BRIEFING

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Leveraging EU policies and climate ambition to close the cost gap between conventional and Sustainable Aviation Fuels

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In 2021, the European Commission released a suite of climate proposals known as the "Fit for 55" package. These policies aim to reduce economy-wide greenhouse gas (GHG) emissions 55% by 2030 from a 1990 baseline in line with the European Union's (EU) broader decarbonization goals. The package's updates include a major revision to the Renewable Energy Directive (RED II), sector-specific proposals such as FuelEU Maritime and ReFuelEU to increase the use of alternative fuels in non-road sectors, and revisions to the Energy Tax Directive (ETD) and Emissions Trading System (ETS). Taken together, the "Fit for 55" proposals have significant implications for the entire transportation sector; in this briefing, we focus on policy proposals relevant to the aviation sector.

Over the coming decades, the aviation industry will need to be innovative and quick in deploying new technology if it is to help meet global climate goals. In contrast to the road sector, whose decarbonization focuses on widespread electrification, the aviation industry has looked toward alternative aviation fuels, (i.e., sustainable aviation fuels [SAFs]), as a primary in-sector strategy for achieving decarbonization. In this briefing, we analyze how the EU's newly released "Fit for 55" policies can work in conjunction to generate new revenue streams for SAF and assist in meeting blending targets. We also assess the environmental integrity of overarching regulations and their ability to deliver on economy-wide decarbonization goals.

POLICY BACKGROUND

Several components of the overall "Fit for 55" package are intended to increase the level of climate ambition for the EU aviation sector. The proposed revisions to the RED increase the stringency of the Directive by modifying the existing renewable energy

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mandate into a greenhouse gas (GHG) performance target and by setting sub-targets for advanced fuels (i.e., second-generation biofuels and renewable fuels of non-biological origin [RFNBOs]). The proposed ReFuelEU Aviation regulation establishes interim blending targets including a 5% blend mandate and 0.7% power-to-liquids sub-mandate in 2030.[1] Similarly, the proposed revisions to the ETS and ETD expand the scope of both programs and create a greater financial incentive to reduce aviation sector emissions. While ReFuelEU proposes explicit blending targets to guide the rate of SAF deployment, the ETD and ETS could act as complementary policies to overcome the financial barriers to deploying SAFs. In the following sections we provide an overview of these three policy proposals and how they might effectively interact to accelerate the adoption of SAFs.

ENERGY TAX DIRECTIVE

The ETD was implemented in 2003 and generated an estimated €114 billion in annual revenue for Member States in 2019. The ETD was designed to promote a low-carbon and energy efficient economy while mitigating energy tax competition across Member States.[2] The regulation sets minimum excise tax rates for energy products including transportation fuel, heating oil, and electricity across the EU.[3] EU Member States have discretion to set higher tax rates. Norway also adheres to ETD regulation in its "state aid rules", although its participation is voluntary.[4]

To date, the ETD has done little to support a transition away from fossil fuels to low-carbon alternatives and to encourage innovation in energy efficiency technologies.[5] The regulation (2003/96/EC) only specifies tax rates for fossil fuels, lacks an indexation mechanism, is weakened by numerous exemptions for commercial industry, and is non-uniformly implemented across Member States.[6] Article 2 para. 3 implies that alternative fuels such as biofuels and RFNBOs are taxed at the same rate as fossil fuel, unless granted an exemption. Further, Member States are prohibited from taxing jet kerosene and shipping fuel in most cases, apart from domestic flights and flights between two Member States that have a bilateral agreement. Accordingly, no Member State has taxed aviation fuel to date. Recognizing that the current ETD is out of alignment with the EU's climate goals, authors of the "Fit for 55" revisions wrote their proposals to encourage greater clean energy deployment and to reward the use of fuels with the lowest environmental impact through the tax code.

Under the proposed ETD revisions, tax rates are restructured based on the energy content and environmental performance of a larger set of fuels; low-emitting energy sources such as electricity and advanced biofuels are assigned a minimum €0.15/GJ tax rate while higher emitting fuels including fossil and "non-sustainable" biofuels are assigned a minimum €10.75/GJ tax rate. In shifting from a volume-based to an energy-based taxation rate, the revision will also lower taxes on fuels that have a lower

1 European Commission, "Sustainable Aviation Fuels – ReFuelEU Aviation," Have your say, accessed January 28, 2022, https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12303-Sustainable-aviation-fuels-ReFuelEU-Aviation_en.

2 European Commission, "Restructuring the Community Framework for the Taxation of Energy Products and Electricity," Council Directive 2003/96/EC § (2003), https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32003L0096&from=EN.

3 European Commission, "Restructuring the Union Framework for the Taxation of Energy Products and Electricity," accessed December 22, 2021, https://eur-lex.europa.eu/resource.html?uri=cellar:1b01af2a-e558-11eb-a1a5-01aa75ed71a1.0001.02/DOC_2&format=PDF.

4 Norwegian government, "A European Green Deal: Norwegian Perspectives and Contributions," April 20, 2021, https://www.regjeringen.no/contentassets/38453d5f5f5d42779aaa3059b200a25f/a-european-green-deal-norwegian-perspectives-and-contributions-20.04.2021.pdf.

