FAQ: the what and how of e-kerosene

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

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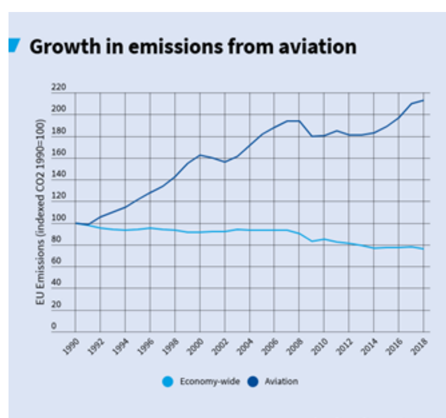
Summary

E-kerosene has 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 negotiates the legislation which will bring about an uptake of Sustainable Advanced Fuels (SAFs), known as ReFuelEU.

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 CO_2-emissions in Europe, having grown by 26% between 2013 and 2018 and now [representing 3.7% of European emissions](). Aviation's non-CO_2 effects, which represent two times the effects of CO_2, 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 important, 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 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 the 2030s or 2040s, and it will be especially challenging for them to replace conventional aircraft for long-haul flights. Reduced flying will also play an important role, especially until new fuels and technologies are deployed, but it will not be sufficient alone.

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-fuels’ are a broader term covering all fuels produced using electricity. E-kerosene refers to the subcategory of e-fuels suitable for aviation, and is generated by combining hydrogen (H_2) and carbon dioxide (CO_2). Another term, synthetic kerosene, can mean e-kerosene, but could 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 renewable electricity (so-called “green hydrogen”). This renewable electricity must be additional, meaning it must not divert existing renewables away from being used in other sectors.Secondly, 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 CO_2 neutral. Non-CO_2 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 CO_2, 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)?

Firstly, e-kerosene uses a more scalable source of renewable energy: renewable electricity compared to the biomass feedstocks used for biofuels. Secondly, 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 due to 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 serves some other energy or economic purpose, meaning it will have to be replaced. For example, if Palm Fatty Acid Distillate (PFADs) are used in SAF then their use in other sectors will be replaced by palm oil, leading to higher lifecycle GHG emissions than fossil fuels. 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 can be 100% paraffinic, meaning that it is free from aromatics, the chemical compounds that produce soot, the main "culprit" for contrail formation.

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

Finally, airlines will be able to gather operational benefits from the use of e-kerosene: it can have up to 2% more specific energy than fossil kerosene, as e-kerosene has a higher hydrogen to carbon ratio, and would lower maintenance costs due to lower soot build-up in the engines. This benefit needs to be better quantified, and therefore requires further study.

7. What is the cost of e-kerosene?

In a recent study commissioned by T&E, Ricardo Energy and Environment estimated a levelised cost of energy of 137-233 €/MWh (i.e. 1.3 - 2.2 €/L) for e-kerosene in 2030 depending on the cost of DAC. That is 3 to 4 times the average price of fossil kerosene in 2019[1].

However, the US Energy Information Administration projects Jet A price to double by 2050, while e-kerosene prices are likely to decrease as the market gets mature and technology improves. E-kerosene production costs will also drop substantially as renewable electricity becomes cheaper. For example, DENA projects the domestic costs of DAC-kerosene in the EU to decline from 125 €/MWh in 2030 to 70 €/MWh in 2050.

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 drops 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 approaches (contracts for difference, industrial investment policy). For e-kerosene to reach cost-competitiveness with fossil kerosene, these policies need to start being enforced as soon as possible. Taxing fossil kerosene can likewise help close the price gap between fossil and e-kerosene. There is also potential for the EU to import cheaper e-kerosene, considering the lower cost of renewable energy outside the EU and the negligible transportation cost. However, domestic production will remain important since the EU should not simply replace its import dependency on fossil kerosene with imports of e-kerosene.

[1] 557€/t as per Stratas Advisor data (Jet fuel Northwest Europe)

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

No, for two reasons. Firstly, the mandate will have a minimal effect on ticket prices. A 2% e-kerosene target in 2030 would result in an extra cost of just €1 per passenger for every 1000km of flying (the average length of an intra-EU flight)[2].

Secondly, by the time the mandate is higher, the production costs of synthetic kerosene will have come down enough to ensure competitiveness with taxed fossil kerosene.

10. Are e-fuels only a solution for aviation?

Yes, because it is 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?

If aviation demand is not managed, the sector will require around a quarter of all renewable electricity generated in the EU in 2050 to produce the e-kerosene necessary for its decarbonisation, or 1304 TWh. Dedicating this amount of domestically produced electricity to one sector is obviously problematic. Importing electricity or e-kerosene doesn't come without challenges, such as guaranteeing the additionality of the renewable electricity, and goes against the principle of energy sovereignty. That is why managing demand in the coming years will be absolutely key to decarbonising European aviation. If business travel is halved and leisure travel is kept to 2019 levels, electricity needs for aviation can be reduced by a factor of two (658 TWh).

Other challenges posed by e-fuel production are the significant land area, sea area and water demand required. E-fuels are an inefficient use of electricity compared with direct electrifications, which means that policymakers need to make the right choices now and reserve them for sectors that really need them, such as aviation.

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[2] Based on the ReFuelEU Aviation Impact Assessment, it will cost up to 2,97€ to produce 1 kg of PtL-kerosene in 2030, while fossil jet fuel will cost 1€/kg in the same year (without added taxes). The cost differential between the two is therefore approximately 2€/kg. The fuel consumption of currently employed aircraft will be about 24 kg per passenger per 1000 flight-kilometers in 2030. This means that on a 2000km flight in 2030, one passenger consumes 48kg of fuel, costing 48€. If 2% of those 48kg (ca. 1kg) cost 2€ more, this results in an added cost per passenger of 2€ for a 2000km flight.

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 can be 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 ('greenhouse gas (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 targets that are too high. 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-kerosene 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 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 should mandates 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 flights represent 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 fuel purchases exempted.

16. Should mandates just support e-kerosene?

E-kerosene is perhaps the most promising means of getting zero carbon renewable fuels 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.

17. 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 e-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. It is also crucial that investments in e-kerosene production facilities are coupled with investments in new renewable capacities. 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.

18. Why are current RED II safeguards not 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, DAC CO_2 is not required in the production of e-kerosene. This enables e-kerosene produced with smoke-stack CO_2 to be used which, as explained above, is not sustainable in the long run since it encourages the industry to continue carbon-intensive activities. The EU is revising this Directive as part of its European Green Deal, which is an opportunity to fix some of these issues.

19. 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. Anything ICAO would be able to introduce would most likely be weak and contain no form of financial backing, which would further slow down the uptake of e-kerosene. Instead, the EU has the potential to implement an ambitious framework, which will encourage other major aviation markets to adopt a similar 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.

20. 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. Firstly, due to 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. Secondly, safety being a prime concern for all stakeholders in the aviation industry, certification timeframes are expected to be very long. Thirdly, the cost of development is expected to be high, and it is 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 e-kerosene in a mutually reinforcing way. For example, on short-haul routes or private jets, zero emission aircraft might be the better option (if modal shift is truly impossible). The upcoming aviation fuels policy should leave the door open to rewarding these technologies.

21. Recommendations

EU lawmakers should recognise the incredible potential of e-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 ReFuelEU aviation initiative:

- Propose an EU-wide e-kerosene blending mandate of 0.04% in 2025 and 2% in 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

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