Overall, including the effect of avoided ETS penalties, Scenario 1 is estimated to reduce the cost gap between e-kerosene and fossil kerosene by around 56%, and the policy instruments from Scenario 2 could reduce the cost gap by 35%.

We also compared the cost of e-kerosene production with the cost of non-compliance. In this example, in the absence of any policy support and using an MSP of €4.23/L, non-compliance with ReFuelEU would result in a minimum penalty of €5.7 billion.[14] For the same assumed e-kerosene MSP, the cost to produce the fuel to reach the mandate would be €3.3 billion, around 42% less than the non-compliance penalty.[15]

SCENARIO ANALYSIS FOR FT FUELS FROM AGRICULTURAL RESIDUES

For FT fuels from agricultural residues, we considered the cost reductions from decreasing the cost of finance, upfront support for capital expenses from the Innovation Fund or a similar grant, and EREs.

As in the case of e-kerosene, we reduced the discount rate (rate of return) to 9.4% and the interest rate to 4.8% across both scenarios, drawing on Dutch data from Gautam et al. (2023). Similar to the e-kerosene scenarios above, we assumed the Innovation Fund or a similar grant would cover 40% of the equipment cost for fuel production. The average EU contribution through Innovation Fund grants received per biofuel project is €43 million (European Commission, n.d.-d). In this case, 40% of the total installed equipment costs would entail a grant size of around €226 million. We assumed other means of capital support (e.g., national grants) are paired with the Innovation Fund grant to show the impact of this amount of support on the MSP. For the EREs, we assumed FT-diesel supplied to the road or marine sectors received the credits.

Figure 5 illustrates the cost reduction that could be achieved with the policy options described for FT fuels from agricultural residues. Starting from the initial MSP of €2.12/L, a reduction in the cost of capital decreases the MSP by €0.14/L. Then, we consider the application of an Innovation Fund and/or other capital grant, which provides a reduction of €0.51/L, while EREs received from diesel decrease the MSP by €0.32/L. Finally, considering avoided ETS penalties for fossil kerosene of €0.37/L brings down the cost of this fuel to €0.80/L. This reduced the MSP for FT-agricultural residues fuel to around 30% more expensive than the fossil kerosene price. The FT fuels could be competitive compared with the market price of HEFA fuels at €1.58/L from 2024 (€2,058/t; EASA, 2025).

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14   The penalties will be determined by each Member State but should not be less than 2 times the price gap between SAF and fossil kerosene multiplied by the total yearly non-tanked SAF quantity. We calculated the penalties by taking the price difference between fossil kerosene (€0.6/L) and our estimated e-kerosene price (€4.23/L) and multiplying it by the total EU-wide e-kerosene volume mandated by 2031 (0.79 billion liters, given a 1.2% volume mandate) and by 2.

15   This is derived from an MSP of €4.23/L multiplied by 0.79 billion liters (reflecting a 1.2% volume mandate).

Figure 5
Cost reduction from policy options for FT fuels from agricultural residues

Note: The average conventional aviation fuel market price (€0.6/L) from the EASA report (EASA, 2025) is used in comparison to the minimum selling price estimate of FT fuels.

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Overall, the policy options can decrease the MSP in this case by 63% and narrow the cost gap with fossil kerosene by 87%. A large capital grant covering 40% of the equipment costs could decrease the MSP by 24%, while EREs could provide a further 15% decrease.

POLICY CONSIDERATIONS

To meet the ReFuelEU target for 2030, advanced SAF will likely require substantial public investment. Navarrete et al. (2025) found that revenue certainty, as well as capital support, will be critical for advanced SAF producers to overcome barriers and reach a final investment decision in Europe. Targeted financial assistance would facilitate the early commercialization of promising technologies, helping reduce the cost gap in the short term until technological learning and scale economies help reduce production costs over the long term.

This case study of the Netherlands assessed different financial incentives and their impact on the cost of advanced SAF pathways. Our scenario analysis could help identify optimal policy combinations to minimize the cost gap between advanced SAF and fossil kerosene. Should financial support measures prove insufficient, fuel suppliers might prefer to pay the penalties instead of complying with the mandates, especially in

early compliance years. However, paying the penalty would not exempt fuel suppliers from filling their ReFuelEU quotas, which are carried over to the following year.

