Nordregio

Implementing Electric Aviation: Critical Factors and Relevant Policy Instruments

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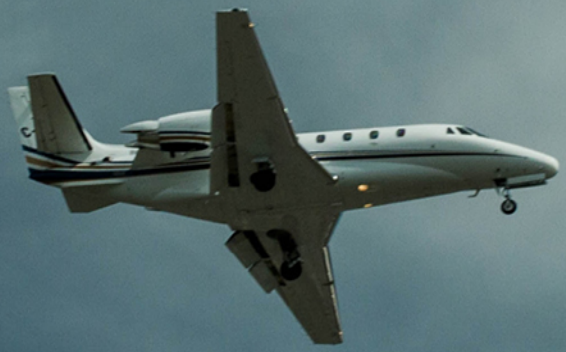

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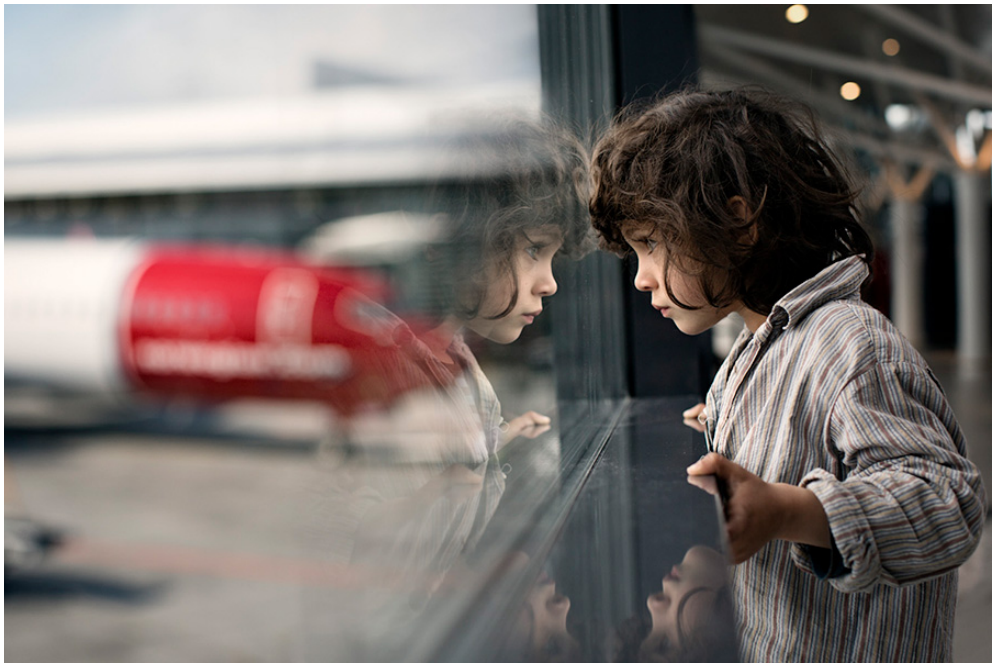