5 KPMG Global, "Energy Taxation Directive," KPMG, September 6, 2021, https://home.kpmg/xx/en/home/insights/2021/08/energy-taxation-directive.html.

6 "Revision of the Energy Taxation Directive (ETD): Questions and Answers," Text, European Commission - European Commission, July 14, 2021, https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3662.

energy density than gasoline (e.g., biofuels).[7] Notably, the updated ETD removes existing tax exemptions for jet kerosene specified under Article 14, para. 2 for domestic and intra-European Economic Area (EEA) flights. Meanwhile, sustainable aviation fuels will be subject to a 0.15–5.38 €/GJ tax rate following a ten-year transition period (Table 1). Biokerosene feedstocks that qualify as "sustainable" but not advanced have not yet been defined under the proposed Directive, but likely include fuel derived from food and woody biomass.[8] The proposed implementation date begins January 1, 2023 and rates on jet kerosene are scaled up to the minimum tax rate by 2033. An overview of the proposed tax rates by aviation fuel type is listed in Table 1 on an energy and volumetric basis.

Table 1. Proposed kerosene tax rates under revised ETD (effective January 2033)

Fuel type	€/liter kerosene-equivalent	€/GJ
Kerosene	0.369	10.75
Sustainable biokerosene	0.185	5.38
Synthetic and advanced biokerosene	0.005	0.15

The ETD already generates a substantial share of revenue for EU-27 Member States. For example, in 2019, Germany generated an estimated €22.7 billion in governmental revenue from the ETD, which we calculate based on motor fuel consumption data[9] and current fossil fuel tax rates. If the ETD were expanded to include taxes on jet kerosene consumed on domestic and intra-EEA flights, Germany's 2019 revenue would have risen by 13%, assuming that higher fuel prices did not suppress demand.

EMISSIONS TRADING SYSTEM

The ETS came into force in 2005 as the world's first carbon trading market and is the primary policy mechanism for reducing GHG emissions in the EU. The ETS operates under a "cap and trade" mechanism that allows regulated parties to purchase emission allowances when their emissions exceed a specified cap, and to sell unused allowances. Emissions allowances are also freely allocated to certain industries to safeguard competitiveness and avoid carbon leakage.[10] As of Phase 3 of the program (2013-2020), GHG emission caps for total stationary installations and the aviation sector are set separately and the cap on aviation emissions declines annually by 2.2% beginning in 2021.[11] Under the ETS, some regulated parties such as power generators must consign and repurchase 100% of allowances via an auctioning system to meet annual compliance obligations;[12] however, airlines and certain industries receive a share of "free" allowances to reduce the burden of compliance. Parties were able to purchase international carbon offsets verified via the United Nations Clean Development Mechanism (CDM) and Joint Implementation (JI) agreements through the end of Phase 3 as an alternate form of compliance.[13] The ETS includes all 27 EU Member States and

7 Sidley Austin LLP, "Proposal to Recast the Energy Taxation Directive," accessed March 9, 2022, https://www.sidley.com/en/-/media/uploads/sidley-eu-fit-for-55-white-papers/proposal-to-recast-the-energy-taxation-directive-12.pdf.

8 KPMG Global, "Energy Taxation Directive."

9 Eurostat, "Simplifed Energy Balances," accessed February 15, 2022, https://ec.europa.eu/eurostat/databrowser/view/NRG_BAL_S__custom_2100817/default/table?lang=en.

10 Claudio Marcantonini et al., *Free Allowance Allocation in the EU ETS*, 2017, https://doi.org/10.2870/55486.

11 "Emissions Cap and Allowances," accessed February 16, 2022, https://ec.europa.eu/clima/eu-action/eu-emissions-trading-system-eu-ets/emissions-cap-and-allowances_en.

12 International Energy Agency, "Implementing Effective Emissions Trading Systems: Lessons from International Experiences," July 2020, https://iea.blob.core.windows.net/assets/2551e81a-a401-43a4-bebd-a52e5a8fc853/Implementing_Effective_Emissions_Trading_Systems.pdf.

13 "Use of International Credits," accessed February 16, 2022, https://ec.europa.eu/clima/eu-action/eu-emissions-trading-system-eu-ets/use-international-credits_en.

three European Economic Area states (Iceland, Liechtenstein, and Norway) and covers roughly 40% of emissions generated within the region.[14]

Over its more than 15-year lifetime, the ETS has been enlarged in several phases. Each phase has expanded the scope of industries covered, provided new compliance mechanisms, and enhanced penalties for non-compliance. The latest ETS proposals under the "Fit for 55" revisions increase the level of ambition for Phase 4 (2021-2030) of the program. Proposed revisions will increase the linear reduction factor (i.e., the annual decline in emissions allowed in the cap) from 2.2% to 4.2%, expand the program to cover road and marine transport emissions, and, most relevant to aviation, phase out free allocation for aviation allowances.

