TULIPS

Demonstrating lower polluting solutions for sustainable airports across Europe

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Assessment of Policy in Relation to a PtL Facility

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Abstract

This report, part of the EU-funded TULIPS Horizon 2020 project, examines policies supporting renewable energy-derived sustainable aviation fuel (eSAF) and provides policy recommendations to enhance the eSAF market development in Europe. The report assesses the impact of key European policies, including the ReFuelEU mandate, the Renewable Energy Directive (RED III) and its delegated acts, the EU Emissions Trading System (ETS), and associated funding mechanisms, on the growth of the European eSAF market. Additionally, the report evaluates global policies such as the US Grand SAF Challenge, the UK SAF mandate, CORSIA, and other direct mandates to analyze their implications for the European eSAF landscape.

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VI. LIST OF ACRONYMS

Acronym	Meaning
AVR	Accreditation and Verification Regulation
ASTM	ASTM International, formerly known as American Society for Testing and Materials
CCU	Carbon Capture and Utilization
CI	Carbon Intensity
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
EASA	European Union Aviation Safety Agency
eSAF	Renewable energy derived Sustainable Aviation Fuel (made from H_2 and CO_2)
FID	Final Investment Decision
GHG	Greenhouse Gas
GO	Guarantee of Origin
IATA	International Air Transport Association
LCA	Life Cycle Assessment
MRR	Monitoring and Reporting Regulation
NRA	National Regulatory Authority
NZIA	Net Zero Industry Act
PPA	Purchasing Power Agreement
PtL	Power-to-Liquids
RED-III	EU Renewable Energy Directive III
RFNBO	Renewable Fuel of Non-Biological Origin
SAF	Sustainable Aviation Fuel
TULIPS	DemonsTrating lower pollUting soLutions for sustaInable airPorts acrosS Europe

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1 Executive Summary

This report summarizes the main policies related to renewable energy derived sustainable aviation fuel (eSAF) and provides recommendations on improving these policies. The report is part of the EU funded TULIPS Horizon 2020 project, which aims is to accelerate the implementation of innovative and sustainable technologies towards lower emissions at airports.

The development of an eSAF market in Europe will be primarily driven by the ReFuelEU mandate, a strong demand-side policy that requires progressively higher volumes of eSAF to be blended with fossil kerosene. The mandate will be enforced by EU member states through significant penalties, set at minimum twice the price differential between eSAF and fossil kerosene, ensuring that fuel suppliers are incentivized to meet blending targets. ReFuelEU is projected to establish a substantial eSAF market, with an estimated annual demand of 0.6 million tons in 2030, increasing to 28 million tons by 2050. [1]

The Renewable Energy Directive (RED III) sets sustainability standards for eSAF, including fuel eligible under ReFuelEU, but is unlikely to significantly impact demand on its own. The EU Emissions Trading System (ETS) may reduce the price gap between eSAF and fossil kerosene, though not enough to fully equalize costs. ETS SAF allowances could be a key tool for financing eSAF facilities if allowances are extended beyond 2030. Funding through EU initiatives like the Innovation Fund, along with penalties collected from non-compliance, are critical for scaling eSAF production given the high costs of eSAF facilities.

Internationally, the UK SAF mandate, the US Grand Challenge, the Carbon Offsetting and Regulation Scheme for Aviation (CORSIA) and other mandates may increase eSAF demand, though they are generally less stringent than EU policies. Nonetheless, these could drive up competition and costs, especially for imported eSAF. Without additional funding and strong domestic policies, Europe may face a supply shortfall, as current projections indicate a potential undersupply relative to mandated demand. Addressing cost barriers and ensuring a competitive production environment will be essential for Europe's long-term eSAF market development.

The main recommendations to strengthen policy and to ensure the advancement of the eSAF market include:

- For the EU Commission to reconfirm SAF mandates, and give investors more certainty ensuring facilities are built before the blending targets go into effect.
- Addressing funding barriers, particularly the high CAPEX and financial risk of first-of-a-kind projects, by extending ETS SAF allowances past 2030.

[1] As calculated in the SkyNRG 2024 market outlook

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- Ensuring SAF allowances are linked to a 10-year offtake as long term off-takers are key to financing projects.
- Making debt funding more accessible by extending low-interest loans from the European Central Bank, and using European Investment Bank guarantees.
- Expediting accreditation of certification bodies for both SAF and renewable fuels of non-biological origin (RFNBO) hydrogen.
- Implement a carbon management strategy to ensure stable CO_2 availability for SAF production, including standards, infrastructure development, and incentives for CO_2 utilization.

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2 Introduction

2.1 Report as part of TULIPS

This report is part of the TULIPS work package 5. The TULIPS consortium, a Horizon 2020 project funded by the EU, aims to facilitate the transition to low-carbon mobility and enhance sustainability at airports. In total there are 13 work packages focusing on different aspects of decarbonising airports with work package 5 focusing on scaling up the sustainable aviation fuel (SAF) market.

The objectives of work package 5 include developing and evaluating large scale and continuous SAF supply at Schiphol airport and developing the PtL pathway for SAF production using inputs from existing projects. Deliverable 5.1 looks at geographic suitability for eSAF projects, providing a replicable framework for developing a successful eSAF supply chain. It enables comparison of potential locations for future eSAF facilities by focusing on key production elements: continuous green hydrogen supply, continuous biogenic or DAC CO_2 supply, conversion to e-SAF/by-products and the e-SAF/by-products supply chain. Additionally, deliverable 5.1 outlines success factors for each production element and identifies promising European countries for eSAF facility development based on these factors. Deliverable 5.2 looks at site selection for eSAF projects outlining a framework for assessing the suitability of airports as sites for eSAF facilities. The framework considers factors critical to construction, operation, profitability, and future expansion, drawing on SkyNRG's prior experience. Key limiting factors include available area, renewable electricity, biogenic CO_2 supply, zoning regulations, and social acceptability. Secondary factors, such as synergies with nearby facilities and access to infrastructure are also considered. It was found that many of the investigated factors involve external risks, which can challenge the suitability of airports for eSAF facilities.

This report constitutes deliverable 5.3 which focuses on the assessment of policy in relation to a PtL facility. This report summarizes key policies affecting eSAF, focusing primarily on the EU but also covering global policies. It examines the implications of these policies on EU supply and offers recommendations for future policy updates.

2.2 Report set-up

Aviation is responsible for approximately 4% of the EU's total greenhouse gas (GHG) emissions and 14% of the EU's transports emissions. [1] Aviation is a hard to abate sector as jet fuel alternatives such as electrification or hydrogen propulsion are only considered feasible for short-haul flights or in the medium to long term. In the short term the most viable option for the decarbonization of the industry is the use of SAF. The EU has set ambitious climate targets as outlined in the Fit-for-55 package, with the overall goal being a reduction in EU emissions of at least

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55% by 2030 and for the EU to be climate neutral by 2050. [2] To achieve these overarching targets the EU has implemented a number of policies specifically for the aviation sector. This report will evaluate these policies from the lens of an eSAF facility.

It is important to differentiate the different terminology that is used within policy frameworks for SAF. Figure 1 below gives an overview of the different jet fuel types. SAF is jet fuel that has been produced either from biobased feedstocks or from synthetic routes. It is important to note SAF is a drop-in fuel that is added to conventional fossil jet fuel at different volumes. Synthetic fuel includes both nuclear SAF (SAF produced from CO_2 and hydrogen using nuclear power) and eSAF which is produced from CO_2 and hydrogen using renewable electricity. This report will primarily focus on eSAF produced at PtL facilities.

