



 Nordic Council
of Ministers

Nordic Sustainable Aviation

Policy Brief

Globally, aviation counts for a modest share of World total greenhouse gas (GHG) emissions from today's energy use. However, air transport has been rapidly increasing and many other sectors are expected to reduce their emissions. Hence, aviation's share of global emissions can be foreseen rise and will constitute a significant part of the problem unless strong counteracting initiatives are taken.

January 2019, the Nordic Prime ministers signed the '*Declaration on Nordic Carbon Neutrality*', committing their countries to strengthen mutual cooperation to attain carbon neutrality domestically. The declaration emphasizes decarbonization of the transport sector.

The report '*Nordic Sustainable Aviation*' examines opportunities for increased Nordic cooperation with regards to increasing sustainability of aviation and propose common policy measures based on evaluation of alternative options.

Bio-jet fuels Today, all production pathways for sustainable aviation fuels (SAF) are far more expensive than fossil jet fuel. This is the main reason why current demand for SAF is insignificant compared to the total aviation fuel consumption and supply is considered scarce or unstable. Only about 0.05% of jet fuel used in the EU is SAF. It is mainly bio-jet fuel produced from waste oil and animal fat residues as feedstock, which is not scalable to significant shares of total aviation fuel demand. The largest volumes of biofuels are today used in other transport modes, predominantly road transport and mainly produced from crops which can also be used for SAF. The sustainability of using crops as feedstock for fuel production is increasingly questioned, as there are severe risks of deforestation and other indirect land use change impacts. Advanced biofuels use residues from agriculture or forestry as feedstock and are considered more sustainable. A crucial issue is therefore which sustainability criteria biofuels must match to be labelled as SAF, especially with regards to the origin of the feedstock.

Electro-jet fuels An even less developed alternative to biofuels are sustainable e-jet fuels, that is synthetic kerosene using hydrogen from water by electrolysis by electricity generated by renewable sources. Converting the hydrogen to liquid fuel requires carbon which can come from biomass, including forest or agriculture residues, or from CO₂ captured from point sources or from the air. The life cycle greenhouse gas (GHG) emissions are very low compared to fossil jet fuel. A main advantage of e-jet fuel is that renewable based electricity is not considered globally limited in the same way as biomass. The big challenge with e-fuels is the costs, due to the large amount of renewable energy needed to produce it and the technical development needed to commercialize it. Costs estimates for e-fuels vary widely but are generally expected to decrease over the next decade.

Electrification Electric propulsion combined with battery storage has recently gained intense attention as an alternative to liquid fuel. The background is the last decades' dramatic development in battery technologies which is expected to continue with higher energy intensity at significantly lower production costs as well as remarkable reduction in costs of solar and wind energy-based electricity. The main barrier is energy intensity (kWh per kg) of batteries and future development in this area will be decisive for the role of battery-electric aircraft. Battery storage is essential for electrification to be a genuine alternative that circumvent the challenges described for SAF. The main disadvantage of batteries is their weight, which is a much bigger challenge for aviation than for surface transport.

The climate impact of aircraft emissions is estimated to be significantly larger than for surface emissions when flying in high altitudes. Contrails from fuel burn and other complex atmospheric chemical reactions can lead to a more than doubling of the CO₂-effect.



Pathways to sustainable aviation

In political mainstream, curbing air travel by strong demand side measures that could stop aviation growth is not considered as an attractive path to significantly reducing the GHG emissions from aviation. The alternatives are to:

- pursue continued energy efficiency improvements and/or
- replace fossil jet fuel with alternative energy sources with no or lower lifecycle GHG emissions,

recognizing that this can also increase costs and ticket prices and thereby reduce air travel.

Over the next two decades, achievable fuel efficiency improvements for new conventional aircraft are estimated to be at best about 40%, and air traffic management is expected to be able to generate another 5-10%. Adding that significant GHG reductions required from aviation to reach the long-term targets implies that a major share of the reductions will expectedly have to come from replacing fossil energy with low-carbon alternatives. This could either be to replace fossil jet fuel with low carbon fuels with more or less identical properties, i.e. *sustainable aviation fuel*, or more radically by transforming fully or partly the propulsion system by electrification.