Beginning with Phase 3 of the ETS (2013-2020) aviation emissions and allowances (known in Europe as EUAAs) are tracked and auctioned separately from stationary sources under an aviation-specific cap. This cap was originally set at 38 million allowances in 2013, or 95% of the average annual emissions between 2004 and 2006.[15] Due to the rapid increase in demand for air travel, the aviation cap covered only 50% of emissions generated from the aviation sector in 2019, and is expected to cover only 30% of emissions in 2030.[16] Aviation sector GHG emissions that are generated above the cap require surrendering allowances purchased through the economy-wide auctioning system.

Relative to some other sectors, the ETS requirements for aviation are lenient. Aviation emissions were not regulated until 2013 and EU airlines were granted 82% of allowances at no cost via free allocation; an additional 3% of allowances were reserved for new and fast-growing airlines through Phase 3 of the program.[17] Thus, airlines purchased only 15% of allowances at auction in addition to allowances for emissions generated above the annual cap. For example, of the 55 million tonnes (Mt) of aviation sector emissions generated in 2019, 4.75 Mt were auctioned under the aviation cap while an additional 25.5 million Mt of CO_2 were auctioned economy-wide. In total, airlines spent an estimated €590 million, or 10% of operating revenue, on ETS allowances in 2019.[18]

Policymakers have justified the need for free emission allowances to support sensitive industries and to mitigate the risk of carbon leakage, that is, the likelihood that industries will relocate outside the EU (yet continue to sell products in the EU) to circumvent ETS compliance obligations. However, little evidence has been found to support the latter claim for aviation.[19] In an effort to strengthen the EU ETS's impact on aviation emissions, the Commission has proposed to phase out free aviation sector allowances beginning in 2024. That year, freely allocated EUAAs will be restricted to 75% of current levels and follow a linear phase-out through 2027, to 0%.[20] Thus, the quantity of auctioned EUAAs and the annual emissions cap for aviation will converge by late-decade.

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14 International Carbon Action Partnership, "EU Emissions Trading System (ETS)," November 17, 2021, https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems%5B%5D=43.

15 Jakob Graichen and Verena Graichen, "Analysis of Potential Reforms of Aviation's Inclusion in the EU ETS" (Oeko Institut e.V., January 30, 2020), https://www.transportenvironment.org/wp-content/uploads/2021/07/2020_11_Oko_Institute_analysis_potential_reforms_aviation_inclusion_ETS.pdf.

16 "Amending Directive 2003/87/EC Establishing a Scheme for Greenhouse Gas Emission Allowance Trading within the Community in View of the Implementation of a Single Global Market-Based Measure to International Aviation Emissions," February 3, 2017, https://doi.org/10.5040/9781782258674.

17 "Amending Directive 2003/87/EC Establishing a Scheme for Greenhouse Gas Emission Allowance Trading within the Community in View of the Implementation of a Single Global Market-Based Measure to International Aviation Emissions," 87.

18 Jennifer Janzen, "European Airlines Will Pay Over €5 Billion in Environmental Taxes and ETS Contributions in 2019," Airlines for Europe, July 10, 2019, https://a4e.eu/publications/european-airlines-will-pay-over-e5-billion-in-environmental-taxes-and-ets-contributions-in-2019/.

19 Marcantonini et al., *Free Allowance Allocation in the EU ETS*.

20 European Commission, "Amending Directive 2003/87/EC as Regards Aviation's Contribution to the Union's Economy-Wide Emission Reduction Target and Appropriately Implementing a Global Market-Based Measure" (2021), 87, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021PC0552&from=EN.

The EU ETS has shown a limited capacity to incorporate carbon pricing into aviation due to the low cost of allowances and the use of free allocation. Because the bulk of aviation allowances (i.e., EUAAs) are given away at no cost and EUAAs cannot be traded outside the aviation sector, the cost for airlines to emit a tonne of GHG emissions is lower than the compliance cost for other obligated sectors.[21] We expect EUAAs and economy-wide allowances (i.e., EUAs) to reach cost parity under the proposed ETS revisions as free auctions are phased out through 2030 and as all future allowances are eligible for banking.

Although the proposed ETS revisions will increase the stringency of the program, these changes will apply only to flights operating within the EEA and to the United Kingdom, accounting for approximately 20% of global aviation carbon dioxide emissions.[22] Rather than expand its jurisdiction to the entire EU ETS, the Commission has proposed that the international Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) program govern GHG emission requirements for the remainder of flights departing from or arriving in the EEA from an outside location.[23]

ReFuelEU

The proposed ReFuelEU regulation is intended to support growth of the EU sustainable aviation fuel industry by setting mandatory blending targets for alternative fuels. Under the most recent proposal, both a 5% general SAF blend mandate and 0.7% power-to-liquid (PtL) sub-mandate are set for 2030; annual targets increase up to a 63% blending mandate and 28% PtL sub-mandate in 2050.[24] Fuel suppliers are obligated to deliver jet fuel containing the minimum share of SAF in a given year to qualifying airports across the EU, to demonstrate compliance.

