Legislating for aviation alternative fuels

How EU legislation can drive an uptake of sustainable advanced fuels in aviation

July 2020

Summary

For aviation to reach zero emissions, sustainable advanced fuels are needed to replace fossil kerosene currently used by the sector. The European Green Deal (EGD) includes a legislative proposal which would bring about a long overdue development and uptake of such fuels for the sector, that legislative proposal is now being developed under the EU's ReFuelEU initiative. However this initiative will only succeed if its support is limited to those fuels which can truly deliver emission reductions, and which can be scaled up sustainably to meet the demand from the aviation sector. The paper recommends how such objectives can be achieved.

Recommendations for ReFuelEU initiative:

i) a focus on the development of *new and scalable* advanced fuels, beyond the sort of crop-based biofuels currently in production which are capped in EU legislation and must be excluded from this initiative

ii) credible target for efuels, which can be ramped up over time to meet the needed cuts by the sector. Such a target would start at between 1 and 2% by 2030, with the possibility to be increased under the right conditions.

iii) due to uncertainty of supply and competing demands, the availability of advanced biofuels for aviation will likely be lower than the potential availability of efuels for the sector, therefore regulatory efforts should focus on developing the latter over the former.

iv) a broad industrial strategy to support all aspects of the development of these fuels, including the launching of contracts for difference (CfDs) for efuels.

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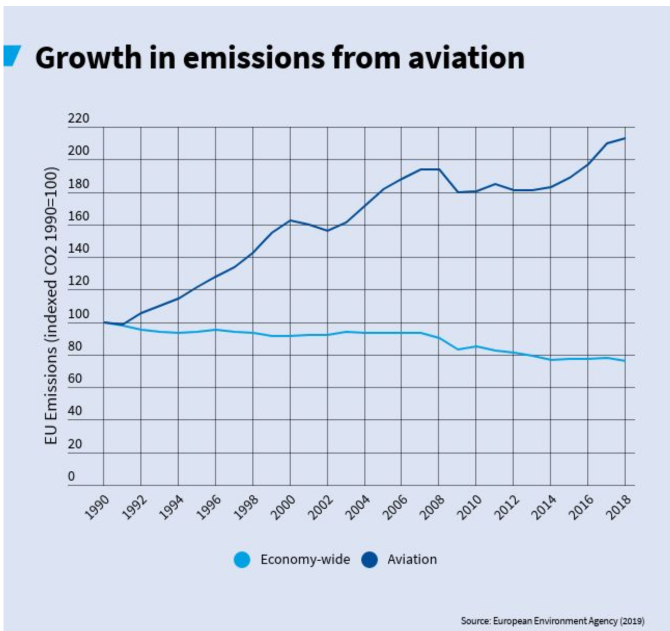
1. Background

Aviation remains the fastest growing source of emissions in Europe, having grown 26% between 2013 and 2018 and now representing 4.2% of European emissions[1]. Aviation's non-CO2 effects even further expand the climate impact of the sector[2]. This growth in emissions is the result of decades of failure to effectively regulate aviation emissions with countries, including Europe, leaving jet fuel untaxed and international aviation emissions outside of national climate efforts. The Covid crisis is having a severe and immediate impact on aviation emissions, causing a temporary drop, however emissions will rebound in time unless governments act now to put measures in place to mitigate such a return to business-us-usual emissions growth.



Having failed for so long to regulate this climate impact, a range of measures are needed to bring down emissions, with the ultimate objective of an aviation sector which no longer burns fossil kerosene. Carbon pricing (such as taxing jet fuel and reforming EU ETS) will help reduce demand for that fossil kerosene and to reduce the price gap with sustainable fuels, so too will modal shift to low-carbon rail. More efficient aircraft and engines will also have an important role to play, though for decades now improvements in efficiency have been overtaken by growth in passengers. Radical new aircraft designs, such as battery electric and hydrogen aircraft, won't arrive in time to reduce emissions as required by the Paris Agreement.

Ultimately, for the sector to decarbonise in time, it needs an alternative to fossil kerosene which can be scaled up to meet the fuel demands of the sector, and which is "drop in" ready in that it can be introduced into the sector without requiring a major overhaul of infrastructure. Sustainable advanced fuels (SAF) can meet that requirement, however significant work is needed by regulators to ensure these fuels deliver the promised significant emission reductions, and are deployed at a scale needed to bring aviation emissions in Europe to zero by 2050.

[1] https://www.transportenvironment.org/what-we-do/aviation-and-eu-ets
[2] https://elib.dlr.de/59761/1/lee.pdf

A commitment to such measures is contained in the European Green Deal (December 2019), which recognises that for aviation decarbonisation to be advanced, significant action is required at European level. Action at international level, such as through the UN's International Civil Aviation Organisation (ICAO), has for decades failed to deliver any results.

