E-kerosene mandate: key steps for ReFuelEU success

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Summary

Europe's forthcoming ReFuelEU initiative, which aims to bring about an uptake of sustainable advanced fuels (SAFs) in the aviation sector, has the potential to finally start decarbonising the emissions of this carbon intensive industry. Though the sector is currently going through a major crisis, demand will come back in some form, and so long as that demand is powered through fossil fuels in traditional jet engines, the aviation industry will have a major problem.

However like many climate policies, there are good and bad ways in which this policy can be drafted and implemented. Europe's experience with alternative fuels in its road transport sector shows what can go wrong: unsustainably high targets driving crop biofuels which competed with food and indirectly drove deforestation. Europe must avoid this mistake in drafting its ReFuelEU initiative.

This paper is partly based on analytical work by consultancy Cerulogy and shows what policy-makers need to do to put aviation fuels on a most sustainable footing post-Covid.

Recommendations:

1) Mandates should exclude all crop-based biofuels, only permit advanced biofuels on the basis of strict sustainability criteria and include a subtarget for e-kerosene
2) The overall target should be a GHG intensity reduction target of 2.9% by 2030, with a volumetric based subtarget of 1% for e-kerosene, with the latter subject to upward revision mid-decade.

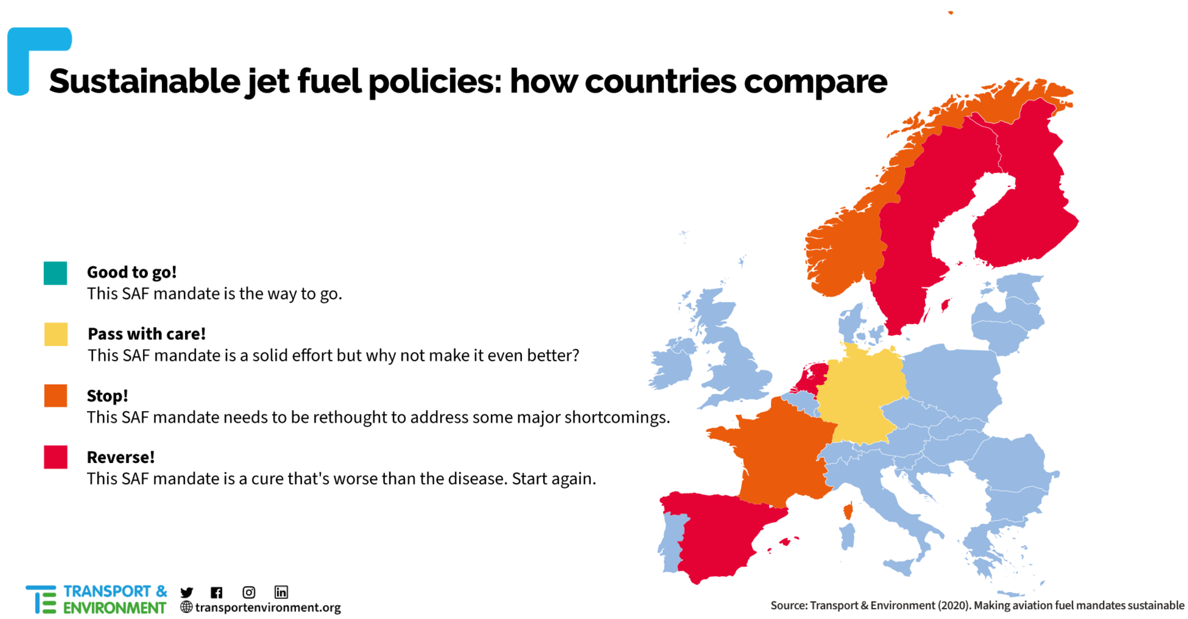
3) The expected contribution of advanced biofuels has to be assessed carefully. Setting a target for advanced biofuels is challenging due to the range of potential feedstocks and competing uses with other transport modes.
4) Europe has ample potential for renewable energy, therefore hydrogen used in the production of e-kerosene should be exclusively renewable-derived (green hydrogen).
5) Direct Air Capture (DAC) CO2 must be required from the start of production, with any project receiving public support requiring a minimum share of 30% DAC, increasing over time to 100%.
6) The scope of the target must include all fuel sales in Europe, to ensure long-haul emissions are included and market distortions are avoided.
7) A non-compliance penalty of €70 per gigajoule should be introduced in order to ensure that e-kerosene is deployed.
8) Fuel suppliers should be allowed to comply with ReFuelEU through support for zero-emission aircraft, provided they also abide by the minimum e-kerosene sub-target.