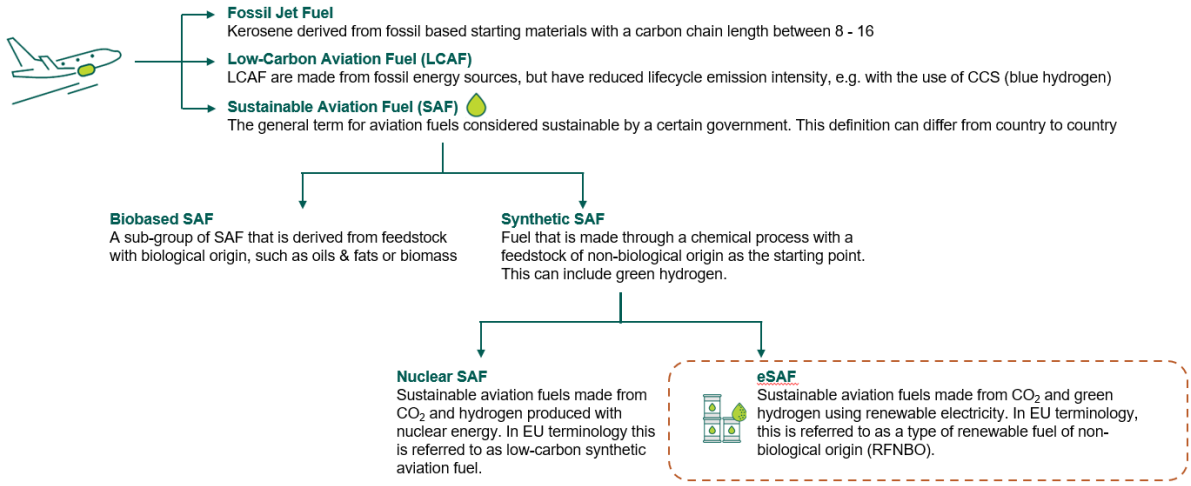

Figure 1. Definitions of aviation fuel used in this document

The first section of the report covers EU policies relevant to the aviation sector including the ReFuelEU aviation mandate, the Renewable Energy Directive III (RED III) as well as its first and second delegated acts on renewable fuels of non-biological origin (RFNBO's), the EU Emissions and Trading Scheme (ETS) and European funding for SAF. These sections will go into detail on the key parameters and sustainability requirements as well as any financial implications of the policies. The second section will cover global SAF policies including CORSIA, the UK aviation mandate, the US landscape supported by tax incentives and other global policies. The third section will summarize the financial and demand implications of the European and global policies on the European eSAF market. The final section will provide recommendations on future policy updates as discussed by various members of the TULIPS consortium.

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3 EU Policies

3.1 ReFuelEU

ReFuelEU Aviation is an EU mandate that went into effect on the 1st of January 2024 with the aim of ensuring the supply and uptake of SAF. ReFuelEU provides blending requirements of SAF with conventional jet fuel at a gradual increase starting in 2025 and going towards 2050. The blending requirements cover both SAF from biobased feedstocks as well as eSAF from PtL facilities. The mandate also provides offtake requirements to ensure that blended fuel is used for all flights departing the EU. The EU wide mandate replaces any nationwide mandates that may have existed, harmonizing policy and creating market certainty for larger scale deployment of SAF. The mandate covers drop in aviation fuels that are ASTM certified and compliant with the sustainability criteria of RED III, which will be covered in detail later in this report.

The purpose of the mandate is to reduce emissions of the aviation sector, which is key for the EU to achieve their emissions reduction targets in line with the European Green Deal and Fit-for-55 package. The target is for the EU to become climate neutral and to reduce all transport emissions by 90% before 2050.

In addition to reducing emissions from the aviation sector, ReFuelEU also aims to create a level playing field for the EU aviation fuel market by establishing a clear framework for all stakeholders involved. The mandate applies to all EU member states and covers aircraft operators, airports, airport managing bodies and critically fuel suppliers. The mandate covers any flight taking off from an EU airport and is primarily focused on commercial flights with extension to cover private flights depending on the aircraft type.

3.1.1 Key Requirements

ReFuelEU sets a primary target of achieving a 70% SAF blending rate across all European airports by 2050. This mandate specifies annual blending targets, representing SAF as a percentage of total jet fuel consumption. The targets cover SAF derived from biobased feedstocks starting in 2025 and add a sub-target for synthetic fuels beginning in 2030. Synthetic aviation fuels include both eSAF and nuclear SAF. For PtL facilities producing eSAF, the mandated blending requirements start in 2030, with a minimum blend of 1.2%, translating to approximately 0.6 million tons per year according to SkyNRG's 2024 market outlook. [3]

Up until 2030 there is a leniency period where fuels suppliers can meet their blending obligations by averaging supply across multiple locations instead of having to achieve the exact mandated percentage at each individual airport (the so-called flexibility mechanism). Past 2035 the eSAF blending targets increase rapidly jumping to 5% by 2035 and more than 35% by 2050. In Table 1

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there is a detailed break-down of the eSAF blending targets and the estimated volume of fuel this will correlate to.

Table 1. ReFuelEU Aviation eSAF Blending Mandates

Year	Synthetic fuels	Total SAF Share	Synthetic aviation fuels Mt/y (SkyNRG scenario)[2]
2025		2%	
2030	>1.2 %	6%	0.6
2035	>5%	>20%	3.0
2040	>10%	>34%	7.2
2045	>15%	>42%	11.6
2050	>35%	>70%	28.1

The responsibility to meet blending requirements rests with fuel suppliers, while airlines are required to meet offtake obligations, meaning they must source fuel from the airports they depart from. Specifically, aircraft operators are obligated to refuel at least 90% of the fuel needed for their next flight at the departing airport. Exceptions to this rule apply if the airport handles fewer than 10,000 commercial flights annually or in cases of operational challenges, which must be clearly documented. There is however, the potential risk for carbon-leakage if airline operators provide alternative routes that go through non-EU hubs such as Turkey or Egypt where there is no offtake obligation.

There are also a number of sustainability requirement that must be met for blended aviation fuel to comply with the ReFuelEU mandate. Both eSAF and nuclear SAF must achieve a well-to-wing emissions reduction of at least 70% compared to a fossil fuel baseline of 94 gCO_2eq/MJ. More detail on the emissions reduction target is provided in the 'RFNBO Delegated Act' section of this report. In addition, eSAF must be in line with the requirement set forth by the RED III delegated acts on feedstock criteria and renewable electricity used for the production of fuels. Biogenic or fossil fuels can only be used for the energy needs of an eSAF facility but the biogenic or fossil molecules themselves cannot end up in the fuel.

There are some inconsistencies for the requirements of SAF between ReFuelEU and RED. RED allows a certain amount of food and feed based feedstocks with a cap of 7% set for the entire transport sector. By contrast, ReFuelEU does not allow any food and feed based feedstocks at all. As this discrepancy does not extend to eSAF feedstocks it is not discussed in further detail.

[2] Numbers are taken from the SkyNRG Market Outlook 2024

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3.1.2 Financial Implications

The EU commission has defined a minimum fine for non-compliance of twice the difference between the price of fossil kerosene and the price of eSAF for the undelivered fuel in the subsequent annual reporting period. The penalty of non-compliance falls to the fuel supplier who must meet the minimum blending targets and are to be paid to the member states. The price of eSAF used will be published by the European Union Aviation Safety Agency (EASA), however it is still unclear how this will be done.

EU member states can set their own fines of non-compliance to suppliers as long as the fines are above the minimum stipulated by the EU commission. The EU commission may then approve all fines proposed by member states as well as the implementation mechanism that member states put forward. The first year of the mandate (2025) is considered a transitional period and as such there will be more lenient penalties levied on suppliers. The Commission may make an adjustment to the minimum penalty and suppliers will also be allowed to generate and trade SAF credits to allow for some flexibility in compliance. The flexibility mechanism in the initial years of the mandate allows fuel suppliers to average their supply across all airports instead of requiring the exact blending targets at each location. However, as the mandates must be enforced by each member state individually this flexibility will currently not be able to be carried out between EU member states, reducing the effectiveness of the flexibility mechanism.

Penalties will carry over into future years, meaning fuel suppliers who miss blending targets must pay the penalty and also supply the shortfall in addition to the required fuel in the next reporting period. Revenue that is generated through the payment of fines, or equal amounts to this, should be invested by member states to encourage the uptake and research into SAF related innovation projects.

3.2 RED III

RED III is an EU directive aimed at increasing the share of renewables used. The directive sets out a minimum target of achieving 42.5% renewable energy within the EU by 2030. RED III also sets the requirements for RFNBOs, as which eSAF is also classed. This will be covered in more detail in the following section. RED III also provides targets for specific sectors, such as the transport sector, on e-fuel and renewable hydrogen use. It should be noted that RED III is an amendment to the previously published RED II directive that increased the ambition of targets as well as providing more sector specific guidance. The revised RED directive entered into effect on the 20th of November 2023 and covers targets for the use of hydrogen from 2030 onwards. Member states will need to add provision of the directive into law by May 21st 2025. At the time of publication of this report (December 2024), no member state has implemented RED III.

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The purpose of the directive is to promote energy from renewable sources in line with the European Green Deal and in creating a favourable regulatory and investment environment for renewables. The directive also aims to promote and set targets for the use of e-fuels in specific sectors where electrification is difficult or not feasible.

