FAQ: the what and how of e-kerosene

Why the aviation sector needs e-kerosene, and how to deploy it sustainably

February 2021

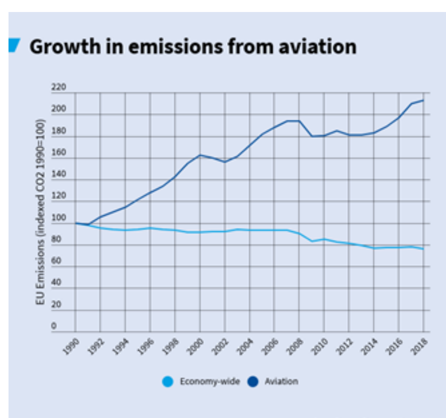
Summary

E-kerosene, sometimes known as efuels and synthetic kerosene, have the potential to substantially reduce the climate impact of aviation, one of the most carbon intensive sectors of the economy. However much confusion remains about these fuels, including how we can ensure they are sustainable, and how we can ensure their deployment in the aviation sector.

This FAQ seeks to answer these questions, and is published as the European Union drafts legislation to bring about an uptake of Sustainable Advanced Fuels (SAFs), known as its ReFuelEU paper.

As this FAQ details, deploying e-kerosene in the aviation sector is essential, but will require strong regulatory action here in Europe.

1. What is the magnitude of aviation's CO2 emissions and non-CO2 effects?



Pre-covid-19, decades of regulatory failure meant that aviation was among the fastest growing sources of emissions in Europe, having grown 26% between 2013 and 2018 and now [representing 4.2% of European emissions](). Aviation's non-CO2 effects, which represent two times the effects of

CO2, even further expand the climate impact of flying. As a result, serious regulatory action is needed in order to drive decarbonisation of the sector.

2. Why does aviation need e-kerosene?

For the aviation 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. Equally importantly, e-kerosene is “drop in” ready in that it can be introduced into the sector as a blend with fossil jet fuel and therefore does not require a major overhaul of infrastructure.

We don’t rule out the role that radical new aircraft designs could play in significantly reducing aviation emissions, for example hydrogen or electric aircraft. However such aircraft are not expected to be in operation in significant numbers until late 2030s or the 2040s, and will find it especially challenging to replace conventional aircraft for long-haul flights. Reduced flying can also play an important role, especially until new fuels and technologies are deployed, but alone will not be sufficient.

We therefore know that significant liquid fuel demand will exist right through to 2050, and for that reason, it is important to focus on how such fuels can be decarbonised, for which e-kerosene is the solution.

3. What is e-kerosene, how is it produced and how can it be carbon neutral?

E-kerosene is generated by combining hydrogen (H2) and carbon dioxide (CO_2). The terms “e-fuel”, “synthetic kerosene”, “synfuels” and “power-to-liquid” are often used interchangeably. E-fuels is a broader term covering all fuels produced using electricity; e-kerosene refers to a subcategory of e-fuels suitable for aviation. Synthetic kerosene can mean e-kerosene, but can also refer to other means of producing kerosene, for example directly from coal as occurred during the second world war.

Two conditions are essential for e-kerosene to have zero greenhouse gas emissions. First, hydrogen needs to be produced using additional renewable electricity (so-called “green hydrogen”). Second, carbon dioxide needs to be captured from the atmosphere, a process otherwise known as direct air capture (DAC). This way, the combustion of e-kerosene will, apart from some residual emissions, be close to CO2 neutral - non-CO2 effects are another issue, discussed below.

4. Why use DAC and not “smoke stack” CO_2?

There is indeed another way to provide carbon dioxide, which is to capture it directly from a concentrated source, such as an industrial site. This technique, also known as point-source CO2, collects the gas from fossil fuel industrial users and is therefore not fully zero carbon, as would have been the case if the CO2 was extracted from the atmosphere. Furthermore, it may have the indirect effect of encouraging industries to continue to rely on fossil fuels.