SAF uptake has remained low for a variety of reasons, largely due to lack of policy incentives to use SAFs and to the significant cost gap between SAFs and conventional jet fuel.[25] Depending on the SAF pathway in question, SAFs may cost from two to seven times as much as an equivalent quantity of fossil jet fuel. The proposed ReFuelEU regulation notes the importance of aligning its objectives with other policies such as the ETS to reduce the economic burden on SAF aircraft operators.[26] Critically, a major drawback to ReFuelEU is that it does not establish direct funding streams or incentives to support investment in new aviation technologies, nor does it support their deployment during the early phases of the program. The proposal does stipulate that fines for non-compliance must be invested under the InvestEU sustainable recovery program (Article 11 para. 7).[27]

The expanded scope of the ETD and ETS presents a valuable opportunity to spur decarbonization of the aviation sector, by increasing the cost of emissions and by potentially creating new revenue streams that can be directly reinvested in the nascent

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21 Emilie Alberola and Boris Solier, "Including International Aviation in the European Union Emissions Trading Scheme: A First Step towards a Global Scheme?" (CDC Climat Research, August 2012).

22 ICF Consulting et al., "Assessment of ICAO's Global Market-Based Measure (CORSIA) Pursuant to Article 28b and for Studying Cost Pass-through Pursuant to Article 3d of the EU ETS Directive" (European Commission, September 2020), https://www.actu-environnement.com/media/pdf/news-37353-Etude-commission-europenne-corsia-compensation-carbone-aviation.pdf.

23 ICAO, "Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)," accessed January 28, 2022, https://www.icao.int/environmental-protection/CORSIA/Pages/default.aspx.

24 European Commission, "Proposal for a Regulation of the European Parliament and of the Council on Ensuring a Level Playing Field for Sustainable Air Transport," July 14, 2021, https://ec.europa.eu/info/sites/default/files/refueleu_aviation_-_sustainable_aviation_fuels.pdf.

25 Nikita Pavlenko, Stephanie Searle, and Adam Christensen, "The Cost of Supporting Alternative Jet Fuels in the European Union" (ICCT: Washington, DC, March 20, 2019), https://theicct.org/publication/the-cost-of-supporting-alternative-jet-fuels-in-the-european-union/.

26 European Commission, "Proposal for a Regulation of the European Parliament and of the Council on Ensuring a Level Playing Field for Sustainable Air Transport."

27 European Investment Bank, "InvestEU," EIB.org, accessed March 28, 2022, https://www.eib.org/en/products/mandates-partnerships/investeu/index.htm.

SAF industry. In the next section, we estimate the volume of financial flows these policies could generate and their contribution to closing the gap in production cost between SAFs and conventional jet fuel.

QUANTIFYING THE VALUE OF THE FIT FOR 55 AVIATION PROPOSALS

Assumptions

We estimate the total amount of government revenue that could be generated in 2030 if all "Fit for 55" proposals are implemented. We assume a 2% annual compound growth rate in aviation traffic demand,[28] based on projected 2018-2050 passenger growth rates in the EU,[29] paired with a 2% annual aircraft efficiency improvement based on 2013-2019 fuel efficiency data.[30] Future year projections do not account for suppressed demand due to disruptions from the COVID-19 pandemic. We assume that the ETS aviation cap declines by 2.2% annually from 28.24 Mtonnes over 2021–2022, and by 4.2% through the remainder of the period under the new ETS proposal. We assume that the share of freely allocated allowances is set at 85% through 2024, then declines incrementally to 0% in 2027 (Figure 1). We also estimate emissions in excess of the aviation cap, which decrease by 0.5% annually, assuming a flat rate in fuel demand and a 0.5% increase in the rate of SAF consumption due to ReFuelEU.

An overview of changes in the share of aviation allowances is presented in Figure 1. Free allowances given under the annual cap are shown in brown while the remaining allowances sold under the cap are shown in teal. Allowances purchased in the economy-wide ETS market (i.e., EUAs) for emissions generated in excess of the cap are shown in red. Purchased allowances make up a greater share of EUAAs over time as freely allocated allowances phase out. The quantity of EUAs also increases as the aviation cap declines.