The directive applies to all EU member states, who are required to set national targets in order for the overarching EU targets to be met. Member states are also required to put in place mechanisms for implementing the directive. RED III specifically covers energy producers, the building sector and the transport sector – which includes aviation. The directive covers a broad set of renewable energy sources including solar, wind, hydro, bioenergy , geothermal and ocean as well as RFNBO's.

3.2.1 Key Requirements

RED III establishes a number of key targets for the transport sector, requiring that by 2030, 5.5% of the renewable energy supplied must come from advanced fuels, such as biofuels and RFNBOs. Additionally, over 1% of all energy supplied must specifically come from RFNBOs, including eSAF. Member states can choose between two different overarching targets for the transport sector by either increasing renewable energy use to 29% or achieving a 14.5% reduction in GHG intensity by 2030. This creates a challenge for member states as these targets do not directly align with the ReFuelEU Aviation obligations. The difference in target size between RED III and ReFuelEU means member states will need to decide how to implement RED III. The RED III GHG reduction targets for the transport sector could be spread equally across all fuel suppliers or could be implemented as a total per member states with individual suppliers (e.g. those in the aviation sector) having lower targets in accordance only with ReFuelEU. This complexity means member states will need to decide if the aviation sector will only be bound by the lower ReFuelEU targets having other transport sectors, such as road transport, taking on the difference or if aviation will need to go beyond just the mandated blending targets.

RED provides the EU wide targets that should be achieved for renewable energy and fuel while the delegated acts provide the details on the definitions of what fuels are considered RFNBOs and the accounting principles for measuring emissions. These criteria and the key sustainability requirements for RFNBOs are covered in detail in the next section 3.3.

3.2.2 Financial Implications

RED III does not have any associated penalties for failing to reach targets set out or for the use of non-compliant RFNBO's. It is the requirement of member states to bring RED III into law and decide on how to ensure compliance before the 21st of May 2025. The implementation of RED III will most likely not impact the eSAF market in terms of increased volumes with ReFuelEU being the leading policy stimulating demand. There will be costs for fuel suppliers in achieving certification for RED

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compliant production as well as for purchasing GO's to cover all renewable electricity used. It will fall to member states to measure and implement the targets within their own countries.

3.2.3 Certification Schemes

Certification bodies are independent third parties that design voluntary certification schemes based on the legislation that is set out by the European Commission. Certification is the way for fuel producers to prove compliance with the legislation and to safeguard that minimum sustainability criteria are met. However, certification bodies can choose to include criteria in addition to that which is included in legislature, and so some certification schemes may be more stringent or difficult to achieve than others. Currently no certification body has yet achieved accreditation by the EU Commission, with the first expected to be accredited by the end of 2024.

Certification, along with being key in showing compliance to RED III, provides evidence for emissions of the fuel. An accurate emissions factor will allow for better Scope 1 accounting for fuel producers and Scope 3 accounting for aircraft operators, airports, airport managing bodies and fuel suppliers.

An example of some of the main certification bodies working towards accreditation and high-level information on their proposed methodologies can be found in Table 2.

Table 2. Voluntary Certification Bodies

Category	REDcert EU	CertifHy	ISCC	System KZR INiG	CCEE
Covered in certification	RFNBOs and Recylced Carbon Fuels (RCFs)	RFNBOs	RFNBOs and RCFs	RFNBOs and RCFs	Hydrogen and its derivatives
Regional focus	EU & UK	EU & UK, main focus Germany	Global focus	Global coverage with focus on Poland	Focus on Spain
Additional sustainability requirements		No additional criteria to REDIII, Established green and low carbon hydrogen labels	Additional sustainability criteria on labour, land rights and agriculture		Additional sustainability requirements on footprinting and resource efficiency

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3.3 Renewable Fuels of Non Biological Origin (RFNBO) Delegated Acts

The RFNBO Delegated Acts provide specific criteria and rules for implementing RED III. The Delegated Acts include the 1st delegated act which provides guidance on the conditions under which hydrogen and fuels are considered RFNBOs and the 2nd delegated act which provides a methodology for calculating emissions savings from RFNBOs. The delegated acts aims to support the EU's clean energy goals by ensuring RFNBOs are produced from renewable electricity and that there is a clear EU wide accounting methodology. The purpose of the acts is also to provide regulatory guidance providing more clarity to investors, leading to more projects in the RFNBO space.

The delegated acts, effective since July 2023, apply to all renewable fuels produced from non-biomass sources, including gaseous RFNBOs like renewable hydrogen and liquid RFNBOs such as synthetic fuels (e.g., eSAF). These acts introduce a grace period lasting until 2029, after which compliance criteria will become stricter. Applicable across all EU member states, the directives focus on stakeholders involved in the production and certification of RFNBOs, including hydrogen producers, renewable energy suppliers, RFNBO fuel providers, and regulatory and certification bodies.

3.3.1 Key Requirements

RED III RFNBO requirements span all the components in the eSAF pathway, including emissions reductions, renewable power sourcing, and fuel certification. Figure 2 below outlines the main components in the eSAF pathway. Overall eSAF facilities must demonstrate a significant and measurable reduction in GHG emissions over the entire life cycle of the fuel compared to conventional fossil fuels. To meet these standards, fuel producers should retire Guarantees of Origin (GOs) covering the full amount of renewable energy used in eSAF production and comply with tracking protocols.

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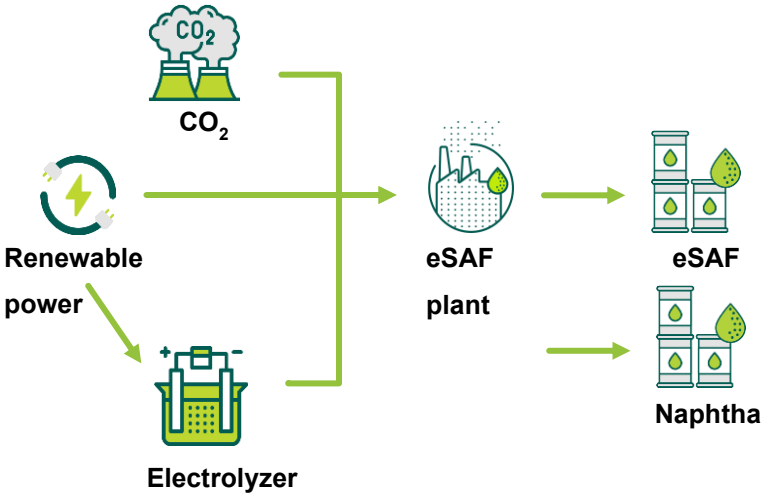

Figure 2. Schematic of eSAF production components

Some of the key requirements set forth in the RFNBO delegated acts include emissions reductions targets, criteria on traceability and critically, a large focus is on the criteria on the use of renewable electricity. According to the delegated acts renewable hydrogen or eSAF must have a minimum 70% well-to-wake emissions reduction compared to a fossil comparator with baseline emissions of 94 gCO_{2e}/MJ. Fuel suppliers will have to prove this minimum emission reduction has been achieved through verification of the fuels carried out by accredited third parties. In addition to complying with minimum emissions reductions, renewable hydrogen must be traceable throughout its entire supply chain. This means the entire journey of the hydrogen from production to sale must be documented including any transfers that happen. The transfers must be shown on a mass balance basis.

To qualify as RED III compliant, eSAF has to be produced from renewable hydrogen with the delegated acts specifying criteria for the use of renewable electricity in the production of RFNBOs. The criteria differ for direct and grid connected generation, with certain scenarios having requirements around additionality of the electricity, geographic correlation of the production and temporal correlation of the production. The additionality criteria refers to the fact that renewable electricity used for the production of fuels should not be taking away from previous supply but should be newly added. This criteria outlines that renewable electricity production should be unsubsidized and production should come online within 36 months of realization of the electrolyzer or e-fuel production site. The geographic correlation criteria outlines that electricity for hydrogen or eSAF production should be produced in the same or an adjacent bidding zone, where electricity moved in the opposite direction of the contracted movement. The temporal correlation criteria states that until 2030 there must be a monthly correlation between production and consumption of electricity and after 2030 an hourly correlation.

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As described in section 3.2.1 both the hydrogen production as well as the eSAF facility must use renewable electricity to be compliant with RED III. There are five specific scenarios in which eSAF production can be considered renewable in accordance with the delegated acts.

