

# Forslag til program for introduksjon av elektrifiserte fly i kommersiell luftfart

MARS 2020



# 11 English summary

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## Background

The Norwegian Ministry of Transport has commissioned Avinor and the Civil Aviation Authority of Norway (CAA Norway) to propose a programme for the introduction of electrified aircraft in Norway. The programme is to be formulated in accordance with the Instructions for Official Studies, which in practice means that recommendations will be expressed as goals, measures and instruments for the introduction of electrified aircraft.

The Ministry of Transport has stated that the report, together with NOU 2019:22 *Fra statussymbol til allemannseie – norsk luftfart i forandring* (From status symbol to public domain - Norwegian aviation in change) and the report *Teknologi for bærekraftig bevegelsesfrihet og mobilitet* (Technology for sustainable freedom of movement and mobility) from the Expert Committee on Technology and the Transport Infrastructure of the Future, submitted on 27.06.2019, will be included as basis for discussions on the electrification of aviation in the Report to the Storting (Parliament) on the National Transport Plan (NTP), which will be published in spring 2021. However, this does not limit the Government in submitting proposals which are relevant to the electrification of aviation to the Storting before the new NTP is submitted.

## What is the problem?

Greenhouse gas emissions from many sources, including air travel, must be reduced significantly over the coming decades. To achieve the targets set out in the Paris Agreement, we must

cut our greenhouse gas emissions from fossil fuel sources to almost zero between 2050 and 2100, depending on the magnitude of possible emission reductions in the short term.

In Norway, we depend on aviation and we must search for fossil fuel-free alternatives.

The aircraft currently in use on the short-haul network needs to be replaced within the next 10-15 years. The present operator of the short-haul network, Widerøe, is clearly stating that the next generation of aircraft should be zero- or low-emission solutions.

If it proves impossible to identify aircraft types capable of operating on the short-haul network, the consequence will be either a reduction in the quality of the service and/or substantial investments in runway extensions, where such extensions are possible.

## What do we want to achieve?

To ensure high-quality transport services continue to be offered in Norway, it is in Norway's own interest – from the perspective of both the environment/climate and transport policy – that zero- and low-emission aircraft are developed which are capable of operating on the unique Norwegian short-haul network under the prevailing meteorological conditions in the country.

In the long term, it is anticipated that electrified aircraft will have lower operating and investment costs than comparable fossil fuel-based aircraft. This is an important premise for the further

development of electrified aircraft, and helps to explain the level of interest amongst many stakeholders. Electrification should also result in more energy-efficient motors, and a consequent reduction in overall energy consumption, in addition to simpler maintenance and greater flexibility in terms of design. In the long term this can enable completely new types of aircraft requiring reduced runway lengths.

An initiative to electrify aviation can also generate new jobs in Norway. No aircraft for use in passenger service are currently being manufactured in Norway, but it is possible to envisage a market in which specialised Norwegian companies operating as subcontractors could produce components and parts for electric aircraft. Rolls-Royce Electrical Norway, which has set up an operation in Trondheim creating over 70 jobs, is a good example. Furthermore, it is possible to imagine industrial development in the aviation ecosystem, e.g. within charging and hydrogen production.

The phasing-in of electrified aircraft can help to ensure the fulfilment of national and international climate commitments. As in the photovoltaic cell industry, the automotive industry and eventually also in ferry traffic, advances made in Norway, i.e. using Norway as a development arena and test market, could have impacts in terms of emission reductions beyond the emission reductions that are actually achieved in Norway.

## Why Norway?

Norway's dependence on aviation, abundant access to renewable electricity, unique short-haul network, active and interested stakeholders and political will to electrify the transport sector, make Norway both well-suited and recognised as a very interesting test area and the first market for electrification of aviation. If Norway does not take the lead, there is also a risk that the zero- and low-emission aircraft developed will be unsuitable for Norwegian winter conditions and runway lengths on the short-haul network. The European Union Aviation Safety Agency (EASA) is also indicating that electrification is presenting an excellent opportunity to show that aviation is actively taking steps to reduce greenhouse gas emissions and that the initiative and level of interest in Norway is of high value from a European perspective.

## Technological status

By 'electrified aircraft', we mean aircraft which are fitted with one or more electric motors for propulsion.

The pace of development of electric aircraft has accelerated over the past four to five years. According to consultancy firm Roland Berger<sup>35</sup>, as of January 2020, there are over 200 initiatives of varying maturity working to develop and realise electric and/or hybrid-electric aircraft for passenger transport use. Many of these are fixed-wing aircraft, which in the short term, we consider to be of greatest relevance for Norwegian conditions in relation to both range and capacity (number of passengers).