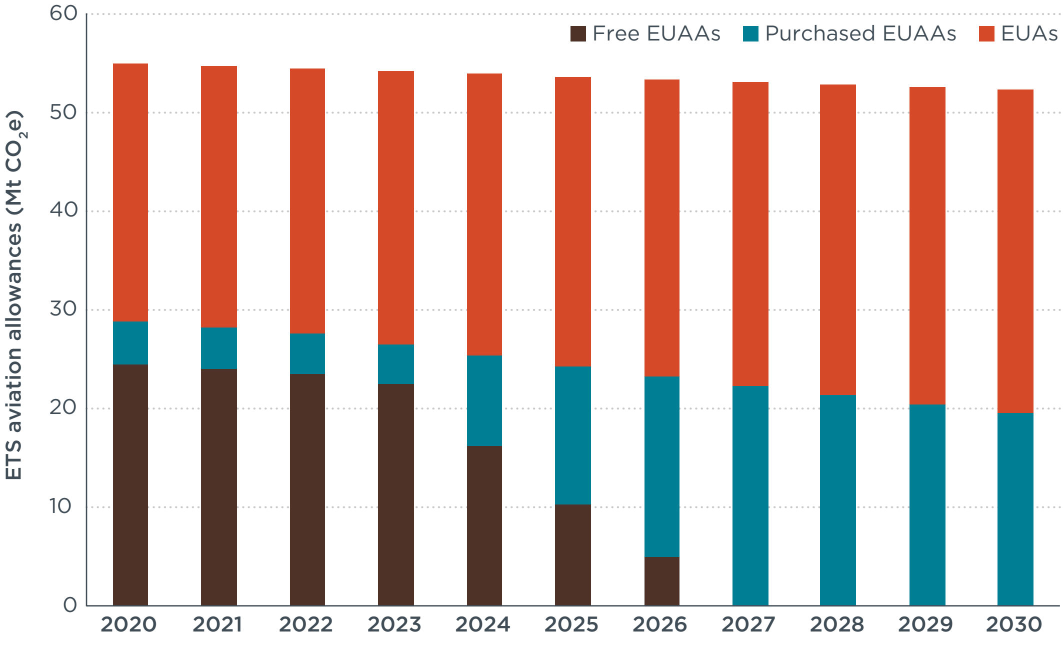

Figure 1. Share of ETS aviation allowances through 2030. EUAs represent economy-wide allowances while EUAAs are aviation-specific allowances.

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28 European Environment Agency, "EEA GHG Data Viewer," Page, November 16, 2020, https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer.

29 Royal Netherlands Aerospace Centre and SEO Amsterdam Economics, "Destination 2050: A Route to Net Zero European Aviation," Prepared for: A4E, ACI-Europe, ASD, CANSA, ERA, February 2021, https://www.destination2050.eu/wp-content/uploads/2021/03/Destination2050_Report.pdf.

30 Brandon Graver, Dan Rutherford, and Sola Zheng, "CO2 Emissions from Commercial Aviation: 2013, 2018, and 2019" (ICCT, October 2020).

To estimate ETS revenue, we assume a mid-range 2030 carbon price of €85/tonne CO_2e based on projections from ICIS, BloombergNEF, and the European Commission.[31] At the low end of projections, 2030 carbon prices may be as low as €50/tonne of abated CO_2e.[32] At the high-end range, we assume a price of €110/tonne based on BloombergNEF predictions. ETS carbon prices are dependent on the supply of allowances, level of program ambition, and the wholesale price of fossil fuels.[33] In 2021, the average EUA traded at €53/tonne CO_2e.[34] Due to significant uncertainty in future EUA prices, we calculate total ETS revenue under low-, mid-, and high-range carbon price estimates.

We refer to a study by Pavlenko et al. for the levelized cost of biomass-based SAF production pathways in the EU.[35] Levelized costs of production range between €0.88 and €2.4 per liter and vary based on technology and type of feedstock. For each technology pathway, we choose the median price for our estimates. For synthetic SAF production costs, we refer to a recent study by Zhou et al, which estimates that synthetic SAF costs are equivalent to €2.78 per liter today and decline to €2.07 per liter in 2030 as technology matures and renewable electricity prices decrease.[36] We assume that conventional jet fuel costs will return to pre-pandemic levels at roughly €0.58/liter.[37]

RESULTS

We summarize the amount of revenue that could be generated under the revised ETS, of which a share could be directed toward the aviation sector to support scale-up of the EU SAF industry. The ETD will continue to provide a source of revenue for Member States, although the level of financial support it could provide for SAFs is less clear. Our calculations are based on current policy proposals that are likely to be modified before they are adopted by the European Commission.

Assuming a median 2030 ETS carbon price of €85/tonne, we estimate that aviation allowances could generate €4.45 billion in revenue. Roughly 37% of that revenue, or €1.7 billion, will come directly from EUAAs auctioned under the aviation cap. The remainder will come from allowances purchased in the economy-wide market. A summary of our total revenue estimates is presented in Table 2 below for illustration. We assume that both updated policies take effect in 2023 and that low-, medium- and high- EUA prices remain constant through 2030.

31 Ewa Krukowska, "Europe CO_2 Prices May Rise More Than 50% by 2030, EU Draft Shows," Bloomberg, June 29, 2021, https://www.bloomberg.com/news/articles/2021-06-29/europe-co2-prices-may-rise-more-than-50-by-2030-eu-draft-shows; Frédéric Simon, "Analyst: EU Carbon Price on Track to Reach €90 by 2030," www.euractiv.com, July 19, 2021, https://www.euractiv.com/section/emissions-trading-scheme/interview/analyst-eu-carbon-price-on-track-to-reach-e90-by-2030/.

32 European Commission, "Proposal for a Directive of the European Parliament and of the Council Amending Directive 2003/87/EC Establishing a System for Greenhouse Gas Emission Allowance Trading within the Union, Decision (EU) 2015/1814 Concerning the Establishment and Operation of a Market Stability Reserve for the Union Greenhouse Gas Emission Trading Scheme and Regulation (EU) 2015/757," July 14, 2021, https://ec.europa.eu/info/sites/default/files/revision-eu-ets_with-annex_en_0.pdf.

33 Simon, "Analyst."

34 Frank Watson, "Commodities 2022: EU on Collision Course with Shipping over Carbon Market Reforms," December 23, 2021, 202, https://www.spglobal.com/platts/en/market-insights/latest-news/energy-transition/122321-commodities-2022-eu-on-collision-course-with-shipping-over-carbon-market-reforms.

