BRIEFING

APRIL 2021

An assessment of the policy options for driving sustainable aviation fuels in the European Union

Nikita Pavlenko

The European Green Deal, initially presented in 2019, puts forward an ambitious vision of a net zero-emissions European Union by 2050 that will necessitate large-scale reductions of greenhouse gas (GHG) emissions in even the most challenging economic sectors.[1] The European Commission's 2020 ReFuelEU Aviation Initiative, which aims to boost the production and supply of sustainable aviation fuels (SAFs), will shape the development of the European SAF sector and could become an important part of the policy landscape for decarbonizing European aviation. At this early stage of SAF industry growth, it is critical that public policies pursue a long-term vision and guide investment and development toward those technologies that are capable of delivering long-term decarbonization.

Because voluntary efforts by airlines to develop SAFs have failed, European governments are now considering policy options to accelerate their uptake, including mandates. Rather than mirroring the past decade of biofuel deployment in the road sector, which has been met with political controversy over the use of food-based biofuels and disappointment over the slow adoption of advanced fuels, the European Union has an opportunity to learn from mistakes and improve on its process. This briefing paper summarizes the policy options for the deployment of SAFs in the EU context and discusses their benefits and drawbacks. Drawing on lessons learned from the difficulties of motivating advanced biofuel production in the road sector, we assess the potential impact of different policy options for supporting the commercialization of advanced SAFs produced using novel or emerging conversion technologies. Based on this assessment, we provide recommendations for policy design for EU SAF initiatives.

1 Communication (2019) 640 final of the European Commission. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of Regions —The European Green Deal, COM/2019/640 final, 11/12/2019, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52019DC0640.

www.theicct.org

communications@theicct.org

twitter @theicct

Acknowledgments: Thanks to Dan Rutherford of the ICCT, Laura Buffet and Andrew Murphy of Transport & Environment for providing helpful review.

THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

BACKGROUND

The European Union has made substantial progress in decarbonizing its economy, reducing overall emissions as of 2018 by more than 20% from 1990 levels. And yet, EU aviation GHG emissions stubbornly continue to rise.[2] The total emissions from aviation in the European Union including international flights to and from the bloc grew to 144 million tonnes of carbon dioxide equivalents (CO_2e) in 2018, reflecting a five-year compound annual growth rate of 4.5%.[3] Of the emissions covered by the EU emissions trading scheme (ETS), primarily those within the European Economic Area (EEA), emissions increased by 27.6% from 2013 levels.[4] Figure 1 illustrates emissions growth through 2018 and projected increases from 2019 onward, showing the relative shares of emissions from intra-EEA flights covered by the ETS and international flights exempt from it, assuming 4.5% annual growth and a 2% annual fuel efficiency improvement for aircraft.[5] These projections do not factor in the impact of COVID-19 on air travel, which may have reduced 2020 air travel by more than half and makes future projections even more uncertain.[6] Short of curbing demand for aviation, increasing the uptake of SAFs in place of conventional jet fuel is one of the only methods for achieving in-sector GHG reductions.

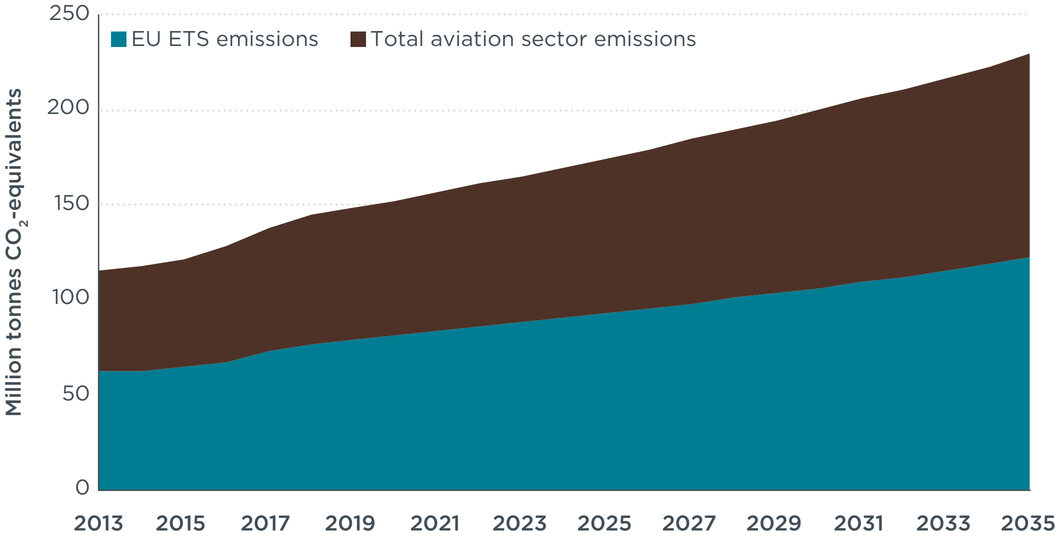

Figure 1: Projected growth of aviation emissions in the European Union, including emissions covered under the emissions trading scheme

The inclusion of aviation in the European Union's emissions trading scheme has done little to curb the growth of aviation emissions. In part, the effectiveness of the ETS has been influenced by uncertainty about its scope and mandate. Almost immediately after aviation was added to the ETS, covered flights within the program were restricted to those between countries of the European Economic Area and domestic flights within those countries, leaving the issue of international aviation emissions to a future, agreed-upon global market-based measure developed by the International Civil Aviation

2 Eurostat (Greenhouse gas emission statistics—emission inventories, accessed August 12, 2020), https://ec.europa.eu/eurostat/statistics-explained/index.php/Greenhouse_gas_emission_statistics

3 European Environment Agency (EEA greenhouse gas—data viewer, accessed August 12, 2020), https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer.

4 European Environment Agency (EU Emissions Trading System (ETS) data viewer, accessed August 12, 2020), https://www.eea.europa.eu/data-and-maps/dashboards/emissions-trading-viewer-1

5 Brandon Graver, Dan Rutherford, and Sola Zheng, *CO_2 Emissions from Commercial Aviation, 2013, 2018 and 2019,* (ICCT: Washington, DC, 2020). https://theicct.org/sites/default/files/publications/CO2-commercial-aviation-oct2020.pdf

6 International Air Traffic Association (IATA), "Remarks of Alexandre de Juniac at the IATA Media Briefing on COVID-19," (April 14, 2020). https://www.iata.org/en/pressroom/speeches/2020-04-14-01/

Organization (ICAO). After ICAO proposed the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) in 2016, the European Commission agreed to a review of aviation's future inclusion in the ETS, pending EU member state implementation of CORSIA and greater clarity on its environmental integrity.[7]