Sustainable aviation fuels (SAF) and electrification

Electrification holds significant potentials in coming years, in particular for small aircraft at short to medium distances. Over the next couple of decades electric aircraft could possibly obtain significant market shares in some part of the short distance market depending on further technological development and cost reductions as well as political commitment. Irrespectively of the timeline, battery-electric aircraft will initially probably be most competitive:

- on routes with very short distance routes where cruise speed is less important and
- in sparsely populated regions, where passenger volumes are very small

Potential routes could be existing services operated with public subsidies (PSO-routes) or routes to one of the many existing small airfields without services today. This would also open up for significantly improved mobility in remote areas, which could be particularly interesting in the Nordics.

On the other hand, it is considered unlikely that fully electrified aircraft relying on battery stored energy will have any significance in scheduled operations on medium to long distances within the next two (or perhaps even three) decades. Taking into account medium to long flight distances' heavy share of total energy consumption, it seems fair to conclude that replacing:

- SAF will be the dominant option for replacing fossil jet fuel toward 2030. Adding slow replacing rates of airplanes due to long service life SAF will most likely also be by far the main contributor to carbon neutral aviation toward 2050 in combination with expectedly strong progress in energy efficiency.
- However, the market readiness for both advanced SAF and electric propulsion is currently relatively low and still requires intensified efforts in RD&D is needed for both SAF and electrification to reach maturity.

Comparative assessment of five policy measures for SAF

The report considers **five policy measures** which have all been part of the public debate about policies to reduce the climate impact of aviation:

A fuel tax targets GHG-emissions directly and creates incentives for travellers to reduce travel demand and for airlines to improve energy efficiency of operations. A common Nordic fuel tax regime will due to international regulation only apply to flights within the Nordics. These flights stands for only about one third of total jet fuel consumption, which will lower the total demand driven reductions accordingly. For a fuel tax to induce significant shares of SAF it has to be set high enough to eliminate the cost premium of SAF.

A passenger tax is a rather blunt instrument for promoting sustainable aviation. It will only reduce CO₂-emissions through lower demand and not create incentives to fuel savings nor use of SAF. Hence, rates have to unrealistically high to result in significant reduction. A clear advantage of a passenger tax is that it avoids the issues of climate leakage from tankering incentives created by measures that increases fuel costs.

A blending mandate or **CO₂ reduction requirement** can secure substantial use of SAF, even if implemented by the Nordics alone. This is necessary to obtain significant CO₂ reductions toward 2030. By increasing fuel costs (like a fuel tax) these measures will at the same time indirectly give (some) incentives to reduce travel demand and save energy. However, this effect is a 'two-edged sword' as the increased fuel costs at the same time creates risks of 'tankering' and other leakage effects.

A SAF fund eliminates the cost premium of the SAF and thereby avoids the risk of leakage but also eliminates the incentives to reduce travel and improve energy efficiency. A main disadvantage of a SAF fund is that it demands funding, which will of course have costs elsewhere in society and thereby violates the fairness of the 'polluter-pays-principle'.

Current regulation

- **Norway** has a blending mandate for 0.5% advanced biofuels as of 2019 and have plans to increase it to 30% toward 2030 but it is not yet converted to law.
- **Sweden** and **Norway** have passenger taxes. The rates per departing passenger are:
76.5 NOK (7.8 EUR) and 62 SEK (5.9 EUR) for domestic and EEA
204 NOK (21 EUR) and 260 or 416 SEK (25 or 40 EUR) for longer routes.
(EEA = European Economic Area, i.e. EU, Norway, Iceland and Liechtenstein) destinations.)
- **Norway** has a fuel tax on domestic flights. The rate is equivalent to about 55 EUR per ton CO₂.

All Nordic countries have a reduced or zero VAT rate on domestic trips. International aviation is not subject to VAT.

In addition, all flights within the EEA is regulated by the **EU Emission Trading System**. The current market price of emission allowances is about 25 EUR per ton CO₂ (August 2020). This level is far lower than national estimates of the marginal CO₂ abatement costs to achieve the emission targets in the Nordics, in particular if we only look at contributions from the transport sector.

International aviation is subject to many international agreements as well as EU legislation. In practice this means that fuel taxes can only be levied on domestic flights or agreed bilaterally and that passenger taxes have to be uniform to all destinations within EEA.

Combining a SAF fund with an earmarked passenger tax

The figure below gives an overview of the study's comparative assessment of the policy measures using twelve indicators. The scores 'YES', 'yes', 'no', and 'NO' are not derived from exact criteria but should be interpreted as an overall assessment of relative ranking among the five policy instruments. The overall picture from the scores is that none of the policy measures stand out as either clearly advantageous or the opposite.