The key takeaways from our analysis and related policy considerations are described below.

With its current structure, the EU ETS cannot bridge the cost gap between advanced SAF and fossil kerosene—but there is an opportunity to use the ETS revenue to provide support to advanced SAF producers.

The 20 million free allowances for aviation fuels in the EU ETS will likely be spent towards commercial HEFA fuels by 2030, given the full price gap coverage for small islands and remote airports, leaving no funds for advanced fuels like e-kerosene. E-kerosene and other advanced SAF will most likely not be commercially available until 2030, so the reinvestment mechanism would need to be extended to benefit advanced fuels.

During the 2026 ETS revision process, the European Commission could evaluate the expansion of this mechanism beyond 2030, with an increased allocation of allowances specifically reserved for advanced fuels. Using the minimum selling price from this study for e-kerosene (€4.23/L), and without any other policy support, 15 million free allowances (€1.5 billion with an ETS price of €100/t CO_2) would be necessary to cover 95% of the price gap with fossil fuels and reach the minimum 0.7% ReFuelEU synthetic fuels target in 2030 (see Table A3). When a reduced minimum selling price is considered (€2.21/L), 7.5 million free allowances would be necessary in 2030.

We estimated that the auction of ETS aviation allowances would generate more than €2 billion annually from 2026 and a total of €13.8 billion in revenue between 2025 and 2030 in the entire EU. The revenue we estimated for the Netherlands from EUAA during the same period was around €720 million. If the ETS covers emissions from flights that depart from the EU territories in addition to intra-EU flights, there would be additional revenue for reinvestment. While the ETS revenue is predominantly distributed to EU Member States, it could be used to support advanced SAF. The STIP encourages Member States to allocate ETS revenues to support the production of sustainable and low-carbon fuels.

A portion of the ETS revenue funds could be put towards a new revenue certainty mechanism. Dedicating just a quarter of the cumulative revenue from ETS aviation allowances (€3.5 billion) by 2030 to advanced SAF could provide substantial financial support under such a mechanism. For example, using the minimum selling price from this study (€4.23/L), this amount could cover 64% of the cost gap between synthetic fuel and fossil kerosene needed to meet the ReFuelEU mandates until the end of 2031 at the EU level (1.6 billion liters or 1.2 Mt synthetic kerosene).[16] The same amount of funds could cover the cost gap for 2.7 billion liters or 2.0 Mt of FT fuels from agricultural residues, using the minimum selling price from this study (€2.12/L) for this type of fuel.[17]

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16 This was calculated by taking the difference between the price of fossil kerosene (€0.6/L) and our estimated e-kerosene price (€4.23/L), considering an ETS penalty of €0.25/L for fossil kerosene.

17 This was calculated by taking the difference between the price of fossil kerosene (€0.6/L) and our estimated FT fuels price from agricultural residues (€2.12/L), considering an ETS penalty of €0.25/L for fossil kerosene.

Whether at the national or EU level, upfront capital grants can go a long way towards reducing the cost gap between advanced SAF and fossil kerosene.

Providing upfront capital grants and market-based incentives could significantly reduce the cost gap between advanced and fossil fuels. As our case study of the Netherlands shows, for FT fuels from agricultural residues, capital support could greatly reduce the cost gap with conventional aviation fuels. For e-kerosene, capital support at typical award levels is likely insufficient to close the cost gap. However, our analysis shows that this form of support is one of the most effective ways to narrow it. As mentioned in the STIP, national governments could make use of the new state aid rules and provide support targeted to advanced fuel projects. To narrow the cost gap, €300–€400 million per project may need to be awarded, particularly if the Innovation Fund or other EU-level programs do not exceed current award levels. However, these high award levels may not be necessary if the producer also has access to revenue certainty measures, which we did not assess in this study.