ICAO's CORSIA scheme provides a framework for tracking and crediting emission reductions or offsets from international aviation toward ICAO's goal of carbon-neutral growth for aviation after 2020.[8] ICAO is in the process of developing a carbon accounting framework and eligibility requirements for the use of SAFs within CORSIA for the purposes of claiming emission reductions, with an initial methodology and default values available for the pilot phase of CORSIA.[9] While SAFs can be used to generate emission reductions toward the CORSIA target, the primary mode of compliance with CORSIA is expected to be the increased purchase of out-of-sector carbon offsets. The International Air Transport Association (IATA) has asserted that CORSIA does not promote SAFs at all.[10] From a pure CORSIA compliance standpoint, the cost of deploying SAFs on a per-tonne of carbon abated basis are several orders of magnitude higher than purchasing carbon offsets, putting them at a strong economic disadvantage within the program.[11] Though CORSIA provides the methodology for crediting emission reductions from SAFs, ICAO has stated that the burden of deploying SAFs will fall upon individual nations.[12]

Despite years of sustained interest in SAFs, the industry has been slow to expand in the face of strong economic barriers to SAF deployment, reaching about 50 million L of neat fuels in 2019, or about 0.01% of global jet fuel use based on IATA estimates.[13] Seven pathways have been approved by the standards organization ASTM International for producing SAFs for commercial use, with multiple feedstocks suitable for each conversion pathway.[14] However, within those broad categories is substantial variation in GHG emissions, technical feasibility, and production costs. Figure 2 illustrates the per-liter costs of a selection of SAF pathways relative to petroleum jet fuel. For each pathway, the per-tonne CO_2e cost of GHG abatement is illustrated on the right-hand y-axis. The cost of GHG abatement across all fuel pathways is generally expensive, ranging from €200 to more than €3,000 per tonne of CO_2e, depending on the fuel.

The chart illustrates that generally hydroprocessed esters and fatty acids (HEFA) fuels are the cheapest to produce. However, some HEFA fuels do not reduce GHG emissions at all. While used cooking oil-derived SAFs are generally cheap to produce and have low emissions, HEFA produced from oilseeds such as palm costs more than petroleum jet fuel and results in greater GHG emissions on a life-cycle basis. Fuels made from

7 Regulation (EU) 2017/2392 of the European Parliament and of the Council amending Directive 2003/87/EC to continue current limitations of scope for aviation activities and to prepare to implement a global market-based measure from 2021. OJ L350/7, 29/12/2017), December 13, 2017. https://eur-lex.europa.eu/legalcontent/EN/TXT/PDF/?uri=CELEX:32017R2392&from=EN

8 International Civil Aviation Organization (ICAO), "Consolidated statement of continuing ICAO policies and practices related to environmental protection – Global Market-based Measure (MBM) scheme," Assembly Resolution A39-3, https://www.icao.int/environmental-protection/documents/resolution_a39_3.pdf

9 International Civil Aviation Organization (ICAO), "CORSIA Supporting Documents: CORSIA Eligible Fuels – Life Cycle Assessment Methodology," (2019). https://www.icao.int/environmental-protection/CORSIA/Documents/CORSIA%20Supporting%20Document_CORSIA%20Eligible%20Fuels_LCA%20Methodology.pdf

10 International Air Transport Association (IATA) "Countering Misinformation on Sustainable Aviation Fuels (blog post)," September 27, 2019, https://www.airlines.iata.org/blog/2019/09/countering-misinformation-on-sustainable-aviation-fuels .

11 Nikita Pavlenko, "ICAO's CORSIA scheme provides a weak nudge for in-sector carbon reductions (blog post)," ICCT staff blog, August 6, 2018, https://theicct.org/blog/staff/corsia-carbon-offsets-and-alternative-fuel

12 International Civil Aviation Organization (ICAO), "Consolidated statement of continuing ICAO policies and practices related to environmental protection - Climate change," Assembly Resolution A40-18, (2017) https://www.icao.int/environmental-protection/Documents/Assembly/Resolution_A40-18_Climate_Change.pdf

13 "Sustainable fuels remain vital," International Air Transport Association (IATA), July 1, 2020, https://airlines.iata.org/news/sustainable-fuels-remain-vital.

14 "Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons," ASTM International, www.astm.org/Standards/D7566.htm.

lignocellulosic wastes and residues are generally costlier than those produced from vegetable oils or waste fats, but they could provide cheaper GHG reductions than food crops. Overall, the fuels investigated cost two to six times the price of jet fuel today.