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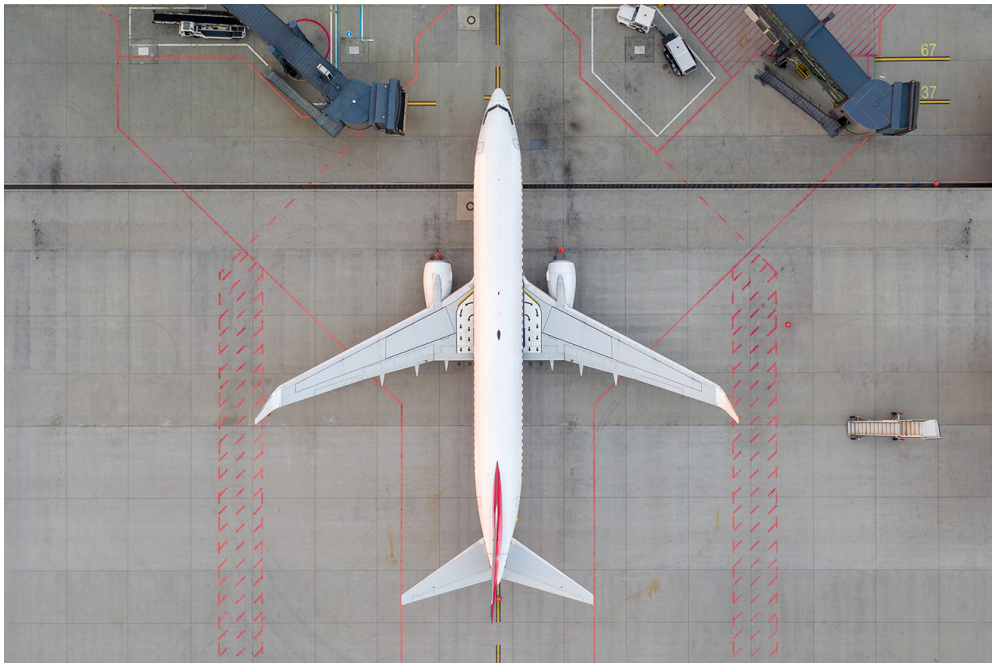
1. Introduction

The Nordic countries have ambitious plans to turn electric aviation into a reality in the Nordic countries in the near future. This working paper describes potential critical factors which might pose a challenge to the further development and establishment of low and zero emissions aviation in the Nordic countries. A special focus will be placed on purely electric aviation solutions.

The publication is based on a literature review comprising first and foremost articles that have been published in the recent years in the Nordic countries. It further presents possible policy instruments which could serve the creation of a Nordic policy framework to help address the identified challenges and support the implementation of electric aviation and other solutions in the Nordic countries. Most of these policy instruments stem from the same sources. Yet, some recommendations have been added that are based on general ongoing debates on the design, development, and market introduction of emerging technologies.

While the review predominantly addresses electric aviation, some notes regarding biofuels have been included due to current debates on the use of hybrid solutions using both biofuels and batteries to reduce emissions and extend the range of these aircrafts. The working paper is divided into ten sections, each focusing on one issue area identified in the literature. Every section is followed by a list of policy recommendations that could serve to address the described challenges.

This publication is one of the outcomes of the project titled "Electric aviation and the effects on the Nordic regions". The project analyses electric aviation's effects on Nordic regional development. The project, funded by the Nordic Council of Ministers, runs between 2022-2024.



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2. Charging Infrastructure

Past reports on the present and future of electric aviation published in the Nordic countries have identified several challenges related to infrastructure. Potential hurdles that past studies listed revolve around the challenges of providing charging solutions and include issues ranging from airport layout, over charging time to grid capacity. A report from the Norwegian aviation industry on the social benefit and climate and environmental impact from aviation notes that there are three possible approaches:

1. Charging airplane batteries directly through the grid,
2. Using stationary batteries or
3. Providing infrastructure for exchangeable batteries (Avinor et al., 2020).

In this context, the final report of the FAIR study also points out that the new charging infrastructure, regardless of its design, will need to consider the airlines' preferably short turn-around times (*FAIR Final Report – How to Accelerate the Implementation of Electric Regional Aviation*, 2022). In this context, it should be noted that Heart Aerospace has estimated a charging time of about 30 minutes for a small airplane using a 1 MW charger.

Apart from the infrastructure itself, and its place within the airlines' business models, questions regarding the operation of the charging stations have been discussed in the literature. For instance, the ownership of the charging infrastructure as well as the associated responsibilities still need to be clarified. Furthermore, the integration of the charging infrastructure into the overall airport layout and organisation have been raised as additional aspects that must be addressed in the future (NewsLab, 2020).