5. What is the advantage of e-kerosene compared to other sustainable advanced fuels (SAFs)?

First, e-kerosene provides a more scalable source of renewable energy - renewable electricity compared to biomass feedstocks used for biofuels. Second, not only is it now clear that crop-based biofuels have created a cure that is worse than the disease, but certain advanced biofuels are also not as sustainable as they appear. Some feedstocks that have been included in the Annex IX of the Renewable Energy Directive (RED II) as sustainable advanced fuels, such as tall oil or animal fats, raise sustainability concerns because of their current use in other industries which drives the uptake of unsustainable cheap substitutes. If a feedstock is good enough to be turned into jet fuel, that likely means it already services some energy or economic purpose, meaning it will have to be replaced. The amount of sustainable advanced biofuels is also extremely limited.

6. What are the non-CO2 effects of e-kerosene?

In the air, e-kerosene is likely to reduce the formation of contrails, which is a significant climate warmer because of its greenhouse effect on terrestrial radiation. Indeed, e-kerosene is made of reduced quantities of particles and aromatic chemicals that produce soot, the main “culprit” for contrail formation. This benefit needs to be better quantified, and therefore requires further study.

On the ground, e-kerosene can also contribute to improving local air quality, especially around airports, because of its significantly lower articulate matter (PM) and sulphur (SOX) emissions compared to fossil fuels.

7. What is the cost of e-kerosene?

In a recent study commissioned by T&E, Ricardo Energy and Environment estimated a cost of 137 - 233 €/MWh (i.e. 1.3 - 2.2 €/litre) for e-kerosene in 2030 depending, that is almost 2 to 3 times the average price of fossil kerosene.

Purchase commitments on the part of airlines would certainly push prices downwards, which is also likely to happen thanks to expected improvements in DAC technology as well as renewable electricity and green hydrogen production.

Estimating future cost trajectories is challenging. Some reports suggest under the right conditions e-kerosene can reach price parity with taxed fossil kerosene by the 2030s, others later. Deployment of renewables and new technology in other sectors has shown that with sufficient support, more ambitious falls in price can be achieved.

8. How can the cost of e-kerosene be driven down?

As detailed below, the cost of e-kerosene can be driven down through a mixture of demand-driven and supply-driven (mandate with contracts for difference, industrial investment policy) approaches. For e-kerosene to reach cost-competitiveness with fossil kerosene, these policies need to start being enforced in 2021. Taxing fossil kerosene can likewise help close the price gap between fossil and e-kerosene.

9. Will the mandated use of e-kerosene harm aviation's competitiveness?

No, for two reasons: First, because the first mandate to be enforced should be low, around 1-2% by 2030. A hypothetical 2% 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, would increase the fuel price by 4% (0.71 to 0.74 €/litre) and 3% (0.83 to 0.86 €/litre) for large and medium airports respectively. That exceeds the difference in price between airports.

Second, because by the time it's a high mandate, the production costs of synthetic kerosene will have come down enough to ensure competitiveness with fossil kerosene.

10. Is e-kerosene just a solution for aviation?

Yes, because it's far too inefficient for road and other non-aviation transportation modes and requires substantial renewable electricity. It should therefore be reserved for those transportation modes for which direct electrification and direct use of green hydrogen/ammonia are not (yet) a solution, such as planes.

11. Is there enough renewable electricity to produce e-kerosene?

There is sufficient renewable electricity potential within the European Union to produce enough e-kerosene to decarbonise aviation by 2050. However, the significant land and sea area required and water demand for production of e-fuel (which is an inefficient use of electricity compared with direct electrifications) means that policymakers need to make the right choices now and reserve green hydrogen and e-fuels for aviation.

The electricity demands to decarbonise aviation in this manner are substantial: aviation in 2050 will account for 22% of all demand for renewable electricity in transport, 535 TWh in total in the base case. 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.

Read more: E-fuel would be wasted on cars while it's badly needed to decarbonise planes and ships.