Many small companies and start-up businesses are positioning themselves in the up to 19 seats segment (certified aircraft in accordance with EASA regulations CS-23), but some of the

larger players also have development projects under way in this segment. As regards larger aircraft, it is the major players, most notably Airbus, Safran and Rolls-Royce, which have a clearly stated strategic position that electrification is part of the future, but Boeing, Embraer and all the major engine manufacturers also have ongoing electrification projects.

Airlines are also expressing interest, and many airlines in the USA and Northern Europe (Widerøe, Logan Air, SAS, EasyJet, etc.) have been clear as regards their wishes and expectations, and also have collaborative projects with aircraft and aircraft engine manufacturers.

It seems clear that there are no insurmountable technological obstacles to developing electrified aircraft. Based on our existing technological know-how and the expected pace of development, it should be technically possible to develop, certify and introduce aircraft carrying up to 19 passengers on regular civil scheduled flights from 2025–2030, and larger aircraft after that.

Battery technology is one of the biggest technological obstacles to the rapid development of battery electric aircraft. Current dominant battery technology (Lithium-ion) offers an energy density of about 250 Wh per kg battery. This figure is expected to increase by 50–75% to 400–450 Wh/kg. Developments are taking place rapidly in this field, and batteries have also become significantly more affordable over the past decade. The next generation of batteries is expected to be 'solid state' batteries, which at present appear to have a potential maximum energy density of just over 650 Wh/kg. This will have a major impact on the range of electric aircraft.

Based on current battery technology and certification standards, up to 19 seats and about 350–400 km of effective range (>500 km of actual range due to energy reserve) appear to be of greatest relevance for first-generation battery electric aircraft. However, this is sufficient for many domestic flights in Norway, including the vast majority of routes on the Norwegian short-haul network.

For longer range, given current known battery technology, it will be necessary to rely on series hybrid solutions, where the aircraft is equipped with a battery and a "range extender", such as a generator powered by jet biofuel, which can charge the batteries as and when necessary, or hybrid solutions that have both electric and conventional jet engines. A third possibility is to use fuel cells. There are players in all these segments.

It is important to stress that the development of electrified aircraft is still in its infancy, so it is not possible at the present time to make accurate predictions as regards timespans or costs. To date, the only certified aircraft with electric propulsion are motorised gliders, but a number of projects are in the process of being certified. As of 2020, many manufacturers are currently testing electric aircraft around the world, but only Pipistrel is actually delivering electric aircraft to customers (the two-seater Alpha Electro with a range of about 130 km + reserve). However, "all" aircraft and aircraft engine manufacturers are actively working on electrification. This is an important difference from the automotive industry, where it could be argued that the dominant car makers initially "obstructed" the electrification of road traffic, but have since fully embraced the idea.



## Challenges which must be overcome

On the technology side, the biggest challenge is to develop appropriate total solutions for new aircraft. Electric motors, generators, power distribution systems, energy storage (batteries/hydrogen/other) and airframes must be developed which are adapted to new technologies. Thermal control, high-voltage, electromagnetic radiation, energy density, weight reduction and safety requirements are some of the challenges highlighted by aircraft and engine manufacturers. Manufacturers do not see these challenges as insurmountable, but overcoming them will require new and effective forms of collaboration and facilitation.

We believe it will be technically possible to develop aircraft that can operate on the short-haul network in Norway (with up to 19 seats and capable of withstanding Norwegian winter conditions) and put them into service between 2025 and 2030. However, there is a risk that aircraft manufacturers will not find the segment sufficiently interesting (especially 800 meter runways) to invest in it.

Aviation regulations have mainly been written for fossil-fuel based engine systems and aircraft. The development of new technology, aircraft and operating concepts will affect the entire aviation system. It may lead to changes in safety regulations and requirements regarding the certification of parts (propulsion systems) and aircraft, airports including all ground-based infrastructure, pilot training and certification, air operations regulations and maintenance systems. If the development of the framework does not form an integral part of technology development, it could delay the processes involved.

Even if effective regulation is facilitated, it will take both time and resources to develop and certify an electrified aircraft. Most companies that are developing smaller aircraft (up to 19 seats) have limited funding available to them, and there is a risk that companies will be unable to secure financing in order to complete the development process and actually launch an aircraft on the market. The larger aircraft manufacturers - which have access to more funding - have so far shown relatively modest interest in developing smaller aircraft for short runways.

For the airlines, there is always some risk associated with being the first to buy a newly developed aircraft, and it can be assumed that this risk will be even greater when brand new propulsion technology is introduced. Risk mitigation for airlines looking to invest in zero- and low-emission aircraft would seem to be crucial.

## Summary of recommendations

Based on the mapping and assessment of technology, challenges and opportunities, we have developed a set of recommended goals and associated measures and instruments to achieve the goals. The sum of the recommendations is Avinor and the CAA Norway's *Proposed Programme for the Introduction of Electrified Aircraft in Commercial Air Transport*.