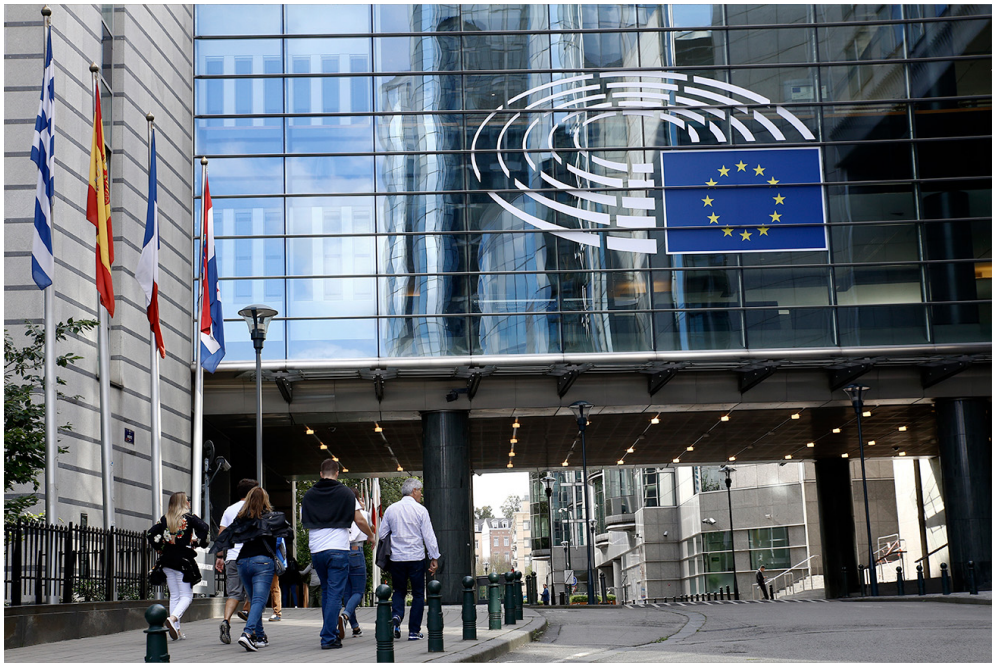
In view of the comprehensive need of infrastructural adaptation, several reports highlight the high investment costs required at an early stage of the electrification process. While countries like Norway are more apt to the integration of electric

airplanes, due to a high overall rate of electrification, other countries would face higher costs linked to the introduction of electric transport (Avinor et al., 2020). To get a better grasp of these potential costs associated with the installation of new infrastructures, but also the necessary grid capacity, more research is needed.

2.1. Possible Policy Instruments: Charging Infrastructure

The reports reviewed for this literature review offered several policy instruments which can be used to address the challenges listed above:

- Politically enable and support the early electrification of aviation through early planning of necessary changes at airports in terms of charging needs, grid capacity, necessary investment in charging infrastructure, and the electrification of ground handling vehicles (*FAIR Final Report – How to Accelerate the Implementation of Electric Regional Aviation*, 2022).
- Energy tax for electric flights or for the establishment/expansion of charging infrastructure and the overall electrification of airports should be lowered or removed to help facilitate the transition even at smaller airports (Trafikanalys, 2020; Ydersbond et al., 2020).
- A grant scheme should be set up to develop charging infrastructure (Avinor et al., 2020).



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3. Political Commitment

Most of the reports and publications on electric aviation in the Nordic countries address questions of political commitment and action as a requirement but also a potential hurdle for the future implementation of electric aviation. The formulation of as well as the continuous commitment to a political vision on the electrification of the transport sector can be named as the overarching challenge identified by the reports – both on a national and a regional level. This can be expanded beyond the electrification of the aviation sector to a more general transition towards novel means of reducing carbon emissions in aviation e.g., using more biofuel (Al-Ghussein Norrman & Talalasova, 2021; Föreningen Svenskt Flyg, 2018).