12. Is e-kerosene a "silver bullet" for aviation?

Unfortunately, it will take some time before e-kerosene is delivered in sufficient quantities, and until then, planes flying with fossil kerosene will continue to cause substantial climate damage. That's why we need to pursue other measures like pricing and managing demand

The lesson here is that governments should have put the aviation sector on its path to decarbonisation sooner. Unfortunately, precious time was wasted on false solutions like offsetting. This underlines the need for governments to act now, with no further delay.

Read more: EU publishes damning report of emissions offsets, calling into question EU's aviation climate strategy

13. What is an e-kerosene mandate?

An e-kerosene mandate is a binding policy instrument that makes it compulsory for all jet-fuel on the market to have a certain proportion of e-kerosene ("blending mandate") or a certain reduction in the carbon footprint of the fuel ('GHG intensity target'). Mandates for alternative fuels exist in the road transport sector, however there are issues with how those mandates were developed. Indeed, the climate effectiveness of a mandate is determined by the sustainability of the energy sources that it allows. Enabling unsustainable sources such as crop-based biofuels creates a cure that is worse than the disease. Another closely related problem arises from setting mandates that have too high targets. While this might seem well intentioned, high targets have the unintended effect of driving the uptake of cheap and unsustainable energy sources to meet the mandated objectives.

Unfortunately, these two problems are still routinely seen in today's national SAF mandates.

14. Why are mandates needed to deploy new fuels?

There's two main reasons for this: first, the currently significant cost difference between e and fossil kerosene (see above) is a deterrent for a demand uptake. Mandates will create demand for e-kerosene that will drive its price down. Second, by creating more certainty of demand, mandates would ensure investors confidence and thus drive investments that will result in a decrease in e-kerosene production costs. This has been the experience to date in other areas, such as the deployment of renewable electricity.

15. Why mandates can and should cover all fuel sales in Europe?

Europe has the legal authority to regulate all fuel sales and should therefore do so in order to cover the largest amount possible of aviation's emissions. Extra-EU represents the majority of the EU aviation's emissions so all flights refuelling in the EU should be included. An additional argument for the inclusion of extra-EU flights is that only including intra-EU flights may lead to market distortions, and some European carriers would have most of their emissions exempted.

16. How would a mandate work?

Mandates can be introduced in two ways: energy or GHG intensity. Energy requires that a certain share of energy comes from using alternative fuels - however this approach can often result in the prioritisation of feedstocks which are available in greater quantity, or cheaper, but have lower environmental integrity. GHG intensity requires the overall GHG content of the fuel to be decreased, which gives a boost to those fuels which can deliver the greatest GHG reductions, such as efuels.

17. Are there any risks of “carbon leakage” if only the EU imposes such mandates?

Whenever a policy only covers a given geographic area, this always comes with a risk that some regulated entities will try to circumvent the rules by making use of non-covered territories. However, for a e-kerosene mandate, this risk is likely to be limited for one main reason: a mandate on all fuel sold in the EU is likely to make it extremely difficult for non-EU airlines to evade the rule.

Indeed, for all long-haul flights and even some medium-haul ones, non-EU airlines will most likely have to refuel in the EU as they would not have enough autonomy to fly both legs with the “normal” fuel collected at their non-EU point of departure. And even if they could evade the rules by “tankering” (on a short-haul flight, for instance), the low cost of abiding by a low mandate would not make it worth it, as embarking more fuel also means flying with more weight and thus consuming more.

18. Should mandates just support e-kerosene?

E-kerosene is perhaps the most promising means of getting zero carbon renewable energy into the aviation sector. However other paths include developing zero emission aircraft (electric or hydrogen). Such aircraft will take time to be deployed at scale, but nevertheless regulators should state now that such developments will be supported through regulation. That can be done by recognising renewable electricity or hydrogen deployed in such a manner.