In the Netherlands, the ERE credit price can also contribute by utilizing co-products from SAF production supplied to the road and/or marine sector. Reducing or removing the grid fees for high-voltage electricity used for e-fuel production, where relevant, could also be effective in reducing operational costs. In our case study, we found that the Hydrogen Bank auction prices are not sufficient to support e-kerosene projects, providing little improvement in the minimum selling price with a subsidy of €0.68/kg of hydrogen. This subsidy amount was based on lower bid prices in previous auctions, which could be due to smaller project sizes (e.g., 5 MW) or lower-cost projects bidding in competition. The STIP specifies that there will be marine and aviation fuel-specific auctions in the Hydrogen Bank; it is possible that these auctions may generate higher prices than those assessed in this study, thereby better supporting e-kerosene. The effectiveness of this sector-specific approach has been demonstrated by the marine-specific call in the second Hydrogen Bank auction, which resulted in higher bidding prices (e.g., €1.8/kg hydrogen) than the regular call. However, constraints on receiving funding from other sources (e.g., the Innovation Fund or state aid) in addition to the Hydrogen Bank premium makes it difficult to bridge the cost gap between e-kerosene and fossil fuels without a per-liter revenue certainty mechanism.

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APPENDIX

Table A1
Estimation of the ETS aviation allowances (EUAA) for the Netherlands (NL)

	2023	2024	2025	2026	2027	2028	2029	2030
Total allocated emissions (EUAA) NL /EU	1,410,241/ 26,912,570	1,349,601/ 25,755,329	1,291,568/ 24,647,850	1,236,030/ 23,587,993	1,182,881/ 22,573,709	1,130,834/ 21,580,466	1,081,078/ 20,630,925	1,033,510/ 19,723,165
Freely allocated allowances NL/ EU	1,164,741/ 21,485,570	863,744/ 16,483,411	555,374/ 10,598,576	0/0	0/0	0/0	0/0	0/0
Auctioned allowances NL/ EU	245,500/ 5,427,000	485,856/ 9,271,919	736,194/ 14,049,275	1,236,030/ 23,587,993	1,182,881/ 22,573,709	1,130,834/ 21,580,466	1,081,078/ 20,630,925	1,033,510/ 19,723,165
% free allowances NL/EU	83/80	64/64	43/43	0/0	0/0	0/0	0/0	0/0
EU ETS price (€/t CO_2)	85.0	64.3	77.9	91.5	105.1	118.8	132.4	146.0
Auction revenue from EUAA NL/ EU (million €)	20.9/461	31/596	57/1,095	113/2,159	124/2,372	134/2,564	143/2,732	151/2,880

Note: Allowances and emissions for 2023 were retrieved from the European Environment Agency (2025). Emissions to 2030 were calculated using a linear reduction factor of 4.3% annually between 2024 and 2027 and a 4.4% linear reduction factor from 2028. The EU ETS carbon price average for 2023 was estimated using the Netherlands' revenues from auctions for 2023 and the number of auctioned allowances. The average ETS price from 2024 and the projection for 2030 were obtained from BloombergNEF (2024). The ETS prices between 2024 and 2030 were calculated assuming a linear increase to €146/t CO_2.

Table A2
Annual SAF demand in the EU calculated using ReFuelEU volume mandates and ICCT annual jet fuel demand projections

	Annual jet fuel demand (million L)	Total SAF mandate (vol %)	Synthetic fuel submandate (vol %)	Total SAF mandate (million L)	Synthetic fuel submandate (million L)
2025	60,485	2.0		1,210	
2026	61,482	2.8		1,721	
2027	62,483	3.6		2,249	
2028	63,500	4.4		2,794	
2029	64,510	5.2		3,355	
2030	65,541	6.0	0.7 (minimum)	3,932	459
Total				**15,262**	**459**

Note: A linear increase was assumed for the SAF mandate volume % between 2025 and 2030.