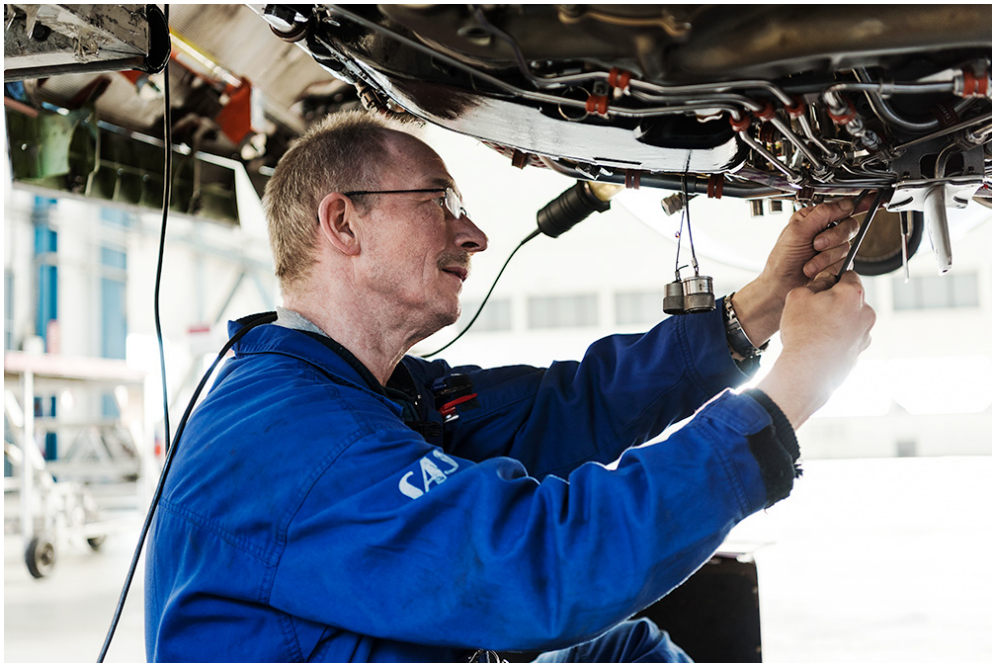
In the reviewed reports, the need for more international political collaboration to reflect the cross-border nature of aviation and climate change was mentioned repeatedly (e.g. Avinor, 2020). Any long-term commitment, from the point of view of the research community, should hence be coordinated in concert with at least the other Nordic countries. This could further strengthen the standing of the Nordics both as a frontrunner in the decarbonisation of aviation (Avinor et al., 2020) but could also help to create sufficient demand for low and zero emission solutions. This could provide the market with additional certainty and resources to tackle persisting technical issues (Avinor, 2020).

The uncertainty associated with the emerging electric aviation technologies has also been addressed beyond the context of international collaboration. Several reports highlight a current lack of public funding which could further undermine the market situation, keeping investors from supporting the electrification of aviation financially. In this context, several reports stress the role of politics to foster more diverse funding opportunities for research and development in the field of zero or low emission aviation (e.g. Al-Ghussein Norrman & Talalasova, 2021).

3.1. Possible Policy Instruments: Political Commitment

Several possible policy measures could be identified in the literature that concern the political/organisational level. These comprise the following:

- More ambitious and harmonised transport policies should be defined that are focused on increasing regional accessibility and reducing the climate impact of transportation by pushing the transition towards zero and low emission aviation (Föreningen Svenskt Flyg, 2018; Trafikanalys, 2020). Such transport policies should be accompanied and followed by "binding and predictable" incentives (Avinor & Luftfartstilsynet, 2020).
- Political support should be stable for one to two decades to signalise stability of the Nordic market to potential investors. This is also relevant in view of the certification of new technologies in this field as this process can take up to a decade (Ydersbond et al., 2020).
- Introduction of specific emission and investment targets should be supported on a political level. This could further support the signalling of political commitment both on the global political stage as well as towards potential investors (Ydersbond et al., 2020).
- The early electrification of aviation requires more political support with regard to the establishment of regional testbeds and the further exploration of regional use cases (*FAIR Final Report – How to Accelerate the Implementation of Electric Regional Aviation*, 2022).
- The cooperation on a regional, national, and international level should be continued to advance research and development and to coordinate implementation (*FAIR Final Report – How to Accelerate the Implementation of Electric Regional Aviation*, 2022).
- Public support schemes should be established for airlines for the purchase of electric aircraft, for instance through government loans and guarantees (Avinor & Luftfartstilsynet, 2020).
- Regular high-level meetings between industry and public authorities should be facilitated to strengthen knowledge exchange in a fast-changing environment (Avinor et al., 2020).