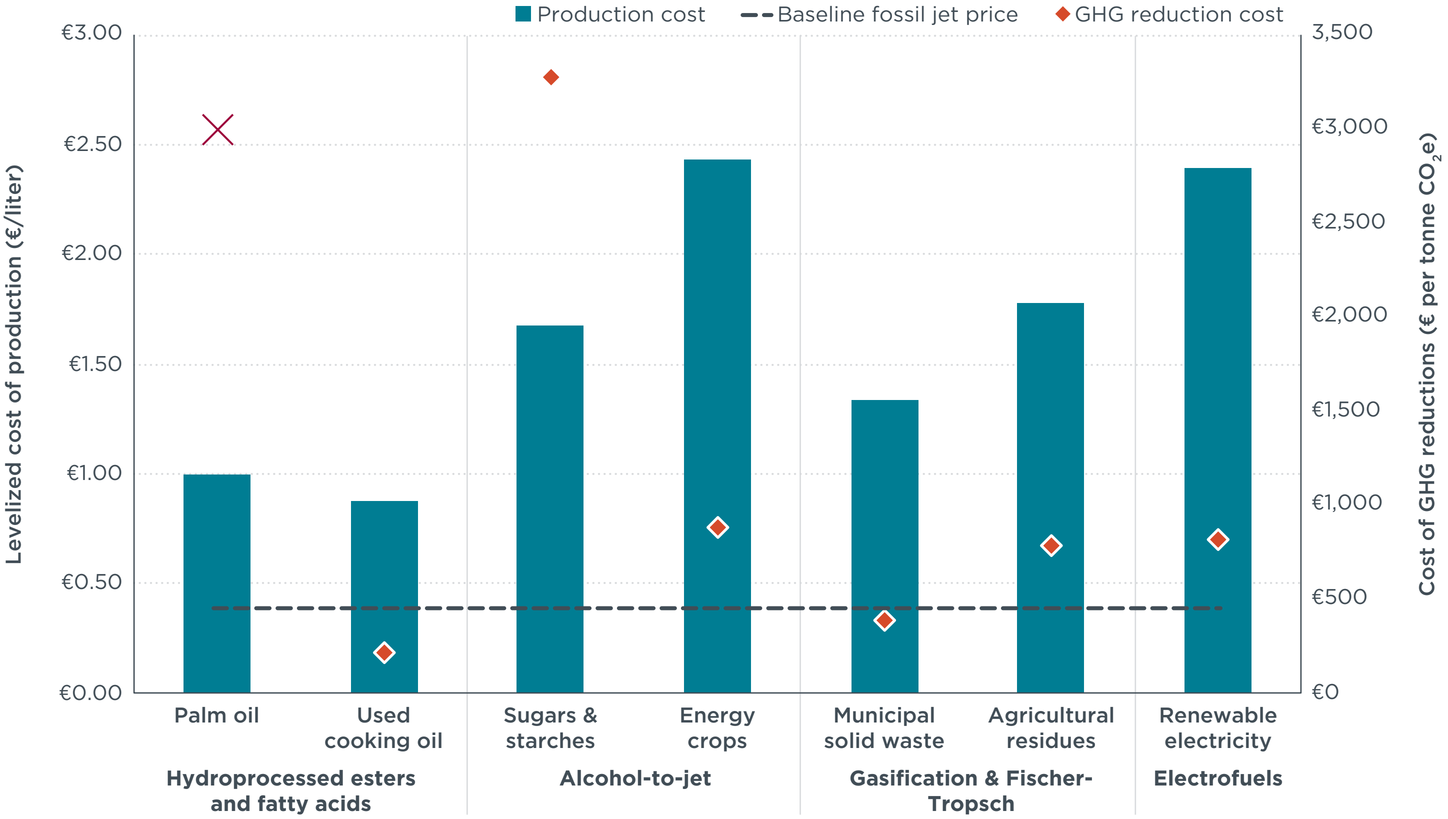

Figure 2: Estimated costs of selected sustainable aviation fuels relative to petroleum jet fuel price and their associated cost of GHG reductions

Note: Palm oil does not deliver any GHG reductions after taking into account indirect land-use change emissions; therefore, it does not have an associated cost of delivered carbon reductions. Source: Pavlenko, Searle, and Christensen, "The Cost of Supporting Alternative Jet Fuels in the European Union."

The cost disparity between SAFs and petroleum jet fuel illustrated in Figure 2 is even greater than in the road sector as petroleum kerosene generally commands a lower market value on an energy basis than road fuels and is untaxed. Furthermore, SAFs may require additional processing to meet specifications for drop-in use—or direct substitution—in airplanes compared with middle distillates produced for use in the road sector.[15] In conjunction with the lower relative life-cycle emissions for petroleum kerosene compared with petroleum diesel, it is more expensive to reduce emissions through SAFs than with road biofuels.

While policymakers have noted the strong performance of SAFs made from wastes and residues, or "advanced SAFs," the availability of these feedstocks is highly constrained. Some of the SAF feedstocks that offer the greatest carbon savings and technical feasibility, such as used cooking oil (UCO) and municipal solid waste (MSW), are also among the most limited.[16] Increased demand for low-carbon alternative fuels may drive competition between multiple sectors for these feedstocks, particularly the

15 Nikita Pavlenko, Stephanie Searle, and Adam Christensen, *The Cost of Supporting Alternative Jet Fuels in the European Union*, (ICCT: Washington, DC, 2019), https://theicct.org/sites/default/files/publications/Alternative_jet_fuels_cost_EU_2020_06_v3.pdf.

16 Jane O'Malley and Nikita Pavlenko, *Estimating the Sustainable Aviation Fuel Feedstock Availability to Meet Growing European Union Aviation Sector Demand*, (ICCT: Washington, DC, 2021), https://theicct.org/publications/sustainable-aviation-fuel-feedstock-eu-mar2021.

road sector, which may be able to bear higher costs.[17] For feedstocks with existing uses in other nontransport sectors, such as animal fats or palm fatty acid distillates (PFADs), diversion from those uses may generate indirect displacement emissions that undermine the benefits of SAF deployment.[18]

The substantial cost disparity between conventional petroleum jet fuel and SAFs necessitates policy intervention for the industry to grow. CORSIA does not include any binding measures to promote SAF uptake and is primarily a carbon offsetting scheme. The outlook for any mandatory blending targets on a global scale is uncertain, particularly for advanced SAFs. Therefore, an important consideration for European policymakers is how to fund SAF policies and where to impose the cost burden of decarbonization. Some European airlines have cited the imposition of an SAF mandate as economically prohibitive for their operations. Industry groups such as Airlines for Europe have stated a preference for a global blending mandate implemented as part of CORSIA, noting that a European Union-only policy would put European airlines at a competitive disadvantage because of the higher costs of SAFs.[19] As part of the public consultation for ReFuelEU, IATA warns against any policies that would increase the cost of air travel.[20]

The weak signal for in-sector decarbonization from the EU ETS and CORSIA underscores the necessity of policy intervention for overcoming the technical and economic constraints to the wide-scale use of SAFs. The ReFuelEU roadmap notes that the existing policy framework for SAFs, which includes the Renewable Energy Directive (RED), the ETS, and the European Taxation Directive have done little to spur SAF deployment and may need to be revisited under the Green Deal.[21] To supplement these policies, the European Commission is considering a selection of SAF policy measures with varying levels of market intervention. While no one policy is necessarily the solution to decarbonizing aviation and supporting the commercialization of the SAF industry, the right combination of incentives could provide a strong long-term signal for a transition away from petroleum kerosene.

POLICY MEASURES TO SUPPORT SAF DEPLOYMENT IN THE EUROPEAN UNION

In this section, we assess several policy options the European Union has for supporting SAF deployment. We evaluate each option's effectiveness in overcoming the barriers to SAF deployment, particularly on commercializing advanced SAFs made using wastes, residues, and electrofuels (renewable hydrogen and power-to-liquids). We also assess each policy option's implementation risks, particularly with respect to unintended sustainability consequences. The policy options we assess here include:

» **Energy, volume and blending mandates:** Binding targets for the aviation sector to utilize a certain quantity of SAFs by a target date.

» **Prioritization of SAFs through multipliers:** For policies that implement mandates for other transport sectors, this option provides for increased crediting of aviation fuels within those policies.

17 Stephanie Searle, Nikita Pavlenko, Anastasia Kharina, and Jacopo Giuntoli, *Long-Term Aviation FuelDecarbonization: Progress, Roadblocks, and Policy Opportunities*, (ICCT: Washington, DC:, 2019) https://theicct.org/sites/default/files/publications/Alternative_fuel_aviation_briefing_20190109.pdf.

18 Chris Malins, "Waste Not Want Not: Understanding the Greenhouse Gas Implications of Diverting Waste and Residual Materials to Biofuel Production" (Cerulogy, 2017), https://theicct.org/sites/default/files/publications/Waste-not-want-not_Cerulogy-Consultant-Report_August2017_vF.pdf.

19 "Position Paper: Production and Deployment of Sustainable Aviation Fuels in Europe." Airlines for Europe (n.d.).

20 "ReFuelEU Aviation: Sustainable Aviation Fuels—Inception impact assessment consultation," International Air Transport Association (IATA), Accessed October 4, 2020 https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12303-ReFuelEU-Aviation-Sustainable-Aviation-Fuels/feedback.