In adopting policies to bring about an uptake of SAF in the aviation sector, governments must learn lessons from the past, particularly regarding support for crop-based biofuels in the road transport sector here in Europe. And it must avoid the inaction of recent years, when much talk of developing alternative fuels for aviation resulted in no meaningful uptake.

2. Lessons learned to date

Aviation sector

The aviation sector has long had ambitions to bring about emission reductions through the use of alternative fuels[3]. The EU's Advanced Biofuels Flightpath, launched in 2011[4], envisaged an uptake of 2 million tonnes of SAF by 2020, a target that is likely to fall significantly short, with an expected uptake of as little as 0.05 million tonnes this year.

Several reasons can be cited for this. The first is the significant price gap between existing fossil kerosene, made artificially cheap by its tax free status in Europe, and the price of SAF which in most cases is more expensive than kerosene[5]. As fuel constitutes a significant portion of an airline's cost, none have been willing to bear the financial burden of purchasing such fuels in significant quantities without a legal requirement or strong incentive to do so.

The second is that measures adopted to date, such as ETS and REDII, discussed further below, have failed to close this gap. Without more effective intervention, these fuels will never see large scale uptake by the aviation sector.

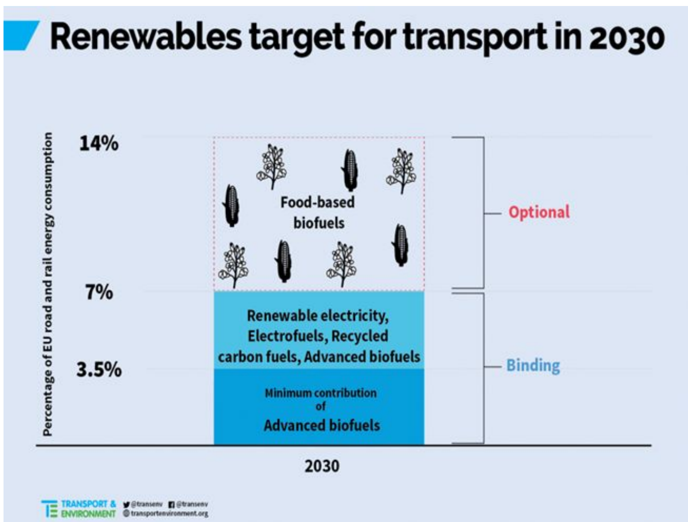
Finally, there is the additional effort required to certify SAF for use in the aviation sector, owing to the additional safety requirements inherent in using fuels in this sector. To date six different routes for conserversion of feedstocks to SAF have been certified, however only one process

[3] https://www.icao.int/Meetings/EnvironmentalWorkshops/Documents/WAAF-2009/4_Rutherford.pdf
[4] https://ec.europa.eu/energy/sites/ener/files/20110622_biofuels_flight_path_launch.pdf
[5] EASA has estimated that SAF derived from used cooking oil may cost between €900 and €1,015 a tonne, compared to €600 a tonne for traditional kerosene https://www.easa.europa.eu/eaer/climate-change/sustainable-aviation-fuels

(hydroprocessing of oils/fats (HEFA)) is at commercial stage[6]. Faced with competing sectors, primarily road transport, where the certification requirements are significantly less and demand is more than ample, producers will mostly sell into that market.

Until the above issues are addressed, there will be no meaningful uptake of SAF in the aviation sector. What has occured in recent years are several pilot programmes by the aviation sector which have been instrumental in demonstrating the technical feasibility of SAF. This provides an important base of knowledge to bring these fuels forward.

<u>Road transport sector</u>



Europe’s Renewable Energy Directive, in its original version and recent recast, contains requirements for the use of alternative fuels in the transport sector. For example the original RED Directive included a 10% alternative fuel target for the transport sector, to be met by 2020 in each member state. That target covered road and rail, and included the use of various types of renewable fuels, including biofuels and renewable electricity. However it mainly drove considerable uptake of unsustainable liquid biofuels in the road transport sector. The Directive was revised in 2018 to set further alternative fuel targets for the transport sector for 2030. The RED requires a minimum share of 14% renewables in transport but allows member states to bring this target down if they have a lower limit on crop-based biofuels . As a result the only binding target is for advanced fuels and is de facto set at 7% (including multipliers).