Table A3
Estimation of required allowances to cover the price gap from using SAF

	Production cost (€/L)	Cost coverage (%)	Estimated cumulative SAF volume by 2030 for ReFuelEU (billion L)	Cumulative price gap by 2030 (billion €)[c]	Required allowances by 2030[e]
Waste oil HEFA	1.11[a]	50	14.8	3.79	18.9
e-kerosene	4.23[b]	95	0.46[d]	1.57	14.9

[a] The market price of aviation biofuels in 2024 was €2,085/t (€1.58/L; EASA, 2025). However, to find an average representative price between 2025 and 2030 to calculate the price gap, we used the production cost estimation from the same report for 2024 of €1,461/t (€1.11/L) to reflect the decrease in prices between 2024 and 2030.

[b] Reflects our own estimate from this work.

[c] To calculate the cumulative cost gap, an ETS price of €0.25/L and the price of fossil kerosene at €0.6/L were first subtracted from the production cost of SAF. The resulting value was multiplied by the cumulative SAF volume by 2030.

[d] Only the SAF volume necessary in 2030 to reach the 0.7% minimum target (0.46 billion liters) was considered for e-kerosene because, currently, e-kerosene is not commercially available.

[e] Required allowances were calculated by multiplying the cumulative price gap by the percent cost coverage.

DESCRIPTION OF THE TEA MODEL

In this study, we employed a publicly available TEA model for FT fuels and adjusted it as necessary (Brandt et al., 2021). The TEA model calculates the breakeven cost needed for a greenfield investment to be economically feasible and achieve a specified rate of return. Key elements of this model include initial capital expenditure, yearly operational expenses, and income from product sales. The model also incorporates financial assumptions about debt and equity, which influence the necessary returns for economic viability. Installed equipment costs are used in the calculation of the fixed capital investment.

For the e-kerosene calculations, necessary electrolyzer and renewable electricity costs and energy flows were added to the FT model because the production process of electrolysis hydrogen from renewable electricity was not included in the original model. For both models, the installation costs for the equipment were added, and the equipment costs were adjusted to 2023 prices using the Chemical Engineering Plant Cost Index for that year (Chemical Engineering Magazine, n.d.). The cost structure of the model has been modified as presented in Table A6 and Table A8 for each model.

Total distillate to carbon feedstock yield is 0.26 t distillate/t CO_2 for e-kerosene (Soler et al., 2022), whereas it is lower at 0.14 t distillate/t of agricultural residues (Brandt et al., 2021). The product slate for the fuel synthesis was assumed to maximize the jet fuel production, with an energy distribution of 40% jet fuel, 40% diesel, and 10% each of naphtha and propane (Zhou et al., 2022).

Economic parameters, such as inflation, discount rate, and income tax rates, were adjusted to conditions in the Netherlands using data from a recent report on the cost of green hydrogen production in the country (Eblé & Weeda, 2024), and we assumed the same parameters for the advanced SAF pathways in this study (Table A4). The costs for the electrolyzer, renewable electricity, and grid fees were drawn from the same report and are listed in Table A5. Table A6 lists the cost components for e-kerosene. Table A7 and Table A8 are operational costs and capital expense components for FT fuel production from agricultural residues.

Table A4

Economic parameters for the Netherlands

Economic parameters	Value
Discount rate	12.0%
Corporate tax rate	25.8%
Inflation	2.0%
Equity	30%
Loan interest rate	6.0%
Loan term (years)	10
Property insurance (% of fixed capital investment)	1.0%
Local taxes (% of fixed capital investment)	1.5%

Note: Discount rate, tax rate, inflation, and loan interest rate for the Netherlands are from Eblé and Weeda (2024).

Table A5

Assumptions on the cost of electrolysis components and the carbon source for 2030

Component	Unit	Price
Electrolyzer system cost[a]	€/kW	1,525
Electrolyzer efficiency	%	68
Renewable electricity cost (Offshore wind)[b]	€/MWh	75
Connection cost (Netherlands specific)[c]	€/MWh	18
Point carbon source[d]	€/t CO_2	100

[a] Electrolyzer system cost with the balance of plant from Eblé and Weeda (2024) was used for a 200 MW electrolyzer.
[b] Renewable electricity cost from Eblé and Weeda (2024) was used, assuming grid connection with a 90% capacity factor.
[c] This is a grid tariff for extra-high voltage applied to large-scale electrolyzers by the transmission system operator
TenneT (€144/kW-yr, equivalent to €18/MWh; Eblé & Weeda, 2024).
[d] High-end estimations for CO_2 cost from point carbon industrial sources were used (International Energy Agency, 2019).