21 European Commission, "ReFuelEU Aviation—Sustainable Aviation Fuels. *Inception Impact Assessment*," (2020) https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12303-ReFuelEU-Aviation-Sustainable-Aviation-Fuels.

» **Greenhouse gas intensity targets**: This option would consist of a performance standard regulating the GHG intensity of the mix of aviation fuels consumed in the European Union.

» **Direct financial support:** This can include production subsidies, grants, and price guarantees to directly finance the production of SAFs.

ENERGY, VOLUME, AND BLENDING MANDATES

A mandate would require that a certain quantity of fuel for a given sector consist of specified fuels. Fuel mandates have ample precedents in the road sector, where many countries have already imposed them to increase the deployment of alternative fuels. Such a policy might consist of a mandate for the volume of fuel supplied, a mandate on the energy value of the fuel, or a blending mandate for the share of fuel consumption. Some examples include Brazil's 10% biodiesel blending mandate, the mandate for renewable energy in transport fuel in the RED, and the U.S. Renewable Fuel Standard (RFS) setting a mandate for volume. Critical policy design considerations for all three options include the target level of the mandate and the eligibility of fuels.

We can look to the design of the RED to illustrate one form in which a fuel mandate can be implemented. The recast RED (RED II) sets a target of 14% for energy supplied to road and rail transport to come from renewable energy sources by 2030. The directive also includes an eligibility framework for which fuels can count toward the 14% target. It also includes sub-targets for advanced biofuels and a cap for food-based biofuels' contribution, phasing down to zero for palm oil-based biofuel. At the same time, member states have some autonomy on how they implement the directive at the national level and can implement their own incentives and penalties to meet the overall transport energy target and sub-targets. For example, member states may further reduce the contribution of food-based biofuels or even certain feedstocks to the overall target.

The introduction of a future SAF mandate would have important implications for the RED II. The directive, along with other policies such as the U.S. RFS and the California Low-Carbon Fuel Standard (LCFS), place the obligation to supply renewable fuel on fuel suppliers. However, the ReFuelEU roadmap leaves open the possibility for obligating airlines directly. If obligations on SAF use were placed on airlines, it might create a case of split incentives between fuel producers and airline fuel customers, particularly if the SAF mandate and the RED II were to have different criteria for eligible fuels. Regulators such as the Swedish Ministry of Infrastructure suggest that implementing an obligation at the fuel supplier level is easier to implement.[22]

A key design consideration for any future SAF mandates is how high to set a requirement and when to set it. A mandate that exceeds the available quantity of sustainable SAF feedstocks or the technological limits for deployment would undermine the certainty of the policy. An assessment of EU sustainable availability of SAF feedstocks and their technological deployment rate estimates that advanced SAFs could contribute about 5.5% of the total projected EU jet fuel demand in 2035.[23] That analysis suggests that while reaching the first 2% of blending is possible using existing, commercialized technology and by diverting existing waste oil-derived renewable diesel production to aviation, the next phase of SAF deployment would be more uncertain and challenging. As a cautionary example, the RFS in the United States set an optimistic trajectory for cellulosic ethanol deployment based on the previous success of food-based ethanol. Production failed to live up to the mandates by wide

22 "Swedish comments on the inception impact assessment of ReFuelEU Aviation—Sustainable Aviation Fuels," Swedish Ministry of Infrastructure, accessed October 5, 2020. https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12303-ReFuelEU-Aviation-Sustainable-Aviation-Fuels/feedback.

23 O'Malley and Pavlenko, *Estimating the Sustainable Aviation Fuel Feedstock Availability to Meet Growing European Union Aviation Sector Demand*.

margins every single year, leading to constant revisions to the volume mandate. The U.S. Environmental Protection Agency revised its 2020 cellulosic fuel mandate to approximately 5% of the original statutory level, with most of the production coming from landfill biogas rather than liquid fuel.[24]

An ambitious mandate on its own may be insufficient to drive the growth of a new industry. For example, India has consistently missed meeting its ambitious biofuel targets.[25] Member states implementing EU directives may therefore need to couple SAF targets with incentives or penalties. To ensure compliance, some policies incorporate a noncompliance penalty, wherein obligated parties such as fossil fuel refiners or blenders pay a fee per unit of fuel or energy short of their obligation. For example, the United Kingdom's Renewable Transport Fuel Obligation has a buyout penalty of £0.30 per liter of fuel.[26] Likewise, the U.S. EPA may enforce a civil penalty on noncompliant parties for the RFS, levying a financial penalty for each day they are out of compliance.[27] Some jurisdictions also implement credit trading markets to facilitate more effective compliance, wherein certificates or credits for the unit of compliance, whether energy or volume, can be traded among alternative fuel producers and obligated parties. The combination of these approaches creates a value signal for blending alternative fuels, wherein their blending is economical up to the cost of a credit or the price of an avoided penalty. Rather than a direct government incentive for producers, this cost is typically borne by fossil fuel suppliers or producers, who might then pass down those costs to consumers in the form of higher fuel prices.

If the timeline of a mandate is too short or uncertain—particularly compared with the 10-plus year-lifetime of a biorefinery—the value signal from that policy may be weakened.[28] Deploying new SAF production may require several years of planning and construction before production of a single liter of SAF, increasing the risk for new producers. Establishing a long-term, stable target in conjunction with transparent compliance penalties should in theory help to stabilize the market and assure new producers that there will be a market for their future production. Establishing an initial policy target for the mandate and minimizing further, mid-timeline changes to compliance or fuel eligibility also aid in reducing regulatory uncertainty for producers.

Mandates generally incentivize the blending of the cheapest eligible alternative fuel. Historically, biofuel mandates have largely promoted cheaper, food-based biofuels rather than advanced fuels with higher production costs. Therefore, some policies have incorporated separate sub-targets or additional incentives for advanced fuels to encourage their production. For example, the RED II allows for advanced biofuels to count double toward the overall 14% target and includes a separate 3.5% target for advanced biofuels made from more challenging feedstocks.[29] The United Kingdom sets a higher buyout penalty for advanced fuels as part of its Renewable Transport Fuels

24 Congressional Research Service. "The Renewable Fuel Standard (RFS): An Overview." (Washington, DC: CRS, 2020). https://fas.org/sgp/crs/misc/R43325.pdf

25 U.S. Department of Agriculture, "India: Biofuels Annual 2019," (2019), https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Biofuels%20Annual_New%20Delhi_India_8-9-2019.pdf

26 "UK proposes to increase RTFO buyout price from 2021," *Argus Media*, July 28, 2020, https://www.argusmedia.com/en/news/2127109-uk-proposes-to-increase-rtfo-buyout-price-from-2021.