1. Mapping of member state initiatives: key lessons learned

In a recent report[1], T&E analysed seven national plans for sustainable advanced fuels (SAF), both detailing the current state of development of these aviation mandates and highlighting areas where national governments risk repeating past mistakes.

As the below map shows, Spain, the Netherlands, Sweden and Finland have unrealistically high SAF targets set or under consideration that could result in unsustainable biofuels being used, especially since they still allow some crop-based biofuels under the mandate. While France and Norway do not promote crop-based biofuels, their strong focus on advanced biofuels could lead to high demand for feedstocks that can only be sourced sustainably in very limited amounts, such as used cooking oil. On the other hand, Germany, which focuses solely on e-kerosene, limits the risk of unsustainable sources being used, assuming that this e-kerosene will be produced with 100% renewable energy and CO2 directly captured from the air.

[1] Transport & Environment (2020). Making aviation fuel mandates sustainable. Retrieved from https://docs.google.com/document/d/1LaqlD5FKKdXDJH_Cyh5ca0oUmup8D9HusvVfgdvX_2s/edit#



Based on this study, the following key lessons emerge:

- **Mandates are an essential tool, but they must exclude all crop based biofuels**, and should only include advanced biofuels that meet strict sustainability criteria
- **Mandates should include a subtarget for e-kerosene**, to ensure investment is directed at these fuels which can substantially reduce aviation's climate impact
- Targets should be established, but should be set based on **realistic and credible forecasts of feedstock availability**, including the availability of additional renewable electricity
- **Targets should be based on the GHG intensity** instead of a volume-based target, in order to incentivise the use of those fuels with the greatest emissions benefits.

2. Level of target

European Commission consultations and other Commission papers have suggested that the ReFuelEU proposal will comprise a mix of targets for advanced biofuels and e-kerosene. Setting an appropriate target is a key challenge for regulators: too low, and it wont drive investment in these fuels, too high and it will cause fears that the target will be abandoned, or will result in the use of unsustainable feedstocks such as crop-based biofuels and blue or grey hydrogen derived e-kerosene.

A further challenge in target setting is making an accurate assessment of feedstock availability, which can be challenging for advanced biofuels due to the range of potential feedstocks and competing uses, and for e-kerosene due to the infancy of its production.

Any target set should be based on a credible assessment of potential availability in 2030, bearing in mind the above uncertainty. Analysis commissioned to consultancy Cerulogy by T&E has found that an overall target of 3% reduction in carbon intensity or 5% in energy share in 2030 may be achievable, but only under strict conditions:

1) **The e-kerosene subtarget should be set at at least 1% volumetric in 2030**, which would require 550 Ktoe (1% of expected aviation fuel demand of 54 Mtoe[2]). A volumetric e-kerosene target under an overall GHG reduction target would ensure that e-kerosene developers receive the required level of demand certainty.
   Under an aggressive deployment strategy, where public support is given to construct 40 plants globally and two-thirds of that supply goes to the EU, then that supply could increase to 730 Ktoe (or just over 1.3%). However constructing 40 plants over the coming decade will be a challenge, therefore the target should start at 1%, with an upward revision to 1.3% mid-decade if such an objective appears feasible.