6 https://www.e4tech.com/news/2027-sustainable-aviation-fuels-obligation-to-be-introduced-in-the-netherlands-by-2023.php

This gives us experience of fuels mandate to draw on, and there are three broad conclusions to draw from this:

1) The original and revised RED legislation omitted safeguards which would exclude the use of alternative fuels with negative environmental effects. These conditions must be included from the start of any development of a market for sustainable aviation fuels and is considered in the section below.
2) The legislation established targets which are unreasonably high, resulting in targets which cannot be met without bringing in poor quality fuels, or through fraud which is proving difficult to detect and prosecute across the Union's markets.
3) With weak environmental safeguards and only partial accounting of greenhouse gas emissions, the principle of 'technology neutrality' has failed to deliver the cleanest fuels. The legislation drove an increase in unsustainable biofuels but did not encourage the uptake of more advanced technologies, e.g. biofuels from sustainably sourced agricultural residues or efuels from green hydrogen.

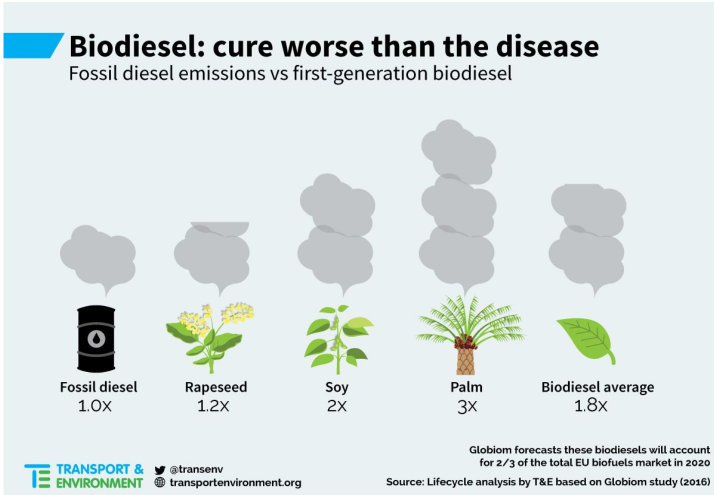
These experiences with the road transport sector give us clear lessons for drafting legislation for SAF in the aviation sector.

3. What type of fuels to support

Perhaps the greatest determinant in the environmental effectiveness of SAF policy is the type of feedstocks used to develop the fuels. That's because the actual emissions reductions can vary wildly, from fuel derived from crop-based feedstocks whose emission reductions can actually be higher than the fossil fuels they seek to replace, to synthetic kerosene derived from additional renewable electricity, which can have close to zero emissions. And at the same time, many feedstocks can have considerable negative environmental (biodiversity, water) and social (land use, indigenous rights) impacts. To avoid this, any SAF policy for aviation must choose wisely its preferred feedstocks, and ensure sufficient safeguards are in place.

3.1 Different feedstocks

1) Crop-based biofuels: the original RED mandated the use of alternative fuels in the road transport sector, and this was primarily met through the use of crop-based biofuels such as those created from rapeseed, palm oil or soy. However the climate impact of such biodiesels are in fact negative when the indirect land use change (ILUC) effects are taken into consideration. When existing agricultural land is turned over to biofuel production, agriculture has to expand elsewhere to meet the existing (and growing) demand for crops



for food and animal feed. This happens at the expense of forests, grasslands, peatlands, wetlands, and other carbon-rich ecosystems and in turn results in substantial increases in greenhouse gas emissions.

ILUC is a key factor that shows why crop biofuels are not a decarbonisation option for transport. Issues relating to impacts on biodiversity, water use, local communities and food prices are also considerable. For that reason, the revised RED removes the binding requirement for member states to use crop-based biofuels in road transport, though it fails to go further and phase-out their existing use, instead placing a cap on the amount and phasing out palm oil based biofuels by 2030 (with exceptions).

2) Advanced fuels: the revised RED sought to promote two types of advanced fuels which are relevant for the aviation sector - waste and residues derived alternative fuels, and renewable fuels of non-biological origin

i) Waste and residues: these are fuels which, as the name suggests, are derived from waste and residue feedstocks. Such feedstocks include used cooking oil, straw and forestry residues. The development of these fuels comes from a desire to support those feedstocks which do not compete with land, and so avoid the ILUC issues raised above. The Annex IX of the RED provides a list of eligible feedstocks. However the feedstocks listed in this Annex are not without issue, for example some feedstocks are not real waste or residues, they have displacement effects as some already have uses (their use as a fuel drives an undesirable uptake of other, more damaging, feedstocks) and some feedstocks have a limited ability to be scaled-up. For municipal waste, only the biowaste separately collected should be considered. Classification of feedstocks can vary between member states. More information on feedstocks in Annex IX, here.

ii) Renewable fuels of non-biological origin: this refers to the fuels which are produced using renewable electricity. This covers green hydrogen (hydrogen derived from electrolysis) as a transport fuel but also synthetic kerosene, or efuels, produced through a process which combines green hydrogen and CO2.

Whether such fuels produce a climate benefit depends on whether the renewable electricity to produce the hydrogen and capture the CO2 is additional, an important safeguard considered further below.