27 U.S. Environmental Protection Agency. "Civil Enforcement of the Renewable Fuel Standard Program." https://www.epa.gov/enforcement/civil-enforcement-renewable-fuel-standard-program.

28 Ibid.

29 Regulation (EU) 2017/2392 of the European Parliament and of the Council amending Directive 2003/87/EC to continue current limitations of scope for aviation activities and to prepare to implement a global market-based measure from 2021. OJ L350/7, 29/12/2017), December 13th, 2017. https://eur-lex.europa.eu/legalcontent/EN/TXT/PDF/?uri=CELEX:32017R2392&from=EN

Obligation of £0.80 per liter of fuel, more than twice that of the buyout price for the overall target.[30]

Targeted policy support may be necessary to back the most challenging technologies, which may otherwise be crowded out by other, cheaper compliance options. For example, electrofuels have high costs even in comparison with other advanced SAF pathways.[31] The combination of renewable electricity prices, conversion losses, and capital expenses make electrofuels particularly expensive to produce. One assessment estimates electrofuel production costs exceeding €2 per liter in 2030.[32] These challenges prompted Germany's Federal Ministry of the Environment (BMU) to propose an electrofuel sub-mandate of 2% of aviation fuel demand as part of its RED II implementation.[33]

The mix of fuels used to meet a mandate can have a substantial impact on its climate performance. While different SAFs may have similar properties at end use, their emissions can vary significantly based on feedstock and production pathways. A mandate met primarily through the deployment of food-based biofuels may be undermined by emissions from indirect land-use change (ILUC), which may cause the life-cycle emissions from some biofuels to approach or exceed those of the fossil fuels they are replacing.[34] Advanced fuels made from more challenging feedstocks generally have lower emissions than food-based biofuels but may be much more expensive to produce amid uncertain commercialization timelines and high upfront capital expenses.[35] Treating all fuels equally in a mandate makes it likely that cheaper, food-based biofuels would crowd out the contribution of more expensive advanced SAFs. To create a stronger policy signal for advanced pathways, it may be necessary to introduce eligibility criteria for fuels such as a minimum GHG reduction, taking into account ILUC emissions, or a positive list of qualifying fuel pathways. For example, the RED II presents a positive list of feedstocks that qualify for the 3.5% advanced biofuel sub-target.

REVISIONS TO MULTIPLIERS AND PRIORITIZATION OF SAFS

The recast Renewable Energy Directive (RED II) finalized in 2018 does not have an SAF mandate and within transportation mandates the use of renewable fuels in only the road and rail sectors. It does allow SAF and marine fuels to qualify toward meeting the road and rail renewable energy target. SAF and marine fuels can opt in to the target. The measure further incentivizes SAF and marine fuels by applying a multiplier for the amount of energy in advanced biofuels used in the aviation and marine sectors that counts toward the target.[36] This multiplier allows for the fuels to count 1.2 times toward

---

30 U.K. Department for Transport, "Consultation Outcome: Increasing the Renewable Transport Fuel Obligation buy-out price to ensure continued greenhouse gas savings., September 29, 2020. https://www.gov.uk/government/consultations/increasing-the-renewable-transport-fuel-obligation-buy-out-price-for-biofuels-suppliers/increasing-the-renewable-transport-fuel-obligation-buy-out-price-to-ensure-continued-greenhouse-gas-savings#:~:text=The%20RTFO%20buy%2Dout%20price%20has%20remained%20at%20%C2%A30.30,in%20it%20being%20%C2%A30.38.

31 Nikita Pavlenko, Stephanie Searle, and Adam Christensen, *The Cost of Supporting Alternative Jet Fuels in the European Union*, (ICCT: Washington, DC, 2019), https://theicct.org/sites/default/files/publications/Alternative_jet_fuels_cost_EU_2020_06_v3.pdf

32 Stephanie Searle and Adam Christensen, *Decarbonization Potential of Electrofuels in the European Union*, (ICCT: Washington, DC:, 2018), www.theicct.org/sites/default/files/publications/Electrofuels_Decarbonization_EU_20180920.pdf.

33 "Referentenentwurf eines Gesetzes zur Weiterentwicklung der Treibhausgasminderungs-Quote" [Draft of a bill for the further development of the greenhouse gas reduction quota]. Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit [Federal Ministry of the Environment, Nature Conservation and Nuclear Safety]. September 25, 2020. https://www.bmu.de/gesetz/referentenentwurf-eines-gesetzes-zur-weiterentwicklung-der-treibhausgasminderungs-quote/

34 Hugo Valin, Daan Peters, Maarten van den Berg, Stefan Frank, Petr Havlik, Nicklas Forsell, and Carlo Hamelinck, "The Land Use Change Impact of Biofuels Consumed in the EU: Quantification of Area and Greenhouse Gas Impacts." (IIASA, 2015). https:// ec.europa.eu/energy/sites/ener/files/documents/Final%20Report_GLOBIOM_publication.pdf.

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

36 European Union (EU). 2018. Directive (EU) 2018/2001 of the European Parliament and of the Council on the promotion of the use of energy from renewable sources (recast), Official Journal of the European Union, L 328/82, https://eur-lex.europa.eu/legalcontent/EN/TXT/PDF/?uri=CELEX:32018L2001&from=EN

the overall policy target, or 20% more than their level of delivered energy. Increasing the relative policy value for SAFs essentially prioritizes them within fuel policy so that an identical quantity of energy has differing compliance value depending on its end use. The European Commission is evaluating the multiplier levels within the RED II as a policy option for encouraging the deployment of SAFs through ReFuelEU.

Most SAF pathways generate a product slate of multiple fuels suitable for transportation. The relative ratios of these fuels depend on the configuration of the biorefinery.[37] Most SAFs in production today are in fact co-products of existing renewable diesel production from the hydrotreated vegetable oil (HVO) process. Because SAF was not clearly eligible as an opt-in fuel for the RED through 2020, it is likely that HVO facilities prioritized production of road diesel. The 1.2 multiplier in the REDII now incentivizes HVO facilities to prioritize SAF, so facilities might shift their product slates in response. Techno-economic analysis suggests that optimizing for higher jet fuel output bears an economic cost as well as reducing the overall quantity of liquid fuels produced. Of that reduced liquid fuel slate, a greater share would go toward displacing petroleum jet fuel, which has a lower carbon intensity than petroleum diesel, further reducing the net emissions benefit of fuel switching.[38] Thus, an SAF multiplier could actually reduce the immediate climate benefit of a fuel policy overall.

Research has also found that the 1.2 multiplier in the REDII may not be sufficient to stimulate new production of advanced SAFs that are not already being produced as a co-product from HVO facilities, such as electrofuels or advanced biofuels derived from lignocellulosic wastes and residues. It is more likely that the immediate effect would be to divert existing HVO production using waste oils or even virgin vegetable oils from the road sector. This change could increase the deployment of SAFs in the near term but would not necessarily do enough to motivate long-term growth in the industry.