2) **The expected contribution of advanced biofuels has to be assessed carefully.** Cerulogy does not recommend HEFA fuels (e.g. those produced from Used Cooking Oil) to be included in a target, as its inclusion would likely only result in a diversion of HEFA from the road transport sector, rather than the development of new feedstocks. As part of its analysis, it found that an estimate of 3.2Mtoe of advanced biofuels could be used sustainably. The estimated amount of sustainable advanced biofuels available will depend on the type of feedstocks considered sustainable and how much are diverted from the road sector. However in its own in-house analysis[3], T&E assumes around 2.8% advanced biofuels for aviation in 2030 or 1.3Mtoe, with 4.5Mtoe being still used in road transport. This underlines the uncertainty regarding the availability of such feedstocks and the allocation between different transport modes, and we therefore propose a more conservative target than the one proposed by Cerulogy is chosen. This target may be revised upwards mid-decade once there is greater clarity on feedstock availability and competing uses by different sectors.

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[2] Estimates of fuel demand in 2030 are sourced from this study:
https://www.sciencedirect.com/science/article/abs/pii/S096969972100003X?via%3Dihub

[3] https://www.transportenvironment.org/sites/te/files/publications/202103_Advanced_renewable_fuels_EU_Transport_Final.pdf

3) **ReFuelEU should contain a GHG reduction target of 2.9% by 2030**. Based on the Cerulogy assessment, this target is equivalent to a 5% volume target. This would be achieved through a combination of e-kerosene (minimum 1% volume target) and advanced sustainable biofuels (4%). Such a target is ambitious, and a concern with an ambitious SAF target is that it would be met through unsustainable feedstocks. On the specific question of advanced biofuels, caution is needed to ensure that the projected quantities match sustainable levels and include a fair vision on the split between different transport modes. Provided the sustainability safeguards in the RED are improved and indirect displacement effects taken into account, a GHG target instead of a volumetric target should incentivise those fuels with the greatest emission reduction potential. The target can further be supported through industrial support for e-kerosene production.

   Were the target to be missed, for example due to a shortage of truly sustainable advanced biofuel feedstocks, fuel suppliers would be required to pay the penalty, discussed in Section 8, which could fund further deployment of e-kerosene.

3. Availability of renewable hydrogen to supply efuels for aviation

A study commissioned by T&E analysed[4] how to decarbonise the entire transport sector with renewable energy (either through direct electrification, producing hydrogen, depending on the mode). The study analysed in particular the ramp-up in renewables deployment that will be needed to achieve full decarbonisation of Europe's transport sector by 2050.

The feasibility study explored different scenarios and the impact of using indirect electrification (hydrogen and synthetic hydrocarbons), even in areas where direct electrification is technically feasible. The study concluded that promoting a significant role for electrofuels in all transport modes – and especially synthetic hydrocarbons – comes with a huge energy penalty and risks derailing the entire decarbonisation effort. Due to major conversion losses in producing synthetic hydrocarbons and the synthesis process in particular, these fuels should be targeted at the aviation sector alone.

Synthetic hydrocarbons like e-kerosene remain the only technically viable solution that would allow full decarbonisation of aviation but will require a significant amount of additional renewable

[4] https://www.transportenvironment.org/press/e-fuel-would-be-wasted-cars-while-it%E2%80%99s-badly-needed-decarbonise-planes-and-ships-%E2%80%93-study

electricity to be produced. This explains why aviation in 2050 will account for 22% of all demand for renewable electricity in transport, 535 TWh in total in the base case (525 TWh of e-kerosene, 10 TWh for battery electric aircraft). Aviation's energy demand in 2050 would be higher than the 500 TWh required for all battery electric passenger cars in the EU in 2050.

This huge demand for renewable electricity to produce the e-kerosene needed will not happen overnight. Road transport - direct electrification with battery-electric vehicles - will drive the additional renewables demand from the transport in the period before 2030 (166 TWh by 2030 in EU27). Indirect electrification and the use of electrofuels in aviation and shipping in the period before 2030 will drive additional renewables demand to a lesser extent (29 TWh in shipping and 14 TWh in aviation by 2030 in EU27).

As it will take a decade to scale up the production of e-kerosene, this means that the year-over-year growth in demand from the aviation sectors after 2030 will be robust, about a 38-fold increase over 20 years, from a modest 14 TWh in 2,030 to 526 TWh in 2050.