35 Pavlenko, Searle, and Christensen, "The Cost of Supporting Alternative Jet Fuels in the European Union."

36 Yuanrong Zhou, Stephanie Searle, and Nikita Pavlenko, "Current and Future Cost of E-Kerosene in the United States and Europe" (ICCT: Washington, DC, March 2022).

37 IATA, "Jet Fuel Price Monitor," accessed January 28, 2022, https://www.iata.org/en/publications/economics/fuel-monitor/.

Table 2. Annual estimated ETS revenue through 2030. Total revenue assumes an 85 EUR/t carbon trading price.

Year	EUA revenue (€ billion)	EUAA revenue (€ billion)			Total revenue (€ billion)
		Low (€50/t)	Medium (€85/t)	High (€110/t)	
2019	2.2	0.2	0.4	0.5	2.6
2020	2.2	0.2	0.4	0.5	2.6
2021	2.3	0.2	0.4	0.5	2.6
2022	2.3	0.2	0.4	0.5	2.6
2023	2.4	0.2	0.3	0.4	2.7
2024	2.4	0.5	0.8	1.0	3.2
2025	2.5	0.7	1.2	1.5	3.7
2026	2.6	0.9	1.6	2.0	4.1
2027	2.6	1.1	1.9	2.5	4.5
2028	2.7	1.1	1.8	2.3	4.5
2029	2.7	1.0	1.7	2.2	4.5
2030	2.8	1.0	1.7	2.2	4.4

Critically, the combination of the ETD and ETS revisions could also narrow the cost gap between SAFs and conventional fossil jet fuel; however, there are large differences in the cost gap depending on the SAF pathway in question. Figure 2 compares the present-day cost of fossil kerosene with a selection of SAF conversion pathways, taking into account fuel taxes and carbon pricing. The levelized production cost of fuel from each pathway is shown in brown, and the carbon price, equivalent to the average price of an ETS aviation allowance (i.e., EUAA), is shown in red. SAF is ascribed zero emissions under the ETS, so its cost is not affected by the allowance price. No Member States have entered into bilateral agreements to tax jet kerosene, so we also exclude potential ETD taxes from our 2020 cost comparisons.

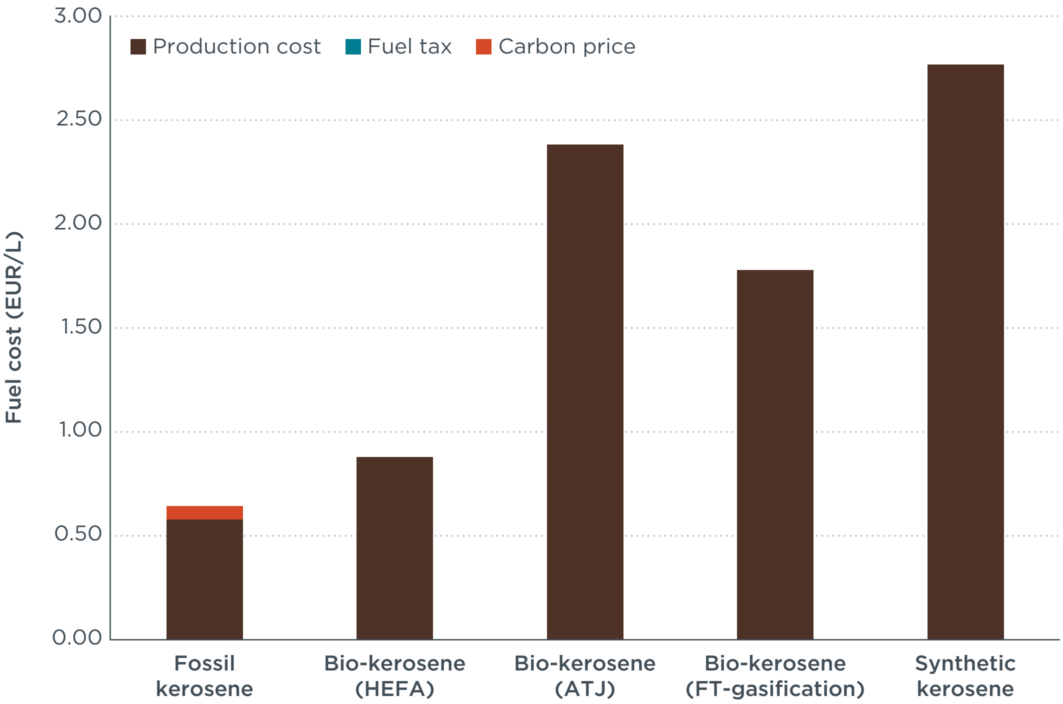

Figure 2. Median jet fuel costs by primary conversion pathway (2020).