GHG INTENSITY TARGETS

A GHG intensity target requires a reduction over time in the GHG intensity of the overall fuel mix used in a particular sector. This is another policy option to encourage the increased blending of SAFs. These policies establish a percentage reduction target relative to a baseline, such as the average carbon intensity of fossil fuel supplied in a baseline year. In this framework, each aviation fuel would be assessed on a life-cycle basis, such as grams of CO_2e per megajoule (g CO_2e/MJ). Fuels above the target GHG intensity would generate deficits, and those below it would create credits. The total deficits accrued by obligated parties in tonnes of CO_2e would need to be offset through the acquisition of credits from low-carbon fuels. Under this approach, the fuels that offer the greatest GHG reductions have the greatest compliance value, incentivizing GHG performance in addition to volumes supplied. A GHG intensity target can also provide an incentive to increase the production efficiency and reduce the upstream emissions intensity for fuels over time, rewarding continuous improvement. GHG intensity targets may also be implemented in a technology-neutral way, allowing for the market to supply the lowest-cost mix of fuels to meet the goal in lieu of a more prescriptive mandate for specific fuels or technologies.

Examples of GHG intensity targets for fuels include Article 7a of the EU Fuel Quality Directive, California's LCFS, and Germany's Federal Emission Control Act (Bundes-Immisionsschutzgesetz [BImSchG]), all of which establish a carbon intensity target for road transport fuels. The Fuel Quality Directive established a 6% GHG intensity reduction target for road and rail fuels to be reached in 2020 and requires EU member

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

38 Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model 2020, Argonne National Laboratory, accessed September 25, 2020. https://greet.es.anl.gov

states to implement that target. California's LCFS requires a 20% reduction in GHG carbon intensity from the transport fuels mix by 2030, relative to a 2010 baseline.[39] The BImSchG, which implements the EU Fuel Quality Directive (FQD) and RED, set a 6% GHG reduction target by 2020 for primarily road sector transport fuels relative to the 2010 baseline of 94.1 g CO_2e/MJ.[40] To facilitate compliance, the LCFS and the BImSchG establish credit trading markets for carbon reductions, allowing for the exchange of credits between alternative fuel producers that generate credits and fossil fuel suppliers that generate deficits. The value of credits is set by market demand and influenced by the stringency of the target and production costs for different compliance pathways. For fuel suppliers that fall short of their year-end obligations, California implements a credit clearance market where they can purchase credits at the policy cap of $200 per tonne, set in 2016 and thereafter adjusted for inflation.[41] Germany enforces a €470 per tonne CO_2e compliance penalty for parties that fall short of their requirements, though the government has proposed to update its compliance penalty system as part of its RED II implementation.

A GHG intensity target is only as effective as the underlying life-cycle assessment (LCA) methodology. For example, British Columbia's LCFS does not include ILUC emissions in its LCA assessment of fuels. Thus, despite ambitious GHG reduction targets, it primarily incentivizes the increased blending of food-based biofuels and has had little impact on the deployment of advanced fuel pathways.[42] Even when ILUC accounting is in place, GHG intensity targets are not necessarily effective at supporting advanced feedstocks and technologies. While California's LCFS includes emissions from ILUC in its assessment of fuel pathways, most food-based biofuels fall below the fossil fuel baseline and can still generate credits under the system, crowding out support for advanced biofuels made from wastes and residues in the early years of the program.[43] The LCFS has greatly increased the comparative value and consumption for biofuel pathways using waste fats, oils, and greases in recent years, necessitating imports from out of state, but it has not yet led to substantial uptake of any lignocellulosic or electrofuel pathways.[44] Increasing the signal for advanced SAFs under a GHG intensity standard may necessitate the introduction of a GHG reduction threshold including ILUC accounting or a sub-target for desired advanced pathways. For example, Germany has proposed to introduce a cap on the contributions of biofuels produced from used cooking oil and animal fats to its GHG quota in conjunction with sub-targets for the contribution from advanced biofuels (REDII Annex IX list A) and electrofuels used in the aviation sector.[45]

39 Low Carbon Fuel Standard Regulation, California Air Resources Board, 17 CCR, January 4, 2019, https://ww2.arb.ca.gov/sites/default/files/2020-07/2020_lcfs_fro_oal-approved_unofficial_06302020.pdf

40 Gesetz zum Schutz vor schädlichen Umwelteinwirkungen durch Luftverunreinigungen, Geräusche, Erschütterungen und ähnliche Vorgänge (Bundes-Immissionsschutzgesetz - BImSchG). [Law to protect against harmful environmental effects by air pollution, noise, vibrations and like processes (Federal Emission Control Act - BImSchG)], Bundesministerium der Justiz und für Verbraucherschutz, last amended June 19, 2020, http://www.gesetze-im-internet.de/bimschg/index.html#BJNR007210974BJNE004907116

41 "Credit Clearance Market," California Air Resources Board, (n.d.), https://ww2.arb.ca.gov/resources/documents/lcfs-credit-clearance-market

42 Government of British Columbia, "BC-LCFS Requirements," (August 2020), https://www2.gov.bc.ca/gov/content/ industry/electricity-alternative-energy/transportation-energies/renewable-low-carbon-fuels/fuel-suppliercompliance-50005; U.S. Department of Agriculture, "Canada Biofuels Annual 2019", https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Biofuels%20Annual_Ottawa_Canada_8-9-2019.pdf

43 California Air Resources Board, "Low Carbon Fuel Standard Data Dashboard," (July 31, 2020), https://ww3.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm

44 Ibid.

45 "Referentenentwurf eines Gesetzes zur Weiterentwicklung der Treibhausgasminderungs-Quote" [Draft of a bill for the further development of the greenhouse gas reduction quota]. Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit [Federal Ministry of the Environment, Nature Conservation and Nuclear Safety]. September 25, 2020. https://www.bmu.de/gesetz/referentenentwurf-eines-gesetzes-zur-weiterentwicklung-der-treibhausgasminderungs-quote/

DIRECT FINANCIAL SUPPORT

Direct fiscal incentives could offer a very different type of policy support for SAFs. High production costs and technical barriers have slowed the deployment of the advanced biofuels and electrofuels industries; these barriers are even greater for advanced SAFs.[46] Depending on the pathway, advanced SAFs can cost €1 to €2 per liter, more than three to five times the cost of conventional petroleum jet fuel, depending on feedstock and conversion pathway. Furthermore, many of the pathways using novel or emerging conversion technologies have uncertain yields and unpredictable commercialization timelines, and they face challenging markets. All of this contributes to a perception of high risk by investors.[47] Direct financial incentives could help bridge the gap between production costs and market value for these fuels while shoring up new projects' stability.