- **1a. Direct connection - general rules:**
  - In this case the hydrogen or eSAF facilities are connected via direct line to renewable electricity generation.
  - The renewable electricity generation cannot be connected to the grid in addition to the production facilities, unless there is a smart metering system installed.
  - Any eSAF production capacity added to an existing eSAF installation within 36 months of initial operation can still be added to the same renewable electricity installation as long as it is added at the same site.
- **2a. Grid connection – general rules:**
  - No operating or investment aid is allowed for the electricity generating installation.
  - A renewable Power Purchase Agreement (PPA) is needed for the electricity used for fuel production.
  - Additionality rules are exempt until 2038 if the hydrogen or eSAF installation came online before the 1st of January 2028.
- **2b. Grid connection – low grid emissions:**
  - When operating in a low-carbon bidding zone, which means a GHG intensity of less than 18 gCO_{2e}/MJ, producers are exempt from the additionality criteria.
  - The additionality exemption means that older assets, such as older wind farms or hydropower plants, can be contracted.
  - A renewable PPA is needed corresponding to the hours of renewables in the grid.
- **2c. Grid connection – imbalance settlement:**
  - Electricity is obtained from renewable power during an imbalance settlement period.
  - It must be proven to the transmission system operator that eSAF or hydrogen production led to reduced need for downward re-dispatching.
- **2d. Grid connection – renewable grid:**
  - The grid must have more than 90% renewable power, in which case there are exemptions from the other criteria.
  - The renewable hydrogen or eSAF can be claimed at the percentage of production equal to the share of renewable in the grid, including biomass.

In the case of scenario 2d. Grid connection – renewable grid, there are a number of additional requirements.

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- **Percentage of Renewables:** an emissions factor of zero can only be claimed for the percentage of renewables in the grid. The grids renewable electricity percentage is determined by either the grid operator, National Regulatory Authority (NRA) or the Joint Research Centre. For multiple bidding zones the NRA, grid operator or a neutral third party would determine the renewable percentage.
- **The production time:** a production site can only produce the number of hours equivalent to the percentage of renewables in the grid mix of the bidding zone. For example, a facility in a grid with 90% renewables in the mix can produce for 90* x 8,760 = 7,884 hours in a year.
- **PPAs:** electricity can be procured through a PPA or on electricity markets in the same bidding zone.
- **Guarantees of origin (GOs):** GOs should be surrendered covering the quantity of electricity used to produce eSAF or renewable hydrogen. No temporal or additionality requirement exist for the GOs however, Member States can add additional demands. The commission has not yet decided on whether geographical correlation will be applicable to GOs.
- **Batteries:** batteries cannot be used to increase the percentage of renewable electricity in the grid unless the batteries are placed behind the metering system.
- **Neighbouring bidding zone:** electricity can be procured from a neighbouring bidding zone, but in this case needs to comply to the rules of the applicable scenario that is used, with additionality and temporal correlation.

The delegated acts also provide requirements on the CO_2 sources that are used in the production of fuels. The CO_2 source used in the fuel production is crucial for achieving the 70% emission reduction target. Allowability of various CO_2 sources is summarised in Table 3. Until 2036 CO_2 produced with fossil electricity is allowable and until 2041 CO_2 produced with other fossil sources can be used. However, fossil CO_2 can only used if the producer is paying into an effective carbon pricing scheme such as the EU Emissions Trading Scheme (ETS).

Table 3. Allowability of different CO_2 sources

Type of CO_2	Allowability
Fossil – Electricity generation	Up until 2036
Fossil – other sources	Up until 2041
Biogenic	Allowed
Geological	Allowed

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Direct air capture	Allowed

The CO_2 input can be counted as negative if it is compliant to the delegated acts and can be used to compensate for the emissions of the fuel according to the GHG methodology. A mix of fossil and biogenic CO_2 can be used in alignment with the above table, however this will then have a negative impact on the life cycle assessment (LCA). It is also important to note that there is limited total availability of biogenic CO_2 in Europe. Mass balancing of CO_2 on producer level is possible and can be allowed by member states, as long as mass balancing occurs over a maximum of three months.

3.3.2 Financial Implications

RED III, and by extension the RFNBO delegated acts, does not outline any penalties for non-compliance. Putting in place implementation mechanisms will be the responsibility of member states who must bring it into law before the 21st of May 2025.

3.4 Low Carbon Delegated Act

A draft version of the Low Carbon Delegated Act was published on September 27, 2024, and was open for feedback until October 25, 2024. With the feedback period now closed, the Commission plans to adopt the act in Q4 of 2024. Similar to the RFNBO delegated acts, the Low Carbon Delegated Act provides rules and criteria for implementing parts of RED III, focusing on accounting methodologies for all types of low-carbon fuels, beyond just renewable fuels of non-biological origin. This includes fuels produced with nuclear energy, such as blue hydrogen, and fuels derived from biological sources. Notably, the methodology for calculating emissions reductions is nearly identical to that outlined in the RFNBO second delegated act. The directive targets stakeholders involved in the production and certification of low-carbon fuels not already covered by the RFNBO delegated acts.

3.5 EU ETS

The EU ETS is a cap-and-trade system designed to regulate sector-specific GHG emissions. It sets an emissions cap for various sectors, with companies receiving a mix of free and auctioned emission allowances. Companies that exceed their allowances face fines, while those with surplus allowances can sell them to companies with higher emissions. The goal of the EU ETS is to encourage emissions reductions in hard-to-decarbonize sectors, including transport, and to help the EU meet its climate goals outlined in the Fit-for-55 package. The EU's new 2030 emissions target is a 62% reduction compared to 2005 levels.

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The EU ETS is applicable to all 27 member states as well as Iceland, Liechtenstein and Norway. All intra-European flights are currently covered by the scheme, and to ensure flights to countries outside the EU will be included, CORSIA will be integrated. Sectors covered by the EU ETS I and II include the energy, industry, transport and buildings sectors which together made up approximately 36% of the EU's total upstream GHG emissions in 2022. [4]

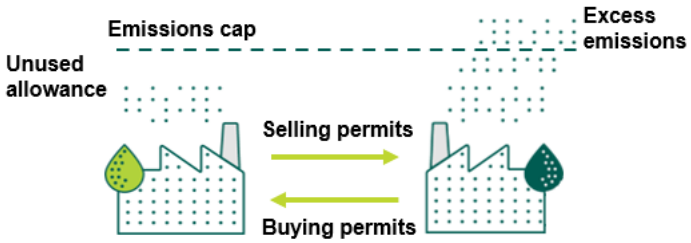

Figure 3. EU ETS set-up

ETS I was expanded with ETS II to cover specific targets for further sectors such as the transport and buildings sectors. ETS I will apply to the aviation industry from 2025 onwards with respect to monitoring and reporting, and targets outlined in ETS II will be in effect from 2027 onwards. Annual emissions targets will follow a linear contraction approach currently set to reach zero by 2039. Within the aviation sector there are approximately 200 million allowances for the period of 2013 – 2020. A portion of these allowances, ~82%, are granted for free to aircraft operators with about 15% auctioned and 3% reserved for distribution to fast-growing aircraft operators and new entrants. The portion of free allowances will reduce sharply each year and are currently set to be 100% auctioned by 2026. The free allowances are distributed to aircraft operators who had submitted verified emissions reports for 2010 based on the airlines efficiencies and the allocation is done by member states within their own borders. There has been a reduction in the allocation of free allowances due to the more ambitious targets.

3.5.1 Key Requirements

The ETS has an annual compliance cycle which includes monitoring, reporting and verification to ensure reporting of GHG emissions is robust, transparent and accurate. The monitoring requirements for aircraft operators are outlined in the Monitoring and Reporting Regulation (MRR) framework. Certification will also be required of fuel producers with detailed regulations on the process of production of fuels and the energy used from agricultural and forest biomass as well as organic waste. Company emissions will be verified through the Accreditation and Verification Regulation (AVR) which will be adopted by the end of 2024.

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There are additional sustainability criteria for biomass which do not directly impact eSAF but will impact SAF from bio based feedstocks. It is required that land-use for biomass has no conversion of high carbon stock and biodiverse areas as well as requiring sustainable agricultural practices in general. The life cycle GHG emissions of biomass must be accounted for including emissions savings from use of biomass. In addition, areas from which biomass is harvested must be regenerated and harvesting must maintain or improve the long-term production capacity of the land.