Norway depends on aviation, and aviation must be considered to be part of the public transport network across much of the country. Avinor and CAA Norway therefore believe that it will be vital for Norway to have concrete and timed goals concerning implementation and emissions reductions, as well as a goal of being a driving force and an arena for the development and implementation of new technology which will lead to significantly lower emissions and help us meet our climate obligations. In the long term, greener aviation is also expected to become significantly more affordable both for air passengers and for the State compared with fossil fuel-based solutions.

Norway already has something of a position as a driving force and is promoting the electrification of aviation, and by setting clear and ambitious national goals, it will be possible to further develop this position. By taking a leading role, we can facilitate the international cooperation that will be necessary and at the same time increase the likelihood of new technological solutions being able to cope with Norwegian climatic and topographic conditions, short runways and the needs of passengers and the market. Aviation will be able to draw on Norway's experiences of electrification within the maritime and private car sectors, and Norway and the Nordic countries may be an important first market for regional aircraft with zero or low emissions.

It is vital that goals, initiatives and instruments are seen as an entirety. We recommend that the Government establishes clear goals which are formulated in such a way that they appear effective and concrete – and that they set out a clear direction. This will be very important for the market players involved. However, the goals will only have the desired effect if they are followed up with binding and predictable incentives which are effective in all phases until zero- and low-emission aircraft are in regular scheduled traffic in Norway. We particularly wish to emphasise the importance of measures that will make the early adoption of new and climate-friendly technology both profitable and attractive to passengers, operators and other stakeholders alike.

We have chosen to divide the development process from today through to the established commercial operation of electrified

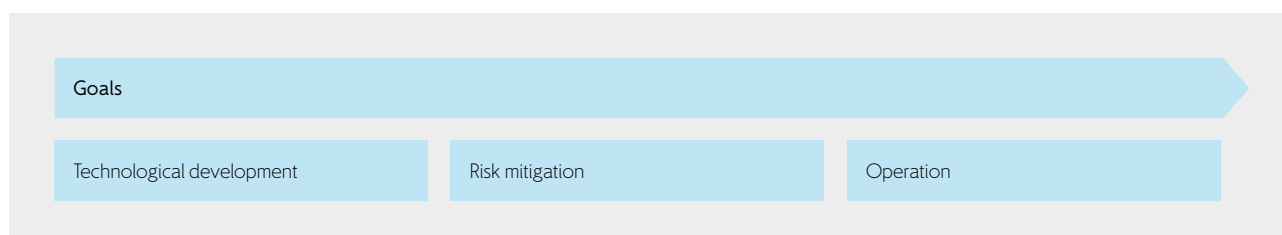


Figure 11.1: Phases in the development and phasing-in of electrified aircraft.

passenger aircraft into three phases. Each of these phases has its own special characteristics and we have assessed initiatives and instruments linked to each of them. The recommended goals are long-term in nature and extend across all phases (Figure 11.1).

## Goals

- Norway will be a driving force and arena for the development, testing and early implementation of electrified aircraft
- By 2030, the first ordinary domestic scheduled flights will be operated with electrified aircraft
- By 2040, all civil domestic aviation in Norway will be operated with electrified aircraft, reducing greenhouse gas emissions by at least 80% compared with 2020.

## Technological development

- To ensure a systematic and holistic approach to technological and conceptual development for regional electrified aviation, the joint multiannual *international* zero-emissions programme developed by the Norwegian and European civil aviation authorities (through CAA Norway and EASA) will be developed further. The programme will include goals, measures, instruments and organisation – and have both national and international elements. It will build on the information presented in this report and the bilateral innovation agreement between EASA and CAA Norway.
- A working group (the High Level Task Force for Zero Emission Aviation) with key international players (airlines, aircraft manufacturers, aircraft engine manufacturers, airports and public authorities), led by CAA Norway, will develop a roadmap for innovation relating to zero-/low-emission regional aircraft for presentation to the Ministry of Transport in summer 2020. It is recommended that the roadmap and associated recommendations form the basis for further measures and that relevant aspects be incorporated into the work relating to the National Transport Plan (2022–2033).
- To address and further develop the zero-emissions programme, an international arena/centre is established in Norway for the development, testing and implementation of zero- and low-emission aviation technology. This will be organised either virtually or physically and will act as an arena for cooperation between players in different fields (aircraft, engines, batteries, airlines, airports, government authorities, research communities, etc.) and other stakeholder groups. Clear criteria for participation and a funding model for the centre must be established, where users, suppliers, the public support system and public authorities contribute. Clear evaluation criteria should also be developed for the selection of measures which will be eligible for support. The centre will contribute to effective and efficient innovation and be organised with provision for both European and national involvement and support.