Clearly, the scale of decarbonising transport using renewable electricity is challenging, but the EU is well positioned to meet that challenge: the report also confirmed that renewables potential in the EU far outstrips future demand, even when considering the energy demand in other sectors like power, buildings and industry. Total renewable potential in the EU27 is 20,430 TWh, compared to an energy demand in 2050 of 2,400 TWh in the transport sector. Lowering the energy demand in the transport sector by promoting public transport, shared vehicle use, modal shift, logistics efficiency and reducing air travel can help to reduce the scale of the challenge.

4. Source of CO2

The production of e-kerosene requires both hydrogen and CO2. The source of CO2 is essential in determining the climate benefits: CO2 secured from industry (point source) is not circular and has only minimal climate benefits, compared to CO2 extracted from the atmosphere (Direct Air Capture - DAC), as it will potentially lead to lock-in of fossil sources of CO2.

A number of European companies are advancing DAC projects, and these will come on stream this decade as e-kerosene production is developed. This will permit **the use of DAC from the outset of e-kerosene production**, boosting public confidence in the environmental integrity of this fuel and boosting the development of a new industry in Europe. Financial support granted for e-kerosene production should require a minimum use of DAC, of at least 30%, increasing over time as supply becomes available.

Under the 2030 e-kerosene target proposed above, 100% DAC use is possible under very optimistic scenarios whereby industrial policy supports the rapid move from current test projects to larger deployment, and where the resulting output is focused towards e-kerosene production. 100% DAC in 2030 would require 4.8 Mt of DAC and result in a price increase of 6% under optimistic price scenarios of 105 €/t CO_2 and 57% under conservative scenarios of 425 €/t CO_2, compared to a point source CO2 cost of 70 €/t CO_2.

By contrast, a lower DAC share of 50% would require 2.4 Mt of DAC and result in a price increase of 3% under optimistic price scenarios of 105 €/t CO_2 and 29% under conservative scenarios of 425 €/t CO_2.

In any scenario where point source CO2 is used, it must be properly accounted for under EU ETS, in that the emitting entity and airline cannot both claim the same emission reduction from that captured CO2.

5. Scope of target

The scope of the fuel mandate can make a significant difference to different airlines. The table below compares the emissions of KLM, Air France, and Ryanair under Corsia reporting[5], the scope of the EU emissions trading system (ETS)[6], and approximate domestic emissions[7]. The ETS covers domestic and international flights within the European Free Trade Area (EFTA), excluding flights from the continent to airports in overseas territories[8]. The Corsia emissions exclude domestic flights, and cover the flights between ICAO contracting parties. Should a fuel mandate cover the current ETS scope, Ryanair would have a mandate on 83% of its fuel burn, whilst KLM and Air France would have shares of 19% and 17%, respectively.

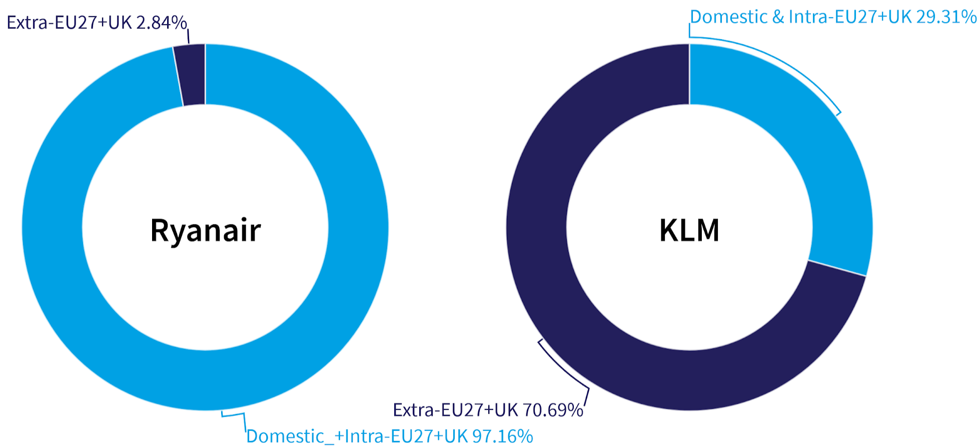
Airline	**2019 corsia emissions (Mt CO_2)**	**2019 ETS emissions (Mt CO_2)**	**2019 domestic emissions (Mt CO_2)**
KLM	10.03	1.89	0.00
Air France	13.32	2.49	1.15[9]