Which fuel for the aviation sector?

In determining which fuel to promote in order to bring about the decarbonisation of the aviation sector, regulators should be guided by experience to date, and the specific requirements of the aviation sector. Experience to date would preclude the use of crop-based biofuels, as such a policy would only drive substantial land use impacts and deforestation. Fuels produced from waste fossil sources, designed as 'Recycled carbon fuels' under the RED, shouldn't be eligible under a renewable fuels aviation policy because of their fossil origin and their negative climate impacts[7].

Electric aircraft could also be included. However that technology remains in its infancy, and a meaningful development and deployment of such aircraft will require a separate industrial policy, potentially in cooperation with other global aircraft manufacturers, and as a result is beyond the scope of this paper. The same is true for hydrogen aircraft, which, if powered by green hydrogen, can bring about substantial emission reductions.

That leaves, as T&E proposed in its 2018 Roadmap to Decarbonising European Aviation[8], a combination of sustainable waste and residues fuels and efuels. Both fuels require safeguards to be put in place, whereas at present such safeguards exist only in limited form for waste and residues. Both fuels have particular limits to their availability which must be considered by regulators. These issues are considered further below.

4. Current and proposed legislation

As discussed above, to date there has been limited regulatory efforts to bring about an uptake of alternative fuels in the aviation sector. The result instead has been voluntary initiatives by industry which, while important in demonstrating the technical viability of such fuels, have had

[7] https://bellona.org/publication/joint-briefing-by-zero-waste-europe-and-bellona-recycled-carbon-fuels-in-the-renewable-energy-directive

[8] https://www.transportenvironment.org/publications/roadmap-decarbonising-european-aviation

limited impact in actual uptake. However that is currently changing due to legislative efforts under way at member state and EU-level.

Member state level

A number of member states have announced an intention to mandate the use of alternative fuels in their aviation sectors, by applying a mandate to all fuel uplifted in that member state (so including both domestic and international aviation). Already Norway has introduced a 0.5% mandate from January 2020[9], limited to advanced fuels as defined by Annex IX of RED II (Norway is subject to this Directive) with an intention to increase that percentage to 30% by 2030, though it is yet to legislate for such an increase.

Member states which are considering their own mandates include Sweden, France, Spain, Finland, the Netherlands and Germany. These proposals are at various stages of development, for example Spain has drafted legislation (with a “preference” for advanced fuels) while Germany is currently earlier in developing its target and fuel preference. Sweden aims to legislate for a mandate later this year, and has signaled in a report issued last year that it will not limit its support just to advanced fuels, though importantly it will recognise efuels[10].

These member state efforts are to be welcomed, as they attempt to redress decades of inaction on aviation emissions. That they apply, or intend to be applied, to fuel used for both domestic and international aviation sets an important precedent that states must regulate all of their aviation emissions.

However, like many climate policies, there are good and bad approaches to how fuel mandates can be adopted. That includes promoting fuels which have negative environmental and social consequences such as crop biofuels, or setting mandates at an unsustainably high level. In developing their national mandates, some of these risks are evident, such as Sweden looking beyond just advanced fuels and the Netherlands proposing a 2030 target of 14% without consideration as to whether there are sufficient feedstocks. It is important for these national efforts to learn from the mistakes made in the road transport sector, in order to ensure that these policies deliver the badly needed emission reductions in the aviation sector. Fuel policies should also be crafted in a way which rewards new technology developments, though without undermining regulatory certainty for fuels which are rewarded in earlier policy stages.

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9 https://www.reuters.com/article/us-norway-airplane-biofuels/airlines-get-ready-for-jet-biofuel-take-off-in-norway-idUSKBN1XV1TQ

10 https://www.thelocal.se/20190301/sweden-to-force-airlines-to-blend-in-biofuels

European level

At European level two legislative instruments currently aim to drive an uptake of alternative fuels in the aviation sector

1) EU Emissions Trading Scheme: aviation was included in the EU's Emissions Trading Scheme (EU ETS) from 2012 for flights within Europe. Under ETS, airlines are able to reduce their allowance surrender obligation through the use of alternative fuels, as defined by RED, whose emissions are zero rated. However due to the low price of allowances, compared to the price of alternative fuels, no airline to date has availed of this option and so the measure has failed in its objective.
2) RED II: the revised RED enables renewable fuels used in aviation to count towards member states' targets. It contains a multiplier for the use of advanced alternative fuels (excluding crops) in the aviation sector of 1.2. The revised RED was only recently adopted (2018) and so this provision has had little time to be tested. However a multiplier of this size is highly unlikely to incentivise an uptake of alternative fuels in the aviation sector, and there are concerns that the cost of compliance with RED II will be offloaded onto the road users[11].