- Suitable airspace should be established, including approach and departure zones, which are intended for testing purposes and meet the necessary safety requirements.
- Government ministries and agencies, State-owned companies and the State public support system must work together more closely and in a more coordinated manner with regard to aviation and climate. The clear delegation of responsibility and appropriate processes for ongoing coordination and prioritisation are essential to facilitate effective and targeted innovation. It is recommended that the Ministry of Transport establishes clear guidelines for further work.
- Design an administrative and economic scheme which supports the establishment and operation of facilities and organisation linked to test activities in Norway. It should be possible to partially fund such a scheme through one or more of the existing national instrument schemes. The scheme must also be based on clear evaluation criteria for the selection of measures which will receive support. A targeted dialogue with the public support system should be established in order to assess whether any of the current schemes can be utilised, or whether new schemes should be established to support measures relating to aviation and climate.
- Norway is taking on a clear role in influencing the EU's Horizon Europe/CleanSky research programme for a comprehensive initiative relating to electrification.
- Develop and implement a communication strategy with messages relating to the initiatives and measures that are being launched. Players must be encouraged to contribute articles, lectures and meetings in important arenas in order to promote the work linked to aviation and climate in general – and the development of low- and zero-emission technology in particular. The communication strategy shall include the need for communication in international arenas.

## Risk mitigation

- Establish a grant scheme to develop charging infrastructure at Norwegian airports (Enova).
- Establish support schemes for the procurement of electrified aircraft. This may be already of relevance in Enova's next four-year programme, so a close dialogue with relevant ministries and Enova concerning how such a scheme could be designed will be important. Alternatively, government loans and guarantees may be an appropriate instrument.
- Consider appropriate new elements in future tender contracts (routes covered by a public service obligation – PSO), such as investment support, residual value guarantees and longer contracts. The latter will require Norway to obtain acceptance for deviations from EU regulations. The purpose of the incentives is to ensure that future contracts are formulated so that the level of risk is reduced to acceptable levels if zero- or low-emission aircraft are introduced on routes covered by a PSO.



Figure 11.2: Summary of recommended goals, measures and instruments

- Exemption from VAT for electrified aircraft used in voluntary activities (e.g. run by flying clubs), flying in flying clubs and private flying. Such an exemption – as applies in the case of road traffic – could have a major impact on general aviation in Norway, while the loss in revenue for Norway will be modest. As it is precisely in the general aviation and flying school segment that electrified aircraft can first be put into operation and tested, the impact will be significant.

## Operation

- The State should require the county municipalities to include emission-based evaluation criteria in future invitations to tender for routes covered by a PSO. Alternatively, explicit zero-emission requirements or defined maximum emissions may be imposed. A grant scheme should be established for county municipalities to cover the added costs that such a requirement can be expected to entail during a transitional phase. In addition, a bonus scheme may be established which will have a positive outcome for suppliers if they phase in zero-/low-emission technology during the contract period. Due to experiences gained during the introduction of electric ferries, consideration should be given to whether Enova can support the county municipalities in the formulation of these requirements.
- The State should give out a clear signal that the tax system will be aligned so that travel by zero- or low-emission aircraft will become more affordable in relative terms. For example, tickets for flights operated by electrified aircraft could be exempted from fiscal taxes for a transitional period. Such a tax policy would accelerate the development, production and procurement of zero- and low-emission technology.
- Exemption from or reductions in VAT on tickets for air travel by zero- or low-emission aircraft through to 2040 (possibly with re-evaluation in 2035).
- Exemption from or reductions in air passenger duty for zero- or low-emission aircraft through to 2040 (possibly with re-evaluation in 2035).
- Reduced aviation charges (Avinor) (evaluated in accordance with EU regulations)
- Reduction in electricity tax for aircraft used in commercial operations in accordance with a model taken from the shipping sector
- The State's travel agreements require business travel to be made in the manner that is fastest and most affordable way for the State. In future travel agreements, climate considerations should be afforded weight and form part of the evaluation basis when procurement agreements are established and employees choose their mode of travel. The aim is to provide clear signals from the public administration in Norway about the importance of more climate-friendly aviation and offer both manufacturers and operators an incentive.
- Norway supports the development of an eco-labelling system in aviation, regardless of whether this is a European or a global scheme. To promote new technology, the system must be scalable, so that zero- and low-emissions in aviation are accorded considerably better eco-labelling than existing traditional solutions. The aim is to help climate labelling become a clear and predictable incentive for manufacturers and operators of zero- and low-emission technology.

## Sluttnoter

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- 25) <https://www.elnett21.no/>
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Avinor og Luftfartstilsynet (2020):

Forslag til program for introduksjon av elektrifiserte fly i kommersiell luftfart. Rapporten er bl.a tilgjengelig på Avinors websider.

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