Starting in 2030, the European Commission plans to include non-CO_2 emissions, such as NOx and contrails produced from fossil kerosene, in its emissions framework. From January 1, 2025, monitoring, reporting, and verification guidelines for these non-CO_2 emissions will become operational. Aircraft operators will also be required to disclose non-CO_2 emissions by 2027. It is still uncertain if or how non CO_2 emission may be included under the ETS allowances however, the inclusion of these emissions could potentially more than triple the EU ETS costs for aircraft operators, a burden which currently does not apply to SAF. [5]

3.5.2 Financial Implications

Emitters that exceed the cap set by the ETS are liable to pay fines of ~100 EUR per tonne in excess. Member states are able to exempt suppliers until 2030 if there is a national CO_2 price which is equivalent to or higher than the ETS price. Emissions allowances are auctioned with a price stability mechanism built in that states if the prices rise above 45 EUR per tonne in the first three years, that additional allowances can be released. In addition to the fine that companies will have to pay if exceeding the cap, companies will need to surrender the amount of allowances equal to their emissions, requiring further permits the following year.

Member states will be responsible for enforcing penalties within their own countries. For persistent non-compliance, operators can face more severe consequences such as being banned from operating within the EU. Member states will be required to use the revenues from the fines for climate action and social measures, with part of the revenue being used for the EU Social Climate Fund to support vulnerable households and micro-enterprises.

SAF that is used on flights within the EU are considered to have zero emissions, which reduces airline operators EU ETS costs. In addition to the normal emission allowances there is a share of the EU ETS revenue that is allocated to incentivise SAF by providing an offtake allowance to cover part or all of the price difference with fossil kerosene. A budget of 20 million allowances (approximately 1.6 billion Euro depending on carbon prices) [6] is allocated to aircraft operators on a first come first serve basis. The allowances can subsidise up to 95% of the average costs of eSAF, up to 70% of the cost of bio-advanced fuels and up to 50% for other eligible SAFs (such as HEFA). However, funds are expected to run out before 2030, with the commission looking at increasing the budget beyond that. If the SAF allowances can be extended beyond 2030 it has the

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potential to be highly impactful in bridging the price premium between eSAF and fossil kerosene. It will be important for the Commission to make their plans for extending these measures clear to assuage investor uncertainty.

3.6 Funding for EU SAF

There are multiple EU tools that are encouraging funding for SAF related projects such as the Net Zero Industry Act (NZIA), the EU taxonomy, ReFuelEU Aviation and the EU ETS. The mandates and regulatory frameworks encourage investment into renewable fuels within the EU and make financial instruments more accessible to such projects.

- **NZIA**: creates a regulatory framework for net-zero technologies and industries as well as setting a European CO_2 storage capacity target. The framework covers products, components and machinery for net-zero technologies including those for sustainable alternative fuels. The NZIA creates extra funding and support options for industries through direct investment through the European Sovereignty Fund, accelerating permitting for key projects and providing subsidies and tax benefits for key projects. [7]
- **EU Taxonomy**: is a science-based framework for defining economic activities that are considered sustainable. This creates incentives for green investments due to favourable lending terms, draws in institutional investors and provides access to EU funds and incentives. [8]
- **ReFuelEU Aviation**: mandate on blending targets within the EU that has penalties attached to non-compliance. Revenues generated through the fines are to be invested by member states to encourage the uptake and research into SAF related innovation projects.
- **EU ETS**: emissions cap and trade scheme with fines of ~100 EUR per tonne emitted in excess. Revenue from fines for exceeding cap limits are to be invested by member states into climate action and social measures. Part of the revenue will be used for the EU Social Climate Fund to support vulnerable households and micro-enterprises. [6]

As eSAF facilities are highly capital intensive, it is imperative that there are financial mechanisms in place to support their development. The high capital expenditures and the uncertainties associated with first-of-a-kind eSAF plants make it challenging for investors to commit, as the risks and financial returns are difficult to predict. Having access to European funding or tools like low-interest loans would significantly ease this uncertainty and encourage investors to move forward. In particular, direct funding mechanisms such as the Innovation Fund could play a crucial role in getting projects off the ground, providing the necessary financial support to reach a final investment decision (FID).

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4 Global Policies

4.1 CORSIA

CORSIA is a global market-based measure to reduce emissions in aviation that was adopted by IATA, a specialized United Nations agency for international air transport in 2016. CORSIA aims to achieve carbon neutral growth for 85% of emissions compared to a 2019 baseline with a requirement of offsets being purchased for the remaining emissions. SAF is an important component in the CORSIA targets for achieving emissions reductions.

CORSIA has outlined a number of reduction goals which include; increasing fuel efficiency by 2% each year up to 2050, achieving carbon neutral growth from 2020 onwards and reaching net-zero carbon emissions by 2050. Further criteria outline by CORSIA states that fuel used must have a minimum net emissions reduction of 10% compared to a lifecycle baseline 89 gCO_{2e}/MJ with a reduction in carbon intensity of 5% by 2030 compared to a 2020 baseline. In addition to the environmental criteria outlined, from 2023 onwards social and governance policies will also need to be implemented including topics on human, labour, land use and water rights as well as food security.

There are four main pillars that will contribute to the achievement of the goals. The yearly gain in fuel efficiency target should be implemented through the use of aircraft related technology and new standards coming out. Operational improvements such as air traffic management will also aid in achieving efficiency gains. Emissions reductions targets will be implemented by the increased use of SAF through further development and deployment. IATA projects the remaining emissions gap to the net-zero target will be bridged through the use of eligible offsets. CORSIA is the scheme to be used for these eligible offsets.

CORSIA provides an accounting framework [9] for airline operators to monitor, report and verify their emission however, the organization does not implement any tools to increase the production of SAF themselves. Member states must develop policies and implementation methodologies to achieve the targets set forth by CORSIA. The price of fossil kerosene should increase to above the 2019 volume threshold through the purchase of required offsets, making SAF more competitive.

Despite CORSIA offsetting reducing the price premium between eSAF and conventional jet fuel, it is unlikely to stimulate additional eSAF as the offset price is unlikely to be high enough currently to increase eSAF uptake on its own.

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4.2 UK

The UK has instated a SAF mandate that goes into effect on the 1st of January 2025. The mandate sets blending targets similar to that of ReFuelEU with a 2% target in 2025 that increases linearly to 10% in 2030 and then reaches 22% by 2040. There is a specific sub-mandate for eSAF starting in 2028 requiring 3.5% of jet fuel to come from eSAF by 2040, the targets for the eSAF sub-mandate can be seen in the Figure below. [10] The current targets only extend to 2040 as there is a lot of uncertainty beyond this, but the targets are under revision and it is expected that targets will be raised above current levels.

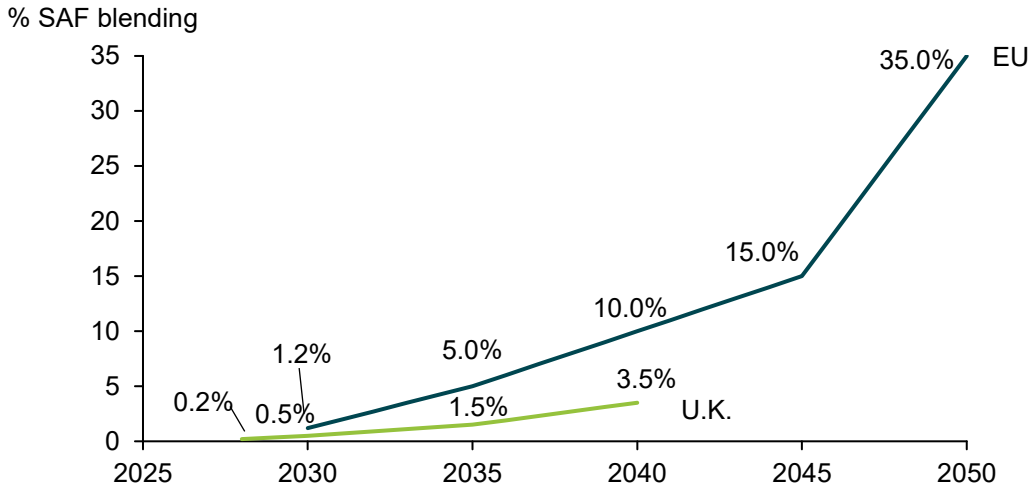

Figure 4. UK eSAF sub-mandate targets

It has been calculated in SkyNRG's market outlook that in the base case these targets would correspond to eSAF mandated demand volumes of 0.02 Mt in 2028, 0.06 Mt in 2030 and 0.8 Mt in 2040.