[5] Retrieved by request from member states
[6] Retrieved from the EU Commission: https://ec.europa.eu/clima/policies/ets/registry_en#tab-0-1
[7] T&E analysis of AIS data provided by PlaneFinder, and ICAO emissions calculator.
[8] The most notable being airports in the Canary Islands, the Azores, Guadeloupe, and Martinique.
[9] For the purpose of this table, domestic emissions are limited to those flights on continental Europe

Ryanair	11.25	10.53	1.45

T&E has also analysed the flights under an intra-EU27+UK and extra-EU27+UK scope. The UK government is currently considering a similar mandate. Were a fuel mandate to apply only departing flights with destinations within the EU27+UK bloc, Ryanair would only have 3% of its fuel burn exempt from a fuel mandate, whereas KLM would have 71% of its fuel burn exempt. To avoid distorting the market, it is critical that a fuel mandate is applied to all departing flights, so as not to allow legacy carriers to fly under the radar of the regulation.

KLM and Ryanair, 2019 emissions by flight sector



Source: T&E analysis of commercial aviation AIS data, provided by PlaneFinder, and ICAO emissions calculator

6. Legal basis

Setting a mandate on fuel suppliers has a solid legal basis under international law. Under customary international law, the EU has the authority to regulate situations or activities occurring on its territory, which means that the mandate has a legal basis

The mandate would also be compatible with the "Open Skies Agreement" provision on fuel (Article 11) since a mandate on fuel suppliers does not establish an explicit tax or levy on fuel supplied. The mandate is also protected by the fact it does not apply to airlines. As for the Open

Skies Agreement's ban of traffic restrictions (Article 3(4)), it is compatible with the proposed legislation thanks to CJEU's jurisprudence on ETS, given that these obligations are not targeted at restricting air traffic.

The Chicago Convention on International Aviation is also no impediment to a mandate since it has both an exemption for fuel loaded at EU airports (Article 24) and is not binding on EU institutions. Finally, there are no ICAO regulations prohibiting a mandatory SAF share on fuel suppliers or buyers.

7. Impact on fuel prices

Table 1[10] shows the jet fuel prices at different size airports in the EU in terms of million passengers per year. It can be seen that there is a visible difference between the average fuel prices depending on the size of the airport. The larger airports tend to have the lowest fuel price and the price is inversely correlated with the size of the airports. The reason might be that the large airports have more efficient fuel delivery (pipeline) and/or, better-negotiating position on the fuel acquisition compared to the small ones.

Airport size	Pax 2019 (Million/year)	Jet fuel price (€/liter)		
		Mean	Min	Max
Large	> 3M	0,71	0,63	0,86
Medium	1 - 3M	0,83	0,74	1,05
Small	0,5-1M	0,90	0,75	1,03
Very small	< 0,5	0,91	0,78	1,08

At present, the cost of e-kerosene is significantly higher than the conventional fossil-based jet fuels. A recent study[11] commissioned by T&E estimated a cost of 137 - 233 €/MWh (i.e. 1.3 - 2.2 €/litre) for e-kerosene in 2030 depending on the CO_2 cost assumptions, that is almost 2 to 3 times the current average price at large airports. The study assumed that the e-kerosene is produced using the three main feedstocks: 1) renewable electricity 2) water - in order to split out hydrogen, and 3) DAC CO_2. The electrolysers that convert electricity into hydrogen are assumed to have 79% efficiency (HHV), and a CO_2 price of 105 or 425 €/t CO_2 captured in 2030 (for optimistic and conservative scenarios respectively) was assumed. In addition, the study highlights that the cost is expected to reduce to 100 - 160 €/MWh (i.e. 0.95 - 1.5 €/litre) in 2050 depending on the CO_2 cost

[10] Source: Stratas consulting (2020)

[11] https://www.transportenvironment.org/press/e-fuel-would-be-wasted-cars-while-it%E2%80%99s-badly-needed-decarbonise-planes-and-ships-%E2%80%93-study

assumptions, as the cost of CO_2 and renewable electricity reduces and the production is scaled up.