Neither of these mechanisms have, or are likely to, bring about an uptake of alternative fuels in the aviation sector to any meaningful extent, and certainly in a timescale consistent with the Paris Agreement. As a result, as part of the European Green Deal the European Commission announced "The Commission will consider legislative options to boost the production and uptake of sustainable alternative fuels for the different transport modes[12]". This was followed-up in early 2020 with a Commission work programme which included a ReFuelEU Aviation initiative - a commitment to a legislative instrument for the uptake of alternative fuels in the aviation sector. Work began on this legislative instrument with an inception impact assessment consultation launched in April[13].

Considering the above challenges which previous alternative fuel efforts have faced, and given the particular requirements of the aviation sector, what would an effective legislative instrument for aviation alternative fuels look like?

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[11] https://www.transportenvironment.org/sites/te/files/publications/2017_09_Aviation_REDII_final.pdf
[12] https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf
[13] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12303-ReFuelEU-Aviation-Sustainable-Aviation-Fuels

5. Recommendations for establishing the ReFuelEU initiative

The ReFuelEU initiative must be based on three core objectives 1) only allow genuinely sustainable fuels to be included 2) ensure sufficient safeguards are in place so that those fuels deliver the promised emission reductions and 3) ensure the development and uptake of these fuels within sustainable limits.

1) Select the right fuels: a legislative instrument, whatever the precise mechanism it contains, will ultimately have to determine which fuels it supports. In doing so, the primary objective should be supporting those fuels which can deliver substantial emission reductions and are capable of being scaled up sustainably to meet the demands of the aviation sector. Excluding crop-based biofuels, due to the issues with ILUC raised above, and Recycled Carbon Fuels, the focus then narrows to advanced biofuels and efuels.

   Advanced biofuels derived from truly waste and residue feedstocks are promising due to their ability to potentially deliver substantial emission reductions. However their availability is limited to perhaps 11.4% of EU aviation demand in 2050[14]. In developing a target for 2030, the figure would be even lower, due in part to competing demand from the road transport sector. This is also due to the limited availability of such feedstocks and competing uses[15]. The EU's waste hierarchy seeks to minimise the quantity of waste residue feedstocks, while sustainability concerns call into question the quantity of forestry and agriculture residues and other sectors such as chemicals are likely to add demand for these feedstocks out to 2050. **EU legislation may support the use of such fuels in the aviation sector to the extent that it is sustainably possible, but it should not rely on them to achieve full decarbonisation of the aviation sector in the line with objectives of the Paris Agreement. It should neither result in demand for advanced biofuel feedstocks beyond the existing targets that were deemed sustainable in the RED recast nor in the widening of the RED definition of 'advanced biofuels', which is already quite problematic.**

   This is especially true in the case of HEFA fuel, produced from waste feedstocks (waste oils and fats). The amount of sustainable feedstocks available for HEFA fuels is extremely

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14 https://www.transportenvironment.org/sites/te/files/publications/2018_10_Aviation_decarbonisation_paper_final.pdf

15 https://docs.google.com/document/d/1sOMXhBvuoOGZNsfO4Co9hMjXo4j56NqOeXWIOSuKluw/edit?ts=5ee9ba85#

limited and most of it is already used in FAME biodiesel production for the road sector[16]. Support for advanced biofuels pathways for aviation should therefore focus on technologies that rely on different types of feedstocks (e.g. agricultural residues) and the RED limit on Annex IX part B should also apply to aviation.

Instead, EU legislation should support new fuels such as efuels which can be scaled up over time to meet the demands of the sector. Efuels have, with a sufficient supply of additional renewable electricity to produce the green hydrogen and capture the CO2 required to produce them, the possibility to be scaled up in such a manner.

<u>Recommendation 1:</u> the legislative proposal should recognise that efuels have the greater potential to be scaled up to meet aviation fuel demands, and therefore prioritise their development over the development of advanced biofuels. In practice this recommendation means that it may include a role for advanced biofuels, but recognises that ultimately this role will be limited. This would involve an impact assessment to be conducted before any target is set. Crop biofuels should be excluded from the scope of the proposal.

2) <u>Ensure sufficient safeguards:</u> both advanced fuels and efuels will only deliver the promised emission reductions if sufficient safeguards are put in place. For each of these types, different safeguards are required:
i) Advanced biofuels: the RED II defines advanced biofuels as those contained in Annex IX, however there are a number of flaws in this Annex IX in that it contains feedstocks such as tall oil and palm oil derivatives which in fact have questionable climate and environmental benefits and can be used for other uses. A legislative instrument for alternative fuels in the aviation sector should rectify these shortcomings through only supporting the fuels which deliver sufficient emission reductions, factoring in competing uses and broad environmental impacts[17].
i) For efuels, these fuels only deliver emission reductions if the electricity used to produce them is additional and if the CO2 used to produce them is captured from the atmosphere. Non-additional renewable electricity will only divert such electricity from more efficient uses, while CO2 from other sources such as smokestacks risks continuing the production of such fossil fuels. Ensuring that the renewable electricity used is additional will ensure that the development of efuels drives greater investment in renewable electricity over the coming decades. Other issues related to land use and water use should be addressed.