The UK mandate specifies a number of key criteria, such as the fact that there must be a minimum 40% emissions reduction of SAF compared to a fossil kerosene baseline figure of 89 gCO_{2e}/MJ. Credit will be given to fuels with an emissions reduction that goes beyond the 40% minimum. For eSAF, all CO_2 sources are permissible however, electricity and hydrogen production must be in line with the UK's RFNBO guidelines or nuclear electricity must be used.

The UK mandate differs from ReFuelEU in its financial implementation. Instead of penalties for non-compliance to fuel suppliers the UK uses a buy-out price. The buy-out price can be paid instead of procuring SAF, with the buy-out price being set above the maximum price for eSAF. The prices currently set by the UK government can be seen in Table 4 below. The price will be reiterated every 5 years with the department for transport aiming to always keep the price above the cost of eSAF.

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Table 4. UK mandate buy-out prices

Proposal	£/tonne for 70 % emission reduction	£/L for 70 % reduction	£/tonne for 100 % emission reduction
General mandate buy-out price	£5,875/tonne (€6,830/tonne)[1]	£4.70/L	£8,392/tonne (€8,755/tonne)[3]
eSAF buy-out price	£6,250/tonne (€7,270/tonne)[1]	£5.00/L	£8,900/tonne (€10,350/tonne)

There are a number of key differences between the UK mandate and ReFuelEU with the EU mandate being more strict on a number of components. The biggest difference is in the emissions reduction target with the EU requiring a more than 70% reduction compared to a fossil comparator and the UK requiring a more than 40% reduction compared to a fossil comparator. In terms of the implementation, in the EU there is a fine for non-compliance with a requirement to still fulfil the undersupplied SAF fuel the following year, whereas the UK uses a buy-out price with no roll-over obligation. The UK permits any type of CO_2 source for eSAF production while the EU does not allow fossil CO_2 past 2041. For both the EU and UK eSAF from renewable and low-carbon (nuclear) sources is permissible, in addition the EU does allow for OPEX support which the UK specifically does not. Finally in terms of grid emissions, in the UK electricity produced from biomass is excluded emissions factors are determined by the national legislator while in the EU emissions from biomass are included and the grid emissions are determined each year by the JRC for every country in the EU.

The UK's eSAF mandate shares many similarities with the EU's, including similar requirements and guidelines for UK RFNBO standards. This alignment means that fuel producers will be able to optimize their production processes to meet the criteria for both markets. As a result, the UK will create a competing demand center for eSAF, potentially driving additional investment and production capacity in the region, while offering an opportunity for producers to cater to both the UK and EU markets. However, the competing demand for eSAF within the UK could present challenges in meeting EU targets, as it may divert production capacity toward the UK market instead. UK eSAF production is unlikely to become competitive in the short term given the high emissions intensity of the grid, meaning there may be a heavy reliance on imports to meet the eSAF sub-mandate. The UK grid is currently at or less than 50% renewable electricity generation and it is expected to take some years before this could be more than 90% as required by RED III. [11]

[3] Calculation has been done with an approximate conversion rate of 1.14 euro/pound

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4.3 US

The US has taken a different approach to the EU and UK, instead of a mandate requiring minimum SAF blending volumes with financial implications for not reaching targets, the US has created tax incentives to promote SAF production. In 2021, the US announced the SAF Grand Challenge which aims to realize three billion gallons of SAF production by 2030. The Grand Challenge is a collaboration between the U.S. Department of Energy, the Department of Transportation, the Department of Agriculture, and other federal government agencies working together to develop a comprehensive strategy for scaling up SAF on a commercial scale. [11]

The Grand Challenge has two overarching objectives, one is to reach a minimum 50% reduction in LCA GHG emissions for SAF compared to conventional jet fuel and the other is to have enough SAF production by 2050 to supply the entire U.S. jet fuel demand. The mechanisms for encouraging the scale-up of these technologies is through federal and state level incentives. Federal incentives came into effect under the Inflation Reduction Act on 1/1/2023 and are aimed at SAF producers and blenders. There are state level incentives in states like California, Washington and Illinois.

The main federal incentives that relates to SAF is 40B. 40B states there is a tax credit of $1.25 per gallon of SAF that achieves a 50% reduction in lifecycle GHG emissions with an additional one cent per gallon for each additional percentage emissions reduced beyond that. The credit has a cap at a maximum $1.75 per gallon. From 2025 – 2027 40B will become the clean fuel production tax credit (45z), where a credit will be awarded based on the fuels carbon intensity (CI) score against a baseline of 50 kgCO2e/MMBTU. The credit will be a baseline of $0.35 per gallon up to a maximum of $1.75 per gallon multiplied by the fuels CO_{2e} emission factor. [12] [13] In addition to these there are a number of tax credits that eSAF can make use of such as the carbon capture and utilization (CCU) credit (45Q), the clean hydrogen production credit (45V) and the clean electricity production tax credit (45Y). Details on the credits can be seen in Table 5. It is important to note that most bonus credits are only achievable when environmental, social and governance criteria have been met, including wage requirements.

Table 5. U.S. inflation reduction act tax credits applicable to eSAF

Credit ID	Credit Explanation	Credit
40B [14]	Sustainable aviation fuel credit	Base credit: • $1.25/gal of SAF achieving a 50% reduction in LCA GHG emissions Bonus credit: • Additional one cent/gal for each additional % reduction. Capped at $1.75/gallon.
45Z [13]	Clean Fuel Production Credit	Base credit: • $0.35/gal multiplied by the fuels CO_{2e} emissions factor <50kgCO_{2e}/MMBTU

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		Bonus credit: • 5 times base amount ($1.75/gal multiplied by the emissions factor) for facilities meeting wage requirements
45Q [15]	Credit for Carbon Oxide Sequestration	Base credit: • Point Source: $17/metric ton of CO_2 captured and sequestered; $12/metric ton for CO_2 that is injected for enhanced oil recovery or utilized. • Direct Air Capture: $36/metric ton CO_2 sequestered and $26/metric ton CO_2 utilized Bonus credit: • 5 times base amount if the facility meets wage requirements
45V [16]	Credit for the Production of Clean Hydrogen	• Maximum of $3/kg hydrogen produced depending on the carbon intensity of the hydrogen • Available for the first 10 years of the hydrogen generation facility
45Y [17]	Clean Electricity Production Tax Credit	Base credit: • 0.3 cents/kWh clean electricity Bonus credit: • 5 times base amount if the facility meets wage requirements

In addition to the federal tax incentives there are also a number of state level incentives available. In California, Oregon and Washington states there are low-carbon fuel incentives available with additional states looking to develop these. Washington, which has the biggest incentives available, has a tax credit of $1 - $2 per gallon of SAF depending on the carbon intensity. The carbon intensity is calculated against a Washington State fossil benchmark with calculation methods still under discussion. The Washington incentive only comes into effect when the production of SAF exceeds 20 million gallon per year. Illinois in contrast to a production tax credit has a SAF purchase tax credit of $1.50 per gallon of SAF. The incentive is set to be valid for 10 years starting from 1/6/2023 and has feedstock criteria associated with it, meaning a maximum of 10 million gallon per year of SAF can be derived from soy beans and none can be derived from palm oil. Currently the state level incentives do not have any social or governance related criteria.

There are some difficulties with the incentive system, one main difficulty lies in the fact that there is a complex set of rules on which credits can and cannot be stacked. For example, the hydrogen tax credit (45V) can only be stacked with the clean electricity production tax credit (45Y) but no other credits. When looking at the hydrogen production credit there are also additional rules on calculating the emissions reduction coming from electrolysis. The state level credits can be stacked with federal credits, which means in certain states such as Washington there can be a strong incentive to produce SAF however, there may not be enough of an incentive to ensure offtake.

In terms of import of U.S. production into Europe there are some complexities here too. Federal production incentives require uptake of the SAF within their own states which means these volumes

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cannot be delivered into the EU. In addition it is difficult to optimize production to be in line with both the US tax credits and RED III requirements. RED requirements on hydrogen production are stringent and in the US hydrogen producers are likely to have to use additional capacity which cannot be subsidized according to RED. The US also has very large grid regions giving rise to high grid intensities, meaning emission factors may not be low enough to comply with RED.

4.4 Other Countries

There are a number of other countries that also have SAF mandates however, no country or region outside of the EU and UK have any eSAF specific sub-mandates.