A 1% e-kerosene mandate for 2030 at airports with passengers more than 1 million, assuming today's fossil kerosene price and 2.2 €/litre e-fuel in 2030, would increase the fuel price by 2% (0.71 to 0.74 €/litre) and 1% (0.83 to 0.86 €/litre) for large and medium airports respectively (and under a €1.3 €/litre, an increase of 1% and 0.5%). **Comparing this with the figures in Table 1 shows that the possible increase in fuel price due to the e-fuels mandate is minor compared to the existing fluctuations in the prices within each airport category, which is already managed by the airlines.** For instance, large airports have a price range of 0.63 - 0.86 €/liter that is a 0.23 €/liter spread, equivalent to one-third increase on the lowest price. This implies that the mandate would lead to the leveling of fuel prices, to some extent, between the airports with slightly different numbers of passengers across different categories.

Under a regulatory proposal where small airports are excluded from an e-kerosene mandate, **this might potentially reduce tankering, for instance, of flights departing from a large airport to the smaller ones.** Tankering occurs when airlines seek to avoid relatively higher fuel cost at smaller airports by uplifting excess fuel at larger airports, however carrying this excess fuel incurs a CO2 penalty.

8. Penalties

To be effective, a mandate requires penalties in cases where the mandate is not achieved. In particular, to be effective, the penalty needs to be set at a rate in excess of the gap in price between fossil kerosene and e-kerosene. Otherwise, there is a risk that the regulated entity will make a calculated decision to pay the penalty, rather than incur the higher cost of compliance. E-fuels are needed to decarbonise the sector in the long-term, so getting them off the ground should be the priority.

In its proposed implementation of the Renewable Energy Directive, Germany has put forward a non-compliance penalty of €70 per Gigajoule for compliance with its e-kerosene mandate. Analysis commissioned by T&E shows that the production costs in the near term are likely to be 3,000 €/tonne for e-kerosene, which is very close to the €70 per Gigajoule. **This rate should therefore be contained in the implementation of ReFuelEU.**

9. Zero Emission Aircraft

Supporting SAFs and especially e-kerosene is a “no-regrets” policy that will be essential at all stages of the path towards zero emission aviation. Indeed, alternatives to kerosene propulsion for commercial aircraft, such as hydrogen or electric-powered aircraft, are currently early in their development stages. Furthermore, they will not be able to power long-haul aviation--which is responsible for most of aviation’s emissions--in the foreseeable future.

However, it is equally important that ReFuel EU adopts a holistic approach and supports the development of zero-emissions aircraft such as hydrogen or electric propulsion in the medium run. In an industry where new designs are both costly and risky ventures, it is indeed the state’s role to encourage investments in disruptive technologies.

As such, fuel suppliers should be encouraged to supply green hydrogen or enter in joint-ventures with zero emission aircraft manufacturers. Such joint ventures should be recognised for compliance under ReFuelEU.

Support for such aircraft can be achieved through counting of green hydrogen or green electricity used towards EU targets for such energy sources. Multipliers could be used to further boost such deployment.

At the same time, ReFuelEU’s tech openness should be accompanied by a precautionary policy: ringfencing the e-kerosene subtarget to ensure that the above mentioned technological investments do not come to the detriment of e-kerosene uptake.

10. Conclusions & recommendations

1. Mandates should exclude all crop-based biofuels, only permit advanced biofuels on the basis of strict criteria and include a subtarget for e-kerosene
2. The overall target should be a GHG intensity reduction target of 2.9% by 2030, with a volumetric subtarget of 1% for e-kerosene, with the latter subject to upward revision mid-decade.
3. The expected contribution of advanced biofuels has to be assessed carefully. Setting a target for advanced biofuels is challenging due to the range of potential feedstocks and competing uses with other transport modes.
4. Europe has ample potential renewable energy, therefore hydrogen used in the production of e-kerosene should be exclusively renewable-derived (green hydrogen)

5. Direct Air Capture (DAC) CO_2 must be required from the start of production, with any project receiving public support requiring a minimum share of 30% DAC, increasing over time to 100%.
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Further information

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