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[16] https://theicct.org/sites/default/files/publications/Alternative_jet_fuels_cost_EU_20190320.pdf

[17] https://www.transportenvironment.org/sites/te/files/publications/2020_05_REDII_and_advanced_biofuels_briefing.pdf

<u>Recommendation 2:</u> a legislative instrument must rectify the shortcomings in existing legislation (REDII) through only supporting those advanced biofuels which can bring about sufficient emission reductions, factoring in competing uses and broad environmental impacts.

<u>Recommendation 3:</u> a legislative instrument should ensure sufficient safeguards are in place for efuels (additionality of renewable electricity and source of CO2). The safeguard to ensure additionality are expected to be contained in delegated act to the REDII, however limiting the source of CO2 to Direct Air Capture will need to be legislated for as either an amendment to REDII or as part of an aviation fuels regulation.

3) <u>Ensure an uptake of these fuels:</u> as considered above, there is currently no existing market for aviation alternative fuels in a meaningful sense, aside from a limited number of demonstrator projects. In order to develop a market, a legislative instrument (or instruments, or a single instrument with additional non-legislative elements) must support both the supply of, and demand for, such fuels.

   The supply of such fuels can be directly supported through payments for their production. The most efficient way to go about this would be contracts for difference (CfD), whereby public subsidies are used to meet the gap between what it costs to produce such a fuel, and what the market is willing to pay. CfDs have been used effectively in the past to support novel alternative technologies such as renewable electricity (wind, solar), and through an auctioning process can be awarded to the producer offering the lowest cost, therefore ensuring public money is put to the most efficient use. CfDs can also be structured to incorporate specific requirements in the fuels they are supporting (i.e. efuels derived fully or perhaps in early stages partially from direct air capture CO2, and maximising the output of ekerosene from such refineries). **CfDs should be funded by revenue derived from the aviation sector such as through the abolition of free allowances under EU ETS.** CfDs can also be issued on a rolling basis (i.e. new CfDs issued at regular intervals), allowing them to take advantage of the best available technology at time of issuance. They could be developed at national level, with funds provided by the EU's recovery fund or the EU ETS innovation. Alternatively it could be examined whether the CfDs are launched at EU-level, managed by a specific agency or Joint Undertaking.

   However ensuring supply of such fuels should also be matched through ensuring demand for such fuels. That demand can be required through a mandate placed, for example, on aviation fuel suppliers to ensure that the carbon intensity of their fuel is reduced progressively over time through the blending of such alternative fuels. If a mandate is adopted, it should be structured as a GHG reduction target to incentivise fuels delivering the greatest emission reductions. If designed on the basis of robust GHG accounting which includes indirect emissions, a GHG target is expected to deliver higher shares of the most sustainable fuels and a greater reduction in GHG emissions compared to an energy mandate[18]. A target needs to be set at a realistic level, following an impact assessment of the sustainable amounts of advanced fuels that could be used by the sector.

Recommendation 4: the legislative proposal for advanced aviation fuels should support the supply of such fuels through financial instruments such as CfDs funded from revenue from the aviation sector.
Recommendation 5: the legislative proposal should set a realistic mandate for the use of such fuels in the aviation sector, preferably through a GHG target to deliver the greatest emission reductions.

6. Details of an aviation alternative fuels instrument

Section 5 details some of the broader recommendations for how the ReFuelEU initiative should proceed. The below section contains more precise proposals on how the above recommendations could be implemented through a legislative instrument.

1. In order to achieve the objectives detailed above, the most efficient instrument would be an EU-level regulation applied to aviation fuel producers.

   i) An EU-level regulation on fuel suppliers to the aviation sector would impact less than ten companies[19] and would therefore be more efficient than an EU Directive which would require transposition to 27 member states before becoming operative.
   ii) It permits amendments to the REDII, to ensure the two instruments interact effectively (i.e. to avoid the combined instruments producing an unsustainable demand for advanced fuels, correcting shortcomings in DAC and feedstock categorisation)
   iii) To ensure an effective implementation, dissuasive penalties should be put in place, in case the obligations are not met. The penalty for non compliance needs to be set at a

[18] https://theicct.org/sites/default/files/publications/RED-II-Analysis_ICCT_Working-Paper_05052017_vF.pdf
[19] https://www.e4tech.com/news/2027-sustainable-aviation-fuels-obligation-to-be-introduced-in-the-netherlands-by-2023.php

level that is effective and proportionate, ensuring that it doesn't work as a disincentive to actually produce and supply new sustainable advanced fuels.