Globally outside the EU and UK there are three other countries that have instated direct mandates, these are Japan, India and Indonesia.

- **Japan**: the Japanese government decided in 2022 to instate a SAF mandate that covers at least 10% of domestic airline's jet fuel consumption by 2030. Under the Japanese mandate, SAF producers will be required to cut GHG emissions by more than 5% until 2035 from 2019 levels and additional targets beyond 2035 are still under discussion. [18]
- **India**: India's government has set SAF blending targets of 1% for 2027 and 2% for 2028 with the aim being for these targets initially to apply to international flights. There are discussions on potentially increasing this target to 5% blended SAF. [19]
- **Indonesia**: Indonesia had set SAF blending targets of 2% in 2016, 3% in 2020 and 5% in 2025 however, the targets for 2016 and 2020 were already missed. Indonesia SAF roadmap currently focuses on used cooking oil and crude palm oil residue as SAF feedstock with seaweed being explored as a potential option. [20]

It is unclear whether the direct mandates proposed by Japan, India and Indonesia will actually come to fruition especially as some of the earlier targets have been missed without penalty. SAF blending targets may still be revised and so there is much less certainty than within the EU on what the estimated global demand for SAF will actually be in the coming years. In addition, without eSAF specific mandates or sub-mandates it will be very difficult to create a global eSAF market. Technologies such as alcohol-to-jet as well as eSAF will not be cost competitive for many years without sub mandates which might ultimately stunt the deployment of them.

There are also a number of countries who have instated or plan on instating in-direct SAF mandates. Canada and Turkey are currently developing SAF mandates and Brazil has an opt-in mandate already in place. Several other countries globally use emission trading systems that indirectly stimulate the use of SAF.

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5 Summary of policy implications on the EU eSAF market

The major driver for establishing an eSAF market in Europe will be through the ReFuelEU mandate as this is a strong demand side policy. The SAF mandate requires minimum volumes of SAF and eSAF to be blended with fossil kerosene in increasing amounts from 2025 – 2050 as well as setting refuelling obligations on the aircraft operators. The SAF will need to be RED III compliant and certified to be eligible to qualify as part of ReFuelEU. The mandate will be enforced by member states through very high penalties, which are currently set at a minimum of twice the difference between the eSAF price and the fossil kerosene price with the obligation to carry over unmet supply when targets are not achieved. As the penalty for non-compliance is very high, this will create a strong incentive for fuel suppliers to reach blending targets however, it is still unclear how non-compliance will be enforced for other stakeholders in the value chain. ReFuelEU will create a European eSAF market with the mandatory demand estimated to be approximately 0.6 Mt per year in 2030 and up to 28 Mt per year in 2050.

Figure 5 below shows the projected demand for both SAF and eSAF for 2030 to 2050 based on the ReFuelEU mandate. Potential SAF demand is calculated by multiplying the projected jet fuel demand by the percentage SAF mandated.[4] It can be seen that eSAF will increasingly make up a larger portion of the total SAF demand.

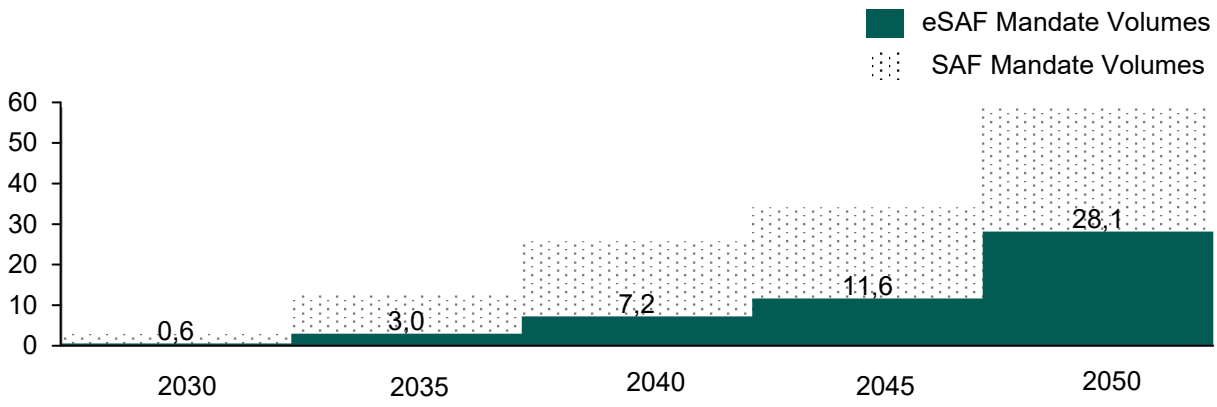

Figure 5. Projected mandated SAF and eSAF volumes in the EU

RED III is unlikely to create any substantial demand for eSAF by itself. Targets set forth in RED stipulate the transport sector must either reach 29% renewable energy use or a 14.5% reduction in GHG intensity by 2030 in addition to 1% RFNBO offtake. Most likely it will be less expensive and easier for member states to reach these targets in the marine or road transport sector than the

[4] Projected jet fuel consumption until 2030 has been taken from Eurostat and ReFuelEU and from 2030 to 2050 it has been taken from IATA.

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aviation sector. Member states have until the 21st of May to bring the requirements of RED into law, which means it is still not clear how exactly member states plan to reach targets and how shortfalls will be penalized. RED III does however, provide a detailed criteria on which fuels are considered RFNBOs and are eligible for ReFuelEU.

The RED RFNBO delegated acts also do not themselves create additional demand for eSAF, but detail the exact sustainability criteria that must be met by fuels as well as providing a methodology for calculating emissions. Fuels must demonstrate a measurable decrease in GHG emissions compared to a fossil baseline, comply with electricity emissions requirements and be certified under an accredited scheme. The requirements outlined in the two delegated acts in relation to RFNBOs are globally some of the most stringent criteria, making it difficult for eSAF production to be eligible for use and import in the EU.

It is likely the ETS costs alone will not be enough to ensure eSAF uptake in the market but it will decrease the price premium on eSAF. In addition, SAF allowances have the potential to be very impactful, but currently funds are expected to run out before 2030. There are clear financial implications of exceeding the ETS cap with aircraft operators having to pay fines for every ton of CO_2 in excess. The price premium for eSAF compared to conventional fossil kerosene may decrease by approximately 330 – 440 EUR/ton which is 3-4 times the EU ETS price.[5] This reduction still does not bridge the gap between the cost of kerosene and eSAF, which is estimated to be approximately 5 – 8 times higher. [21] The ETS could become a key funding instrument if SAF allowances are increased past 2030 and allocations are done over a longer period than 1 year.

Supply side policies in the EU are focused on funding both from fines as well and direct R&D funds which will be critical in growing the European eSAF market. eSAF facilities are highly capital intensive and with current uncertainties about the eSAF market investors have been hesitant to move forward with projects. As CAPEX costs are so high, there are significant risks associated with being a first mover in the space. To lower these risks additional funding or CAPEX subsidies will be needed as well as policies making it easier for producers to access both equity and debt funding. Other support such as additional ETS allowances for specific production pathways can be key in making financing for such projects possible. In addition, fines from ReFuelEU as well as the EU ETS are slated to be invested into R&D for SAF. There are also a number of European direct funds, such as the Innovation Fund, Horizon Europe, LIFE program and CEF.

Figure 6 shows the projected eSAF supply forecast as presented in SkyNRG's 2024 market outlook. [3] Supply up until 2030 was estimated by reviewing all publicly available information on eSAF projects that have been announced. Projects which were deemed to have a low probability of reaching production where excluded, with low probability referring to projects that have not had

[5] Assuming an EU ETS price of 110 EUR/t as used by the Dutch Government

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any updates in over two years, have not reached the feasibility stage or have a high degree of compound risk. For the years from 2030 to 2050 a different approach was taken to estimate supply. The total potential European feedstock availability for different SAF technology pathways was evaluated taking any feedstock constraints into consideration. For eSAF this included looking at projected hydrogen supply [22] and announcement of projects. It was assumed that 20% of the total forecasted hydrogen supply would be allocated to eSAF production.