Direct financial support for SAFs could include a variety of government-funded measures, including production subsidies, grants for capital spending, procurement contracts, and low-interest loans. Direct policy support could be implemented taking a long-term perspective and be used to support technologies that face near-term technical and commercial challenges but could have long-term decarbonization potential. If applied judiciously, targeted financial backing could support the early commercialization stages for promising technologies and help them overcome the viability gap until learning curves and economies of scale bring costs down in later years. As with mandates, direct financial support would be most effective when limited to SAF pathways that deliver strong GHG reductions compared with fossil jet fuel.

Direct subsidies for SAFs would support fuel producers while maintaining lower costs for the aviation industry. As shown in Figure 2, SAFs can cost from €0.50 to €2 per liter more than fossil jet fuel, depending on feedstock and pathway. A per-liter subsidy would need to reach that threshold to bridge the cost gap between conventional fuels and SAFs. Unlike a mandate, the cost of subsidies would be borne directly by government rather than industry. Direct subsidies could therefore be perceived by investors and SAF producers as potentially riskier than policies such as mandates because government expenditures can be cut during times of austerity.[48] However, like all policy support for advanced fuel technologies, it is still necessary that the incentive be guaranteed over a moderately long period to foster regulatory certainty for producers. Direct production subsidies with a time horizon of less than 10 years in many cases would expire too soon to account for the time spent planning and constructing a facility. Rather than stimulating new production, they tend to compensate existing producers. This has been shown for the U.S. biodiesel tax credit, which is sometimes reinstated retroactively to cover production that occurred before the tax credit was in place.[49]

Grant funding could also help projects secure investors and assist emerging, higher-risk technologies. Upfront capital costs are generally prohibitive barriers to advanced SAF pathways as such investments can run into the hundreds of millions of euros for a commercial-scale facility before a single liter of fuel is produced.[50] Offsetting the initial capital costs through cash grants or low-interest loans could immediately improve the economics of new projects. For example, most of the advanced biofuel producers contributing to the RFS received government grants, suggesting that grants were

46 Pavlenko, Searle, and Christensen, *The Cost of Supporting Alternative Jet Fuels in the European Union*

47 Daan Peters, Sacha Alberici, Jeff Passmore, and Chris Malins, *How to Advance Cellulosic Biofuels*, (ICCT: Washington, DC, 2016). https://theicct.org/publications/how-advance-cellulosic-biofuels.

48 Ibid.

49 Stephanie Searle and Adam Christensen, "Does biodiesel really need a tax credit?" (ICCT staff blog, July 2014), https://theicct.org/blogs/staff/does-biodiesel-really-need-tax-credit.

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

important to their success.[51] Due to the scale of investments necessary for a single facility, however, the European Union may be able to support only a small number of facilities at a time with grants. This type of support may be therefore most effective for smaller-scale, first-of-a-kind conversion facilities and projects that may have the most difficulty attracting private investment.

Another way to deliver direct financial support could be through a central auctioning mechanism, synthesizing several approaches to offer an efficient method of promoting scaling up the advanced SAF industry. In this approach, also called "Contracts for Difference" (CfD), multiple potential projects compete in a reverse auction to identify the lowest-cost projects that could deliver fuel at the lowest price. The winning project would then enter into a contract with the auctioning body or government for a fixed quantity of fuel produced over a set period of time, ideally at least 10 years to reduce policy uncertainty.[52] For the duration of the contract, the auctioning body or government would compensate the producer up to the level of the price floor set by the auction, topping the producer up to that level whenever the market value of the fuel is lower than the price floor. The United Kingdom has already implemented this policy to support renewable electricity production, with producers bidding for 15-year contracts.[53] Figure 3 illustrates a hypothetical CfD contract, showing that as the market value of the SAF fluctuates in blue, the CfD program compensates the producer up to the price floor whenever necessary. A CfD can be more cost-effective than direct subsidies because it identifies the most efficient producers in the reverse auction and then subsidizes the fuels only up to the agreed-upon price.[54] Depending on the eligibility of SAFs for other policies such as the RED, a CfD can be a primary financing scheme or a complementary policy to hedge against uncertainty in the incentives provided through other programs.

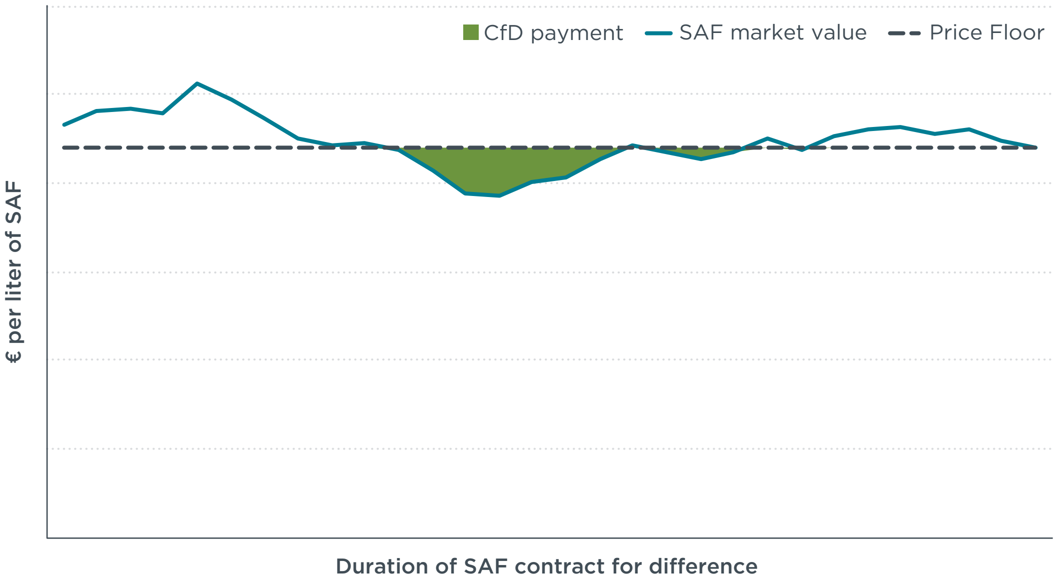

Figure 3: Illustration of a potential contract for difference pay structure for SAF production

51 Chelsea Petrenko and Stephanie Searle, "Is the Renewable Fuel Standard enough to spur progress in advanced biofuels? Probably not." (ICCT Blog, October 2018). https://theicct.org/blog/staff/renewable-fuel-standard-enough-spur-progress-advanced-biofuels-probably-not.

52 Nikita Pavlenko et al., *Development and Analysis of a Durable Low-Carbon Fuel Investment Policy for California*, (ICCT: Washington, DC:, 2016), https://theicct.org/publications/development-and-analysis-durable-low-carbon-fuel-investment-policy-california.