Hydroprocessing waste oils is the lowest cost and most technologically mature technology pathway today, accounting for the majority of SAF produced in the EU;[38] this pathway has the narrowest cost gap, €0.24/l. In contrast, more technologically demanding pathways such as alcohol-to-jet upgrading of biomass feedstocks and synthetic kerosene (i.e., electrofuels) have a higher cost gap, due in part to high capital costs and lower technological readiness; these pathways have a current cost gap of €1.75-2.13/l.[39] The Fischer-Tropsch (FT) gasification process converts low-cost feedstocks such as agricultural and forestry wastes to fuel but has high capital costs, and a cost gap of €1.14/l.

Figure 3 illustrates the effective cost of fossil kerosene compared to the set of SAF pathways in 2030. Consistent with Figure 2, levelized production costs are shown in brown, fully implemented fuel taxes under the revised ETD proposal are shown in teal, and the 2030 aviation allowance price is shown in red. The proposed changes to the ETD and ETS will raise the cost of jet kerosene consumed on domestic and intra-EEA flights by €0.52 per liter at a carbon price of €85/t. Further, the expanded ETD will also raise the cost of advanced bio- and synthetic kerosene marginally, increasing it by €0.0051/l. The production cost of HEFA is lower than the effective cost of fossil jet fuel under the proposed revisions while the cost gap for ATJ and FT-gasification narrow to €1.23/l and 0.62/l, respectively. Ongoing declines in the cost of producing renewable energy[40] could help narrow the synthetic kerosene cost gap further to €0.91/l.

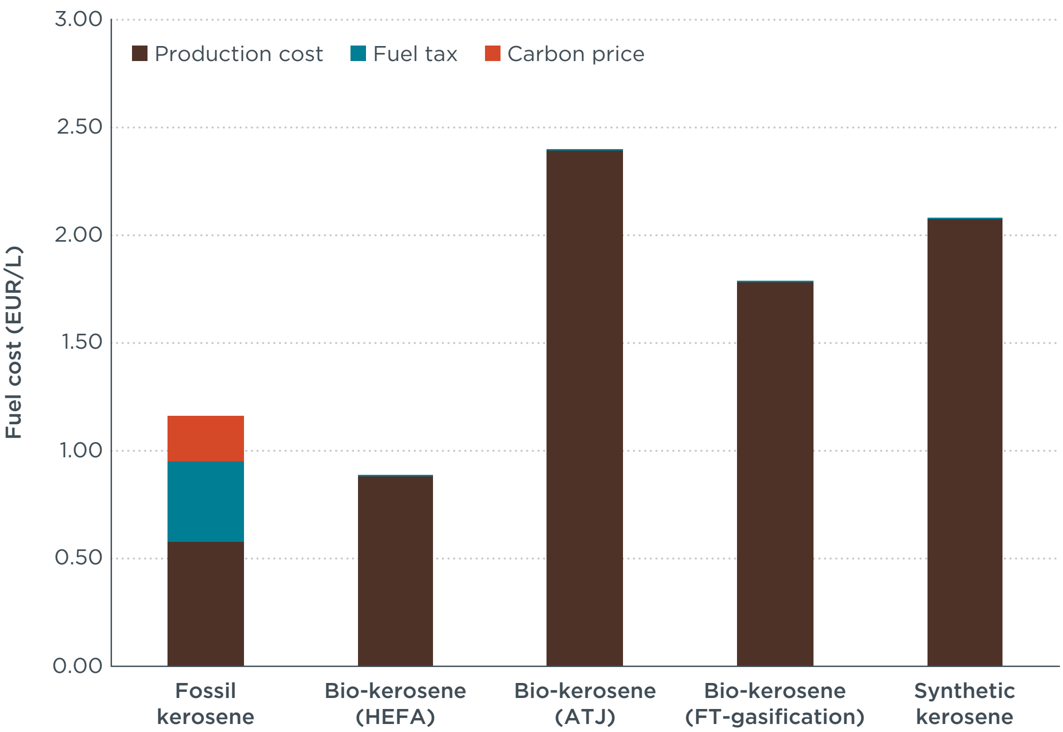

Figure 3. Median jet fuel costs by primary conversion pathway (2030).

We estimate that through ReFuelEU, the EU aviation sector is obligated to blend approximately 2.95 billion liters of SAF in 2030, including 410 million liters of synthetic

38 Susan van Dyk and Jack Saddler, "Progress in Commercialization of Biojet /Sustainable Aviation Fuels (SAF): Technologies, Potential and Challenges" (IEA Bioenergy, May 2021).

39 Pavlenko, Searle, and Christensen, "The Cost of Supporting Alternative Jet Fuels in the European Union."

40 Stephanie Searle and Adam Christensen, "Decarbonization Potential of Electrofuels in the European Union" (ICCT: Washington, DC, September 20, 2018), https://theicct.org/publication/decarbonization-potential-of-electrofuels-in-the-european-union/.

kerosene. We calculate these volumes based on 2030 ReFuel EU blending targets and our 2030 EU-27 aviation fuel demand projections. Closing the average funding gap of €0.62/l across all SAF pathways would require approximately €1.84 billion in additional funding for the SAF industry. We calculate the funding gap based on the average cost differential between alternative and fossil jet kerosene across all pathways in 2030.