2. A carbon intensity target for advanced fuels (waste & residues and efuels) in the aviation sector would be introduced, amending the REDII, reflecting 1) increased direct electrification of this sector and 2) the need to ensure a 'fair share' of advanced fuels for the aviation sector, which does not currently have direct electrification as an option. Because of the limited availability of sustainable feedstocks and increased competing uses, the support for advanced biofuels should not go beyond the mandates already required by the RED recast. There needs to be a cross-compliance mechanism to ensure that an aviation fuels policy doesn't trigger unsustainable demand for advanced feedstocks compared to what is already set in the RED. It is highly challenging to determine a level of advanced biofuels that could be used in the aviation sector in Europe, as this will depend on a wide range of factors, especially the cost of sustainable advanced pathways[20], the pace of road electrification but also the competing biomass demand from a growing bioeconomy.

3. Within this overall target, a subtarget for efuels would be set, initially at a low level in recognition that the technology is still in relatively infancy. However without a target, that technology will not develop, and so a target is the appropriate mechanism. T&E's internal calculations have shown that a mandate for e-fuels of between 1 and 2% by 2030 is feasible, under certain conditions. It would:

   i) Require between 9 and 18 green hydrogen producing electrolysers, 100MW each, to be built, with construction expedited in the second half of this decade
   ii) Require additional renewable electricity generation of 13 to 26TWh, equivalent to between two and four times current Germany installed offshore wind generation[21].
   iii) For each 1% point, drive €9.4bn in investment in renewable energy and electrolysers technology, provided that the correct rules are in place to ensure that these investments are additional to what would have taken place without a mandate
   iv) Would increase fuel costs for airlines by between 4.5 and 9%, outside the range of fluctuations for jet fuel today, and a price gap which could be narrowed through increasing carbon price and/or introducing taxation on jet fuel.
   v) Would reduce fossil fuel demand by between 1,576 and 3,126 ktoe over this period

[20] https://theicct.org/sites/default/files/publications/Alternative_fuel_aviation_briefing_20190109.pdf
[21] https://www.cleanenergywire.org/factsheets/german-offshore-wind-power-output-business-and-perspectives

These figures are detailed in Annex I.

4. Additional legislative instruments would be required to support this policy including
   i) completion of delegated acts under RED II to meet that Directive's objective for renewable electricity used for such fuels to be additional and to generate at least 70% greenhouse gas savings. Several options are being considered for demonstrating additionality, among which the implementation of power purchase agreements (PPAs) between efuel producers and renewable electricity providers but also a new system of guarantees of origin + (GO+).
   ii) amendment to the ETS Directive abolishing free allowances and using the resulting revenue (around €1bn a year) to establish Contracts for Difference (CfDs) for efuels.

5. National mandates, such as those under consideration in the Netherlands, Germany, Sweden may continue, with fuel produced for these mandates eligible to count towards the EU-level target provided that 1) the fuels meet the sustainability criteria in the EU-level target, excluding crop biofuels and that 2) emission reductions from these fuels are only counted once.

A target of 1-2% efuels in 2030 would not be sufficient to put aviation on a pathway to decarbonisation by 2050 , which requires a much greater ramp up in efuel production starting this decade. First and foremost this highlights the need to avoid previously expected growth in demand in the sector; future growth called into question before and during the Covid 19 crisis. Lower expected growth reduces the fuel requirements for the sector, making percentage target increases easier to achieve.

However, the 1-2% target falls far enough short of what is required that demand management will not be sufficient to bridget the gap. Therefore the above target needs to be considered as an absolute minimum, sufficient to begin production of a fuel which is currently not in production. However for the ReFuelEU initiative to maximise its potential to decarbonise aviation, a revision of this target should be envisaged, based on the following principles:

i) a revision should be upward only, to ensure certainty of investment in supply for the proposed target
ii) the target could be revised upward to take advantage of expected falls in the cost of renewables and electrolyser technology, and increased efficiencies in production methods. Such developments should be used to expand the production of efuels, not lower the overall funds spent on support for such fuels

iii) the target could be revised provided that the additionality requirements are not compromised , and the EU has advanced decarbonisation of its electricity system, which would allay concerns that the production of renewable electricity for efuels is diverting from bringing the electricity system to zero emissions
iv) the target could be revised up through importation of efuels, however that would be subject to the conditions considered in the section below.