Table A6

Estimated CapEx for e-kerosene production with a total plant capacity of 128 kt/yr (including 51 kt e-kerosene, 51 kt diesel, 12.8 kt naphtha, and 12.8 kt propane)

Component		Million €
Electrolyzer (1)		611
Reverse water-gas shift (2)		82
FT synthesis (3)		91
Hydroprocessing and separation (4)		67
Total installed equipment cost (5)	(1)+(2)+(3)+(4)	851
Outside battery limits (6)	10% of (5)	85
Direct costs (7)	(5)+(6)	936
Engineering and supervision (8)	10% of (7)	94
Construction and fees (9)	30% of (7)	281
Contingency (10)	20% of (7)	187
Indirect costs (11)	(8)+(9)+(10)	562
Fixed capital investment (12)	(7)+(11)	1,498
Working capital (13)	5% of (12)	75
Total capital investment	(12)+(13)	**1,573**

Note: CapEx includes the installed equipment cost for each equipment and other direct costs such as engineering and supervision, construction, and other auxiliary costs.

Table A7

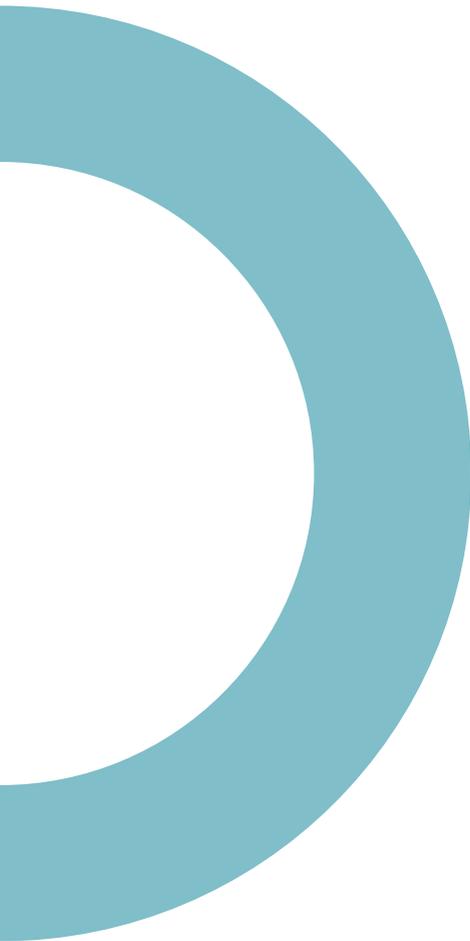**Operational cost for FT fuels from agricultural residues**

Component	Unit	Price
Agricultural residues[a]	€/t	76.8
Grid electricity price[b]	€/MWh	78

[a] Data for primary agricultural residues in the Netherlands from the JRC-EU Times Model for 2030 were used, at 3.7 €$_{2010}$/GJ (Ruiz Castello et al., 2015), assuming a lower heating value of 14.6 MJ/kg used for straw from cereals from the same publication, and adjusted to €$_{2024}$ according to inflation.

[b] Calculated based on Eurostat data for non-household consumers (nrg_pc_205) 500MWh-1999MWh-band IC, without tax (2007–2020 average).

Table A8
Estimated CapEx for fuel production from the FT pathway

Component		Million €
Gasification (1)		336
Syngas cleaning (2)		51
Fischer-Tropsch Synthesis (3)		92
Hydroprocessing and separation (4)		87
Total equipment cost (5)	(1)+(2)+(3)+(4)	565
Outside battery limits (6)	10% of (5)	57
Direct costs (7)	(5)+(6)	622
Engineering and supervision (8)	10% of (7)	62
Construction and fees (9)	30% of (7)	187
Contingency (10)	20% of (7)	124
Indirect costs (11)	(8)+(9)+(10)	373
Fixed capital investment (12)	(7)+(11)	995
Working capital (13)	5% of (12)	50
Total capital investment	(12)+(13)	1,045

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