53 UK Department for Business, Energy and Industrial Strategy, "Contracts for Difference," 2020, https://www.gov.uk/government/publications/contracts-for-difference/contract-for-difference.

54 Nikita Pavlenko, Stephanie Searle, and Brett Nelson, *A Comparison of Contracts for Difference Versus Traditional Financing Schemes to Support Ultralow-Carbon Fuel Production in California*, (ICCT: Washington, DC, 2017), https://theicct.org/sites/default/files/publications/CfD-Cost-Benefit-Report_ICCT_Working-Paper_vF_23012017.pdf.

Given the scale of new SAF production necessary to meet even a small portion of EU jet fuel demand, subsidizing the industry could require a substantial amount of public funding. The inception impact assessment for ReFuelEU suggests that the funding for direct SAF subsidies could come from one or more EU financial instruments.[55] Reforms to the EU ETS for aviation could be one of the most promising sources of funding for SAF policy support as it would 1) leverage an existing policy rather than introduce a new funding source, 2) derive funding from the aviation sector, and 3) generate sufficient funding to encourage large-scale investments in SAFs. The EU ETS regulates overall GHG emissions by using a declining emissions cap, requiring most obligated industries to purchase or trade for emissions allowances equivalent to their emissions every year as the cap declines. However, freely given allowances currently make up about 85% of allowances for European airlines; phasing out these free allowances and auctioning them off could provide a durable, transparent revenue stream for decarbonizing aviation.[56] Transport & Environment's aviation pricing tool estimates that with a carbon price of €25 per tonne, the sale of free allowances alone could generate more than €1 billion in revenue annually. If aviation emissions continue to increase after the 2020–2021 COVID-19 disruption, revenues could approach €2 billion a year.[57] While existing ETS revenue is already largely allocated to EU member states to pursue national-level climate projects, new income from the sale of ETS allowances could be earmarked at the EU level for various SAF support schemes. The European Union already set a precedent for this with the NER 300 program, which uses €2 billion in ETS revenue for innovative, low-carbon technology.[58] This revenue would be sufficient to fully fund the upfront capital costs for multiple commercial-scale SAF facilities every year or alternately to implement a CfD program to support the production of billions of liters of SAF.

Direct financial support for challenging SAF pathways over the next decade could be an important steppingstone for achieving a successful mandate policy in the longer term. Individual grants may improve the viability of emerging technologies and support first-of-a-kind facilities, though upfront grant funding does not necessarily help with operating costs or market risks. An SAF direct support framework built around CfDs financed by ETS revenues, however, might provide a longer-term signal for emerging technologies and provide a smoother transition between direct support and a mandate. For example, the early years of an SAF mandate could use SAFs made at facilities supported using CfDs. In such a case, the CfD payments could even decline in response to increased demand for SAFs to meet blending targets. Transitioning from direct financial support to a mandate could be achieved through the use of a trigger threshold based on indicators of SAF market maturity. The Atlantic Council think tank presents such a condition for a hypothetical U.S. aviation fuels carbon intensity standard as a protection against mandating SAFs before they are commercially available.[59] Trigger thresholds could include indicators such as the quantity of SAF sold onto the market or even a set delay between the announcement of the mandate and when it becomes binding. Direct policy support could therefore be a means of supporting SAF production before the trigger is reached, helping to balance the certainty of the mandate policy with the potential risk of introducing it before the market can support it.

---

55 European Commission, "RefuelEU Aviation—Sustainable Aviation Fuels. Inception Impact Assessment," March, 2020, https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12303-ReFuelEU-Aviation-Sustainable-Aviation-Fuels

56 Transport & Environment, "T&E Aviation's Pricing Tool" (2020), https://www.transportenvironment.org/sites/te/files/downloads/Methodology_Fuel_Tax_Tool.pdf.

57 Ibid.

58 "NER 300 Programme", European Commission, Accessed October 15, 2020. https://ec.europa.eu/clima/policies/innovation-fund/ner300_en

59 Fred Ghatala, "Sustainable Aviation Fuel Policy in the United States: A Pragmatic Way Forward" (Atlantic Council, 2020), https://www.atlanticcouncil.org/in-depth-research-reports/report/sustainable-aviation-fuel-policy-united-states/.

POLICY DESIGN RECOMMENDATIONS

The ReFuelEU initiative offers a critical opportunity to set the tone for the next several decades of aviation climate policy. Taking the long-term view, policymakers might treat putting the aviation industry on the right trajectory for achieving net zero emissions by 2050 as a higher priority over maximizing short-term gains. It is also important to note that SAF alone is not the linchpin for decarbonizing aviation. The rapid increase in aviation emissions stems from a confluence of policy factors, including complementary effects from carbon pricing and energy taxation. Aviation fuel policy alone can reduce emissions only so much without complementary efforts from those other policy levers. Based on the assessment of different policy options available, we offer the following recommendations:

» **Advanced SAFs will require targeted policy support.** To support an SAF industry based on sustainable, low-carbon fuels, it may be necessary to introduce strict eligibility criteria or an advanced SAF-only policy to ensure that policy support goes toward those fuels that offer meaningful GHG reductions. While these decisions would constrain the contribution of volumes supplied in the near term, investors and producers would have increased confidence that investments in projects and technologies over the next decade could contribute to decarbonization objectives long after 2030. The slower deployment rate of advanced SAF pathways may necessitate a trigger threshold based on the maturity of the SAF market and the quantity of fuel produced prior to the imposition of a binding mandate.

» **Develop policy targets based on a realistic assessment of feedstock availability and technology deployment.** Beyond the near-term potential to produce approximately 2% of EU jet fuel demand from waste oils and fats, the contribution and commercialization timeline for other advanced SAF pathways is less certain. Utilizing data on European Union-derived feedstock availability and realistic projections of technology deployment rates will help to ensure that policy targets maintain regulatory certainty and ensure that policy targets are achievable.

» **SAF multipliers may not be effective at driving new advanced-fuel production.** The European Union already consumes most of its domestic waste oil in producing hydrotreated renewable diesel. Increasing the multiplier for SAFs within the RED II could be counterproductive by incentivizing biorefineries to maximize jet fuel while reducing their net liquid fuel production. This could increase the short-term availability of SAFs without sending a sufficient signal to induce new production.

» **Direct financial support may be necessary in the early stages of SAF policy.** Reaching higher advanced SAF blending rates requires investing in even more challenging pathways with higher costs and uncertain commercialization timelines than waste oil-derived SAFs. In the near term, these pathways' production costs are likely to exceed €1 per liter (approximately 2.5 times the current wholesale jet fuel price) and will require some form of policy support to reach cost parity with conventional jet fuel. In particular, a central auctioning mechanism to secure a price floor and market for advanced SAFs could complement other policies while providing greater policy certainty. The sale of ETS aviation allowances could generate a sufficient pool of funding for supporting first-of-a-kind SAF projects and scaling up the industry.