19. Apart from mandates, what can be done to support e-kerosene?

The challenge in increasing an e-kerosene target demonstrates that any e-kerosene 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. In addition, the supply of synthetic kerosene can be directly supported through payments for its 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 should be funded by revenue derived from the aviation sector such as through the abolition of free allowances under EU ETS. Acting on both demand (mandates) and supply (industrial strategy and CfDs) would help bring the costs of synthetic kerosene down towards competitiveness with traditional kerosene possibly even more quickly than 2035.

20. Why current RED II safeguards aren't sufficient?

First, while RED II was supposed to protect the environment from the ill-effects of first generation biofuels and some advanced biofuels, it has partially failed in this endeavour. Its Annex IX, which is meant to define the most environmentally robust "advanced" biofuels, includes feedstocks that raise sustainability questions, such as energy crops or trees. Second, under RED II, the direct air capture (DAC) of CO2 is not required in the production of synthetic kerosene. This enables synthetic kerosene produced thanks to smoke-stack CO2 which, as explained above, is not sustainable in the long run since it encourages the industry to continue carbon-intensive activities. The EU has committed to revising this Directive as part of its European Green Deal, which is an opportunity to fix some of these issues.

21. Is regulation needed at global level?

Ideally, the uptake of e-kerosene would be driven by a solid global legislative framework. However, the only organisation capable of establishing such a framework, the UN's International Civil Aviation Organisation (ICAO), is both remarkably slow and non-transparent at agreeing on new policy instruments and is most likely to only be able to introduce weak rules with no financial backing, which would further slow down the use of e-kerosene. Instead, the EU has the potential to implement an ambitious framework, which will encourage other major aviation markets to adopt such an e-kerosene policy. In the absence of a reliable and ambitious global arena in which to tackle aviation's environmental impact, the EU can and should pave the way for the rest of the world.

22. Are new aircraft (hydrogen, battery) not a better option?

Radically new aircraft have the potential to play a significant role towards making aviation truly sustainable. However, this strategy faces several substantial challenges which makes it unreliable in the short and medium term. First, because of issues related to the weight of batteries or the volume of hydrogen, the range and passenger-load currently reachable by these new aircraft is nowhere near what is needed in regional aviation, let alone long-haul flights. Second, safety being a prime concern for all stakeholders in the aviation industry, certification timeframes are expected to be very long. Third, costs of development are expected to be extremely high, and it's unclear whether manufacturers are prepared to make the scale of investment needed, without assurances that carriers will purchase such aircraft.

Most importantly, committing to net zero emissions in 2050 means that we need to start achieving concrete results now. Too many years have already been wasted sweeping the issue of aviation's climate impact under the carpet.

However, in the longer run, the development of new aircraft designs can certainly co-exist with the deployment of synthetic kerosene in a mutually reinforcing way. For example, on short-haul routes or private jets, zero emission aircraft might be the better option. The upcoming aviation fuels policy should leave the door open to rewarding these technologies.

23. Recommendations

EU lawmakers should recognise the incredible potential of synthetic kerosene to help aviation deliver on its environmental goals in a way that is truly sustainable, scalable, and does not require major technological overhauls. To achieve this, a swift and ambitious action plan is required within the upcoming ReFuelEU aviation initiative:

- Legally clarify that only e-kerosene produced through additional renewable electricity and DAC CO2 is eligible.
- Propose an EU-wide synthetic kerosene blending mandate of around 1-2% by 2030, covering all EU intra, in and outbound flights.
- Support the production of e-kerosene through contracts for difference (CfDs), which would be funded by revenue derived from the aviation sector such as through the abolition of free allowances under EU ETS
- This needs to be accompanied by an industrial strategy to support the development of these fuels, and more rapid decarbonisation of the existing electricity sector.
- Remain open and supportive of new technologies, such as electric and hydrogen aircraft, in particular for short and medium haul routes
- Finally, the EU should press on regional and international third-countries for the adoption of like-minded measures.

Further information

Andrew Murphy
Aviation Director, Transport & Environment
andrew@transportenvironment.org
Mobile: +32(0) 485 00 12 14