The challenge in increasing an efuels target demonstrates that any efuels strategy needs to be broader than just a target for the sector, and needs to be accompanied by an industrial strategy to support the development of these fuels, and more rapid decarbonisation of the existing electricity sector. Increasing the target must also take into account sectors which will compete with aviation for hydrogen and captured CO2 - therefore this aviation fuel's strategy must be firmly rooted in broader efforts to decarbonise Europe's economy by 2050 at the latest.

7. Production of efuels outside the EU

Importation of efuels from outside the EU is a possibility, as certain regions may offer more favourable conditions for the large scale increase in efuel production, for example the Middle East and North Africa (MENA) region. However such an approach presents a series of challenges, primarily

1) The additionality of renewable electricity generation for efuels production is crucial. Renewable electricity capacity must be added, beyond what that state was planning and already expected increases in ambition, to deliver two targets simultaneously, namely allowing that state to pursue an economy-wide decarbonisation strategy and to export efuels in parallel. Safeguards are also needed Such an approach could offer important co-benefits, such as increased overall investment in renewables and increased knowledge capacity in that state. It should not lead to a situation where EU e-fuels delays the necessary decarbonisation of a state's domestic economy. However this raises the second point of safeguards:
2) In determining whether this renewable electricity is additional, and other safeguards such as the source of CO2, there are challenges in terms of ensuring that a third country, outside the jurisdiction of EU enforcement authorities, are in fact complying with these safeguards.
3) Importing fuels from outside of Europe does not increase Europe's energy security, at best it transfers its dependence from one region/group of states to others. It should remain, as far as practicable, an objective of the EU to boost the continent's energy

independence, create jobs and support European industries to develop a competitive position in the efuels industry .

Before efuels are imported into the EU and allowed to count towards meeting the EU's targets, a robust certification system must be in place that verifies whether these imported efuels meet the EU's sustainability standards.

8. Non-CO2 benefits from deployment of alternative fuels

A potential additional climate benefit to a switch to alternative fuels in aviation is the reduction in non-CO2 climate effects resulting from the reduced particles in such fuels, an area which is increasingly being studied[22]. Aviation's non-CO2 climate effects is an area which has long suffered from a lack of research, despite growing acceptance that these effects can equal or exceed the CO2 effects[23]. The ReFuelEU initiative should support greater research of these non-CO2 effects, and include any resulting reduction on these effects in the total benefits to be derived from an uptake of alternative fuels in aviation.

9. Conclusion and key recommendations

Developing new fuels for the aviation sector offers the most promising means to reduce and ultimately eliminate emissions from the sector. Therefore this ReFuelEU initiative is to be welcomed, presenting a long overdue opportunity to address emissions from this sector. However this initiative must learn from past mistakes, particularly in the development of alternative fuels for the road transport sector, where there was misguided support for crop-based biofuels. It must also be realistic as to the level of waste and residues for advanced fuels available, and so concentrate on the development of new, efuels. Support for such fuels begins with a mandate, established at a credible level, however it must also encompass a broader industrial strategy to ramp up their production over time.

The above paper provides a range of recommendations, however the key basis for the ReFuelEU initiative must be:
i) a focus on the development of *new* advanced fuels, beyond the sort of crop-based biofuels currently in production
ii) credible targets for new advanced fuels which can be ramped up over time to meet the needed cuts by the sector

[22] https://www.sciencedirect.com/science/article/pii/S0378382018324081
[23] https://www.carbonbrief.org/explainer-challenge-tackling-aviations-non-co2-emissions

iii) a broad industrial strategy to support all aspects of the development of these fuels

Further information

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Annex I

The calculations contained in Section 6, relating to the requirements for the development of 1% efuels mix in 2030, were based on the following assumptions:

	Description	**Assumption**
Production of green hydrogen	Construction of nine 100 MW electrolysers to meet 1% of aviation demand by PtL.	Each electrolyser is assumed to have a utilization of 8,000 hours and the PtL efficiency rate of 52%.
Additional renewable electricity generation	3.4 GW, roughly equivalent to two times the installed offshore wind capacity in Germany in 2019	Off-shore wind electricity is assumed.
Additional investment in renewable electricity generation and electrolysers	~€9.4 bn, including off-shore wind installations, electrolysers and fuel synthesis plant.	Based on the level of investment needed to be made in 2025 in order to develop this output by 2030. Investment costs of 2350 EUR/kW for off-shore wind, 679 EUR/kW for electrolyser, and 730 EUR/kW for PtL are assumed.
Increase in jet fuel cost	4.5 % increase, outside the range of fluctuations for jet fuel price today, for 1% PtL	

	share in the EU aviation demand.	
Reduce fossil fuel demand by between 1,576 ktoe over this period	Reduction of fossil fuel demand due to the uptake of efuels over the period 2021 - 2030.	Presuming that production begins in 2022 on a limited basis (3ktoe) and increases to 574ktoe by 2030.