DISCUSSION

As illustrated above, the proposed revisions to the ETD and ETS could be leveraged to both raise the cost of fossil jet fuel and generate revenue to reinvest in SAF production and technology development. We estimate that approximately €1.84 billion is needed to close the 2030 SAF production cost gap. Aviation allowances (i.e., EUAAs) purchased under the ETS could provide a dedicated funding stream for SAF scale-up. Under a medium carbon price scenario, EUAAs could generate €1.7 billion in revenue, falling short of our estimated production cost differential. Additional funding could be directed from general ETS allowances (i.e., EUAs) or ETD tax revenue, although these funding streams are currently pooled under general Member State budgets.

Though waste oil-derived HEFA SAFs are a cheaper near-term technology, feedstock availability constraints for waste oils mean that meeting the ReFuelEU blending targets will require scaling up SAF production from more challenging SAF pathways that utilize more sustainable and abundant feedstocks. HEFA fuel is by far the cheapest SAF pathway with a current cost gap of between €0.24 and 0.30/l, assuming 2019 tax rates and 2019 carbon pricing for domestic and intra-EEA flights and international flights, respectively. The cost gap for other pathways is between €1.14 and 2.13 per liter of fuel for domestic and intra-EEA flights and €1.20–2.20/l for international ones. These results indicate that HEFA already requires little additional financial support to compete with fossil jet. Furthermore, HEFA output will be constrained by feedstock availability and competing demands from the on-road sector in the coming years. O'Malley et al. estimate that availability constraints will restrict HEFA output to a maximum 1.5 billion liters per year, or 1.9% of 2030 EU-27 jet fuel demand.[41]

To move beyond HEFA fuels and meaningfully introduce lower-carbon advanced and synthetic fuels into the market, the EU could use EUAA auction revenue to scale up the SAF sector and a portion of ETD and EUA revenue to better align the regulation with long-term climate goals. This would require all of EUAA auction revenue plus 6% of EUA revenue, or €0.17 billion, to close the 2030 production cost gap. This cost gap will become increasingly hard to bridge when mandatory blending targets increase to 15% in 2035. In later years, additional revenue sources such as frequent flier levies may be needed to sustain the SAF industry's cost-competitiveness.[42] Reinvestment could come in the form of direct fiscal incentives such as capital grants, low-interest loans, and public-private partnership (PPP) contracts.[43] In the longer term, mechanisms such as contracts for difference (CfDs) could provide a guaranteed funding stream to subsidize higher-cost SAF projects. CfDs are a financial agreement between a fuel producer (i.e., seller) and government agency (i.e., buyer) that establish a fixed value for the price of fuel sold over a set contract period (e.g., ten years). If the market value of fuel falls below the price floor, the buyer agrees to compensate the seller for the cost

41 Jane O'Malley, Nikita Pavlenko, and Stephanie Searle, "Estimating Sustainable Aviation Fuel Feedstock Availability to Meet Growing European Union Demand" (ICCT: Washington, DC, March 8, 2021), https://theicct.org/publication/estimating-sustainable-aviation-fuel-feedstock-availability-to-meet-growing-european-union-demand/.

42 Sola Zheng and Dan Rutherford, "Design Principles for a Global Frequent Flyer Levy" (ICCT, *In Press).*

43 Nikita Pavlenko, "An Assessment of the Policy Options for Driving Sustainable Aviation Fuels in the European Union" (ICCT: Washington, DC, April 1, 2021), https://theicct.org/publication/an-assessment-of-the-policy-options-for-driving-sustainable-aviation-fuels-in-the-european-union/.

difference. Likewise, if the value of fuel fluctuates above the price floor, the seller must compensate the buyer.

In addition to providing new funding streams, the revised ETD and ETS proposals will raise the cost of conventional jet fuel, making investments in aircraft operations and efficiency improvements more appealing. Airlines can reduce emissions by replacing old aircraft with more efficient models, improving operations to carry more weight per flight, and seeking out optimal flight paths via advanced air traffic management.[44] In combination, we estimate that these measures could reduce emissions by 2% annually, reflected in the above calculations. Emission reductions may also come at the consumer level in the form of reduced demand due to higher carbon trading prices. In the longer term, the EU could also expand the ETS legal scope to cover the entirety of emissions generated from flights within and departing from the EU; this would expand the coverage of the ETS carbon pricing and generate additional revenue for reinvestment. Implementing jet kerosene taxation on select international flights via bilateral service agreements could raise revenue to a lesser degree.

We find that together ETD and ETS will raise the cost of conventional jet fuel and generate an attractive pool of revenue to support scale-up of the EU SAF industry. Together, these proposed policy changes can improve the feasibility of meeting the ambitious ReFuelEU blending targets and sustaining the emerging SAF industry in its early stages. Targeted investment in second-generation SAF pathways, rather than existing, commercialized fuels in the near-term, will be especially important to scale up the industry to meet long-term targets. The proposed set of "Fit for 55" aviation policies, each on its own, are likely insufficient to decarbonize the aviation sector, but can be much more effective as complementary measures.

44 Daniel Rutherford, "Standards to Promote Airline Fuel Efficiency" (ICCT: Washington, DC, May 8, 2020), https://theicct.org/publication/standards-to-promote-airline-fuel-efficiency/.