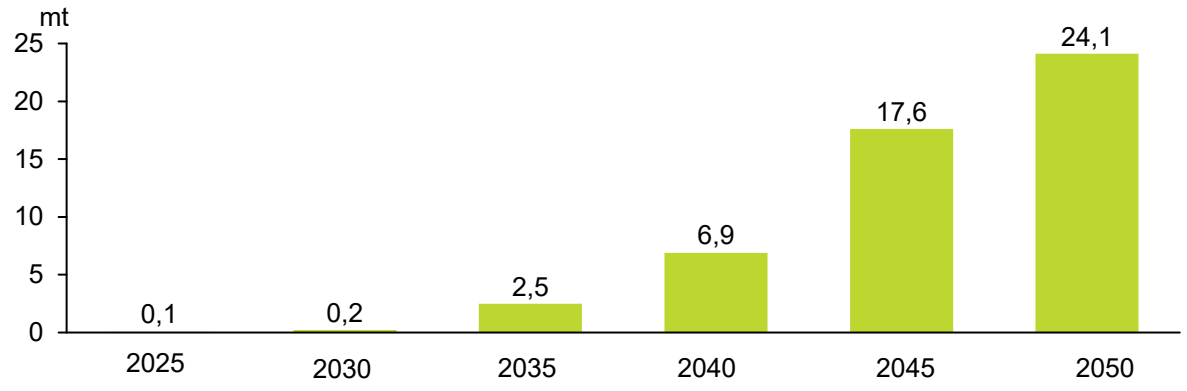

Figure 6. EU eSAF supply forecast

From Figure 7 below it can be seen when comparing the projected eSAF demand volumes from the ReFuel EU mandate and the projected supply volumes there is a small undersupply predicted for most years. Feedstock constraints on other technology pathways, such as HEFA (hydro-processed esters and fatty acids), means that eSAF will be necessary to reach IATA and Europe wide targets.

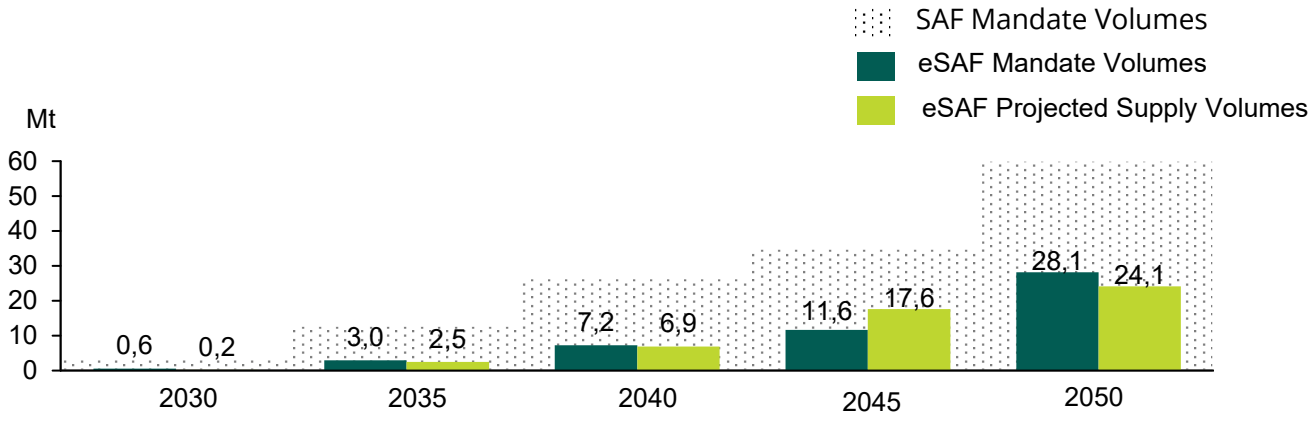

Figure 7. EU projected eSAF supply and mandated demand volumes

Projected supply volumes are theoretical based on a number of assumptions and effective policy support is needed for these volumes to be achieved. While based on current assumptions in

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SkyNRG's 2024 market outlook a small undersupply is predicted, projections show that fulfilling mandated volumes could be technically feasible. Prior to 2030 there are a number of projects that have been announced, but none that have taken FID. [21] Effective policy is imperative to create more investor certainty and to expand funding options to overcome the risks associated with (first-of-a-kind) eSAF facilities.

There are a number of regions outside of the EU that have also adopted SAF policies with many more in the process of doing so. Non-EU policies include CORSIA, the UK SAF mandate, the US SAF Grand Challenge and a number of other direct and indirect mandates. In general global mandates are not as stringent as the EU, however, may create competing demand for eSAF, especially in the UK. CORSIA's global scheme covers flights into and out of the EU and reduces the price premium between SAF and fossil kerosene. It is unlikely that the offset prices will be high enough to increase eSAF uptake on its own, with offset costs currently hovering just above 20 $/t. The UK's SAF mandate is the most comprehensive of any outside the EU, with a similar eSAF sub-mandate. The buy-out fee for non-compliance is intended to be set above the cost of eSAF and therefore should be a strong policy for stimulating demand. As eSAF in the UK must comply with the similar RFNBO requirements this may create competing demand with the EU. The US's approach has been on the supply side with a number of tax credits for SAF, renewable hydrogen and clean electricity. The US policy provides a strong incentive for eSAF production, though it may be difficult to align production in the US with the EU's RED III criteria. Outside of the EU and UK no other regions have instated financial penalties for failing to meet direct blending targets.

As Figure 7 demonstrates currently an undersupply of eSAF is projected in the 2030-2040 timeframe. If EU supply is insufficient to meet mandated demand volumes, remaining quantities will need to be imported or high penalties will need to be paid. Mandates have created a demand pool in Europe, if eSAF can be produced at lower cost elsewhere a larger portion could also be imported without industry creation. Transportation costs are considered marginal compared to total eSAF costs and would not be a barrier to importing eSAF. There are of course risks associated with relying on imports to be able to make up the mandated demand in Europe. Other countries are starting to implement their own mandates which may lead to competing demand and could drive up costs and reduce the available supply. In addition, assumptions on feedstock availability may change if there is greater competition for green hydrogen and RED III eligible biogenic CO_2. In addition to having policy that creates adequate supply, to ensure industry creation in Europe is successful, eSAF plants must be cost competitive with the rest of the world.

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6 Conclusion & Recommendations

Conclusions	Recommendations
Targets	
• There is uncertainty under investors about the firmness of the set eSAF mandates which means there are currently no projects that have moved to the FID stage	• Provide regulatory certainty by reconfirming mandates • Ensure member states have put legislation into place to enact mandates
• Currently member states cannot set higher country specific targets	• Provide more flexibility to member states that are wishing to set more ambitious targets on SAF supply
Project funding	
• High initial CAPEX and risks associated with first-of-a-kind eSAF projects make it difficult to secure debt and equity funding for these projects	• Increase the possibilities to use financial guarantees of the EIB for RFNBO SAF projects • Ensure low interest loans from the ECB or similar institutions are available for RFNBO SAF projects • Increase the support RFNBO SAF projects through public funding such as the Innovation Fund

• ETS SAF allowances expected to run out by 2028 due to the first-come-first-serve principle which is before eSAF plants are expected to become operational	• Create a long-term incentive for off-takers who procure and supply eSAF beyond the mandated volume. This incentive should mitigate financial exposure for fuel suppliers and/or airlines to commit to long-term offtakes from first of kind production facilities.
	• One measure that could support long-term offtakes form airlines is to amend the current ETS SAF allowance scheme to incentivize additional uptake of eSAF, by reducing the price premium for RFNBO SAF
	  • Ensure SAF allowances are linked to a 10-year offtake as long term off-takers are key to financing projects
	  • Propose to reduce funding for advanced SAFs to 50% of the cost difference between conventional jet fuel and SAF and eliminate funding for HEFA-based SAFs
	  • If auctioning revenues under the ETS continue to be allocated to SAF allowances, it is estimate that between 2029 – 2040 the program could be endowed with 100 M allowances which would be sufficient to bring approximately 10 advanced SAF projects to FID

Certifications	
• Currently, it is not possible to certify RFNBO SAF as no independent third parties have successfully put together a certification scheme yet • Currently, it is impossible to certify RFNBO hydrogen and thus comply with the mandate, as no certification bodies are accredited yet	• The commission should accredit certification bodies for the production of RFNBO SAF as soon as possible (expected to happen soon) • The commission should accredit a certification body for the production of RFNBO hydrogen as soon as possible.

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CO_2 See next page

CO_2	
Conclusions	Recommendations
• The implementation of legislation on negative emissions and CCU can influence the availability and price of CO_2 as a feedstock	• The commission should develop an industrial carbon management strategy through a broad legislative package that strengthens the overall CO_2 market through setting CO_2 standards, realizing CO_2 transport infrastructure and realizing financial incentives for the utilization of CO_2

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