Combining a SAF fund with earmarked aviation taxes that raises a revenue can address both the financing and polluter-pays-principle issues with a SAF fund. A fuel tax can only be levied on internal Nordic flights. Hence, to finance a significant percentage SAF for all flights by a fuel tax, it has to be rather high. This will result in a quite distortive fuel price differential between internal Nordic and extra-Nordic flights.

A passenger tax can be levied on all flights and avoid the risks of tankering and other leakage effects. In addition, a passenger tax can apply higher rates for flights to outside the EEA to reflect the higher GHG impact of these long-haul flights. This might reduce long-haul trips or shift them to shorter distances and thereby reduce GHG-emissions. Hence, it will be more in accordance with the 'polluter-pays-principle' than a fuel tax confined to flights within the Nordics.

The right-most column in the figure below presents the scores of a combined SAF fund and a passenger tax along the same lines as for the single measures. The combined measures generally have positive ratings, because one measure in many cases compensates for the disadvantage of the other. Only one negative rating stands out: The combined measure does not create additional incentives to more fuel efficient operations. However, as mentioned above, this is the unavoidable downside of avoiding risks of leakage from increasing fuel costs at Nordic instead of at EEA or global level.

Assessment of measure with regard to:	SAF blending requirement	CO ₂ e reduction requirement	SAF Fund	Fuel tax	Passenger tax	SAF fund & Passenger tax
Overall CO ₂ -reduction impact	YES	YES	YES	yes	yes	YES
Flights to outside the Nordics	YES	YES	YES	NO	YES	YES
Reducing demand: Fewer trips Shorter distance	yes	yes	NO	YES	YES yes	YES yes
Fuel efficient operations ⁽¹⁾	yes	yes	NO	YES	NO	NO
Using (more) sustainable fuels	yes	YES	YES	yes	NO	YES
Market creation for SAF	yes	yes	YES	no	NO	YES
Avoid leakage risks ⁽²⁾	NO	NO	YES	no	yes	yes
Government budget revenue	no	no	NO	yes	YES	yes
Polluter-pays-principle	yes	YES	NO	YES	yes	yes
Cost effectiveness	NO	no	yes	YES	NO	yes
Administrative burden minimised	no	NO	yes	no	yes	yes
International regulation compliance	YES	YES	yes	yes	YES	yes

(1) Including occupancy rate, cruise speed, etc.

(2) Tankering or displacing operations abroad. The leakage risk is less for a fuel tax than for a SAF blending and CO₂ reduction requirement because the fuel tax is assumed to be imposed only for flights within the Nordics.

A common Nordic vision for sustainable aviation

Progress toward sustainable aviation can be accelerated by political and financial support. Irrespectively of considerations about SAF versus batteries as energy carrier, clear signals of political commitment can contribute to reassure investors and other stakeholders without favouring one of these technological paths rather than the other. At strategic level this could be done by formulating:

A common Nordic vision for sustainable aviation backed by an ambitious joint target for the share of renewable energy in aviation by 2030.

In addition, Nordic cooperation, e.g. by a joint funding scheme, is likely to have potential gains beyond the sum of unilateral initiatives.

Main policy recommendations for promotion of SAF

Today, the market for SAF is far from mature and volumes insignificant compared to total jet fuel consumption. A political commitment to implement a certain share of SAF in 2030 can create a strong and reliable long-term demand and reduce investors' risk. A target of about 30% is currently on the political agenda in Norway and put forward by stakeholders in Denmark, Sweden and Finland. Starting at very low levels and raising the share progressively toward e.g. 30% in 2030 can allow for a gradual ramp-up of supply based on large-scale production.

A SAF fund financed by earmarked passenger taxes can be established to compensate the price premium of SAF. If the target for the SAF share of all Nordic jet fuel consumption in 2030 is set to 30% it would require a revenue of about 1 billion EUR per year. This revenue could be financed by a common Nordic passenger tax with rates roughly corresponding to the average of the current Norwegian and Swedish passenger tax rates (assuming a SAF price premium at 0.57 EUR per litre). Based on model calculations it is estimated that such a common Nordic passenger tax amounts to about a 4% of ticket prices on average.

The findings in the report lead to the following overall policy recommendations for a common Nordic initiative to promote SAF:

- **Supply side measures** with a long-term perspective are needed to promote sustainable aviation. In a 2030 perspective, this will in practice mean pushing for a gradual increase to significantly higher share of SAF of total jet fuel consumption.
- **Demand side measures** in terms of increased taxation can remedy excessive air travel from under-taxation of aviation both compared to its climate impact and to other consumption, in particular road transport. However, national or Nordic taxes alone are not likely to lead to a profound leap forward toward sustainable aviation over the next decade under existing international regulation.
- **A SAF fund combined with an ear-marked passenger tax** on all aviation may both minimise carbon leakage from tankering and provide financing mechanism for the additional costs of a significant share of SAF in total jet fuel consumption.
- **A common Nordic policy framework** consisting of a joint Nordic (or parallel national) SAF fund(s) financed by harmonised Nordic passenger taxes can secure demand for significant and stable volumes of SAF toward 2030. A joint Nordic long term commitment will enhance opportunities for large scale production by reducing investor risks.

Initiatives to accelerate innovation in electric aviation

Electric propulsion can contribute to more sustainable aviation in two ways:

- Firstly, by higher energy efficiency of electric motors compared to conventional combustion engines.
- Secondly, by battery storage of electricity based on renewable energy. Battery storage is essential for electrification to be a genuine alternative to SAF.

The relatively low technology readiness level of airplanes with electric propulsion means that it can be politically difficult to credibly commit to stable long-termed framework condition in general at the current stage of maturity where high uncertainty prevails.

- Political initiatives should focus primarily on measures that can encourage and financially support RD&D and accelerate innovation. This could include programmes for Nordic cooperation, experience exchange, etc.
- Widespread market creation in line with the strategy for SAF described above appear to be premature until higher technology readiness levels (TRL) is reached.
- Nordic cooperation to promote electric aviation should target short routes up to about 500 km. Toward 2030 this is most likely the only segment where electric airplanes will have potential. This includes some of the most travelled Nordic routes, but most will be domestic.
- Very short routes (<200 km) will be most suited for the earliest demonstration projects. An agreement on financial support to parallel demonstration projects in all or several Nordic countries could be part of a common vision. All countries have suitable routes, but about two thirds of the very short routes are Norwegian due to the country's challenging geography with fjords and mountains which hampers surface transport.

Over the next decade, certified electric airplanes will predominantly be small; with up to 9 or 19 seats for certification reasons. This means that additional staff costs and other operational costs per passenger will be higher than today. This will counteract and possibly more than outweigh the potential cost savings on propulsion energy and engine maintenance. In that case, commercial operations will require political subvention:

- Clear signals of political commitment to economic support that can reduce risks and secure viable business cases for electrified routes are crucial to attract operators in the early phases.
- The financial implications of securing viable business cases for operating electric airplanes on a limited number of short routes are manageable. Many handles can be pulled to support operators willing to invest in electric aviation.

Several of these initiatives will be strengthened by a joint Nordic approach.

The global perspective

Finally, reductions of GHG emissions stemming from Nordic aviation contributes little to the overall climate impact of global aviation. This is not to say that common Nordic initiatives are not essential, on the contrary. But arguably, the most significant overall impact may be via its influence on European and international climate change policy and perhaps by pushing for technology development. If so, a common Nordic policy framework should also take into account how this influence can be optimized.

Next steps ...

This report has outlined overall recommendations for a joint Nordic approach to promoting more sustainable aviation in the Nordics. If the Nordic countries agree to move forward in line with the suggested approach outlined above next steps in the preparation of concrete common initiatives could be to:

- **SAF fund.** Conduct a juridical assessment of alternative models for construction of a Nordic or parallel National SAF fund(s), in particular which financing mechanisms would be in accordance with the EU's state aid regulation.
Elaborate the detailed design of the financial support mechanism a SAF fund, including sustainability criteria for eligibility of SAF.
- **Passenger taxes.** Nationally implement harmonized passenger taxes in each Nordic country, taking into consideration the size and structure of existing and expected passenger taxes in neighbouring European countries.
- **Electric aviation.** Politically adopt a common Nordic commitment to pursue the potentials of electric aviation
- **RD&D.** Finance a common Nordic research and innovation programme for SAF and electric propulsion
- **International cooperation.** Form a united position in EU and international fora pleading for EU-wide GHG taxation of fossil jet fuel or alternatively a wider scope for national implementation of distance-based passenger taxes.



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