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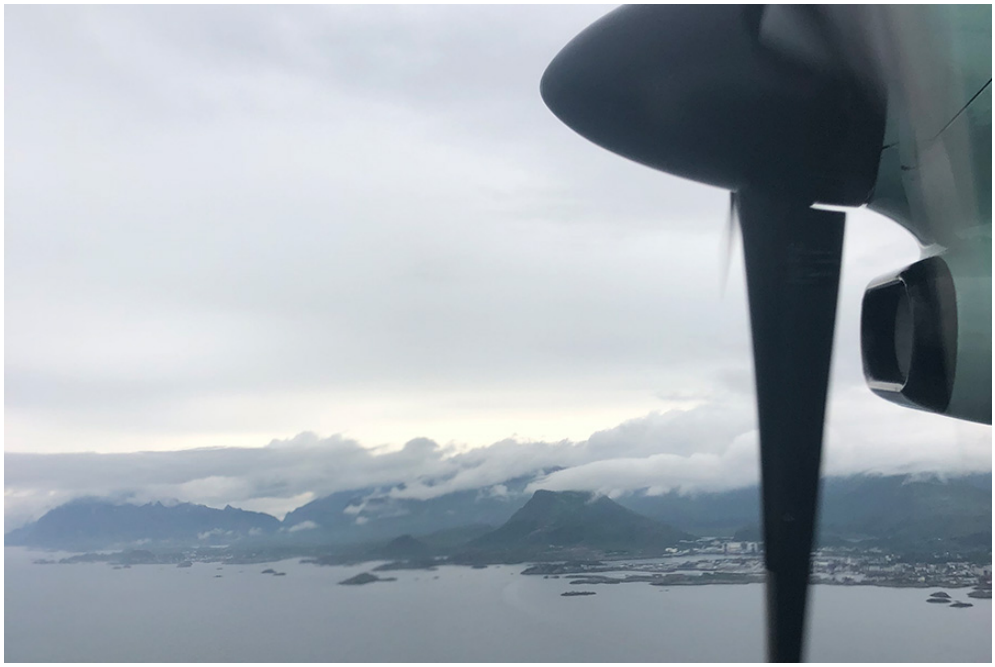
4. Labour Market, Skills, and Competences

Some publications reviewed for this report discussed the implications of zero and low emission aviation for the labour market in terms of required skills but also effects on employment. Particularly in the Norwegian context it is mentioned that fossil-free aviation might restructure the wider aviation industry. While this comes with certain challenges, such as the need for adapting relevant training opportunities in the R&D and construction sector as well as the aviation sector itself, such a development could also help to secure jobs in an emerging and transforming industry branch. Beyond aviation itself and construction of e.g., parts, this could spill over in other sectors such as export, and tourism (Avinor et al., 2020). As also mentioned in this document's Section 5 on "regulation and certification", the report from Avinor and Luftfartstilsynet notes that the certification of pilots and other technical personnel must be adapted (Avinor & Luftfartstilsynet, 2020).

4.1. Possible Policy Instruments: Labour Market, Skills and Competences

While effects on the labour market in the region are evaluated to be mainly positive, the literature proposes different instruments that can further support the identified potential and address challenges related to the development of new training programmes:

- Governments should help to facilitate the development of local economies to create a new competitive industry related to the electrification of aviation. This can also involve elements of cross-border cooperation and innovation initiatives. The report refers explicitly to targeting local students and start-ups in this context (Avinor et al., 2020; *FAIR Final Report – How to Accelerate the Implementation of Electric Regional Aviation*, 2022; Trafikanalys, 2020).
- The increased regional accessibility through electric aviation should be framed and fostered in the context of enhanced cooperation between existing businesses (*FAIR Final Report – How to Accelerate the Implementation of Electric Regional Aviation*, 2022).
- Research studies on the required retraining measures in the aviation sector and related industries can support the development of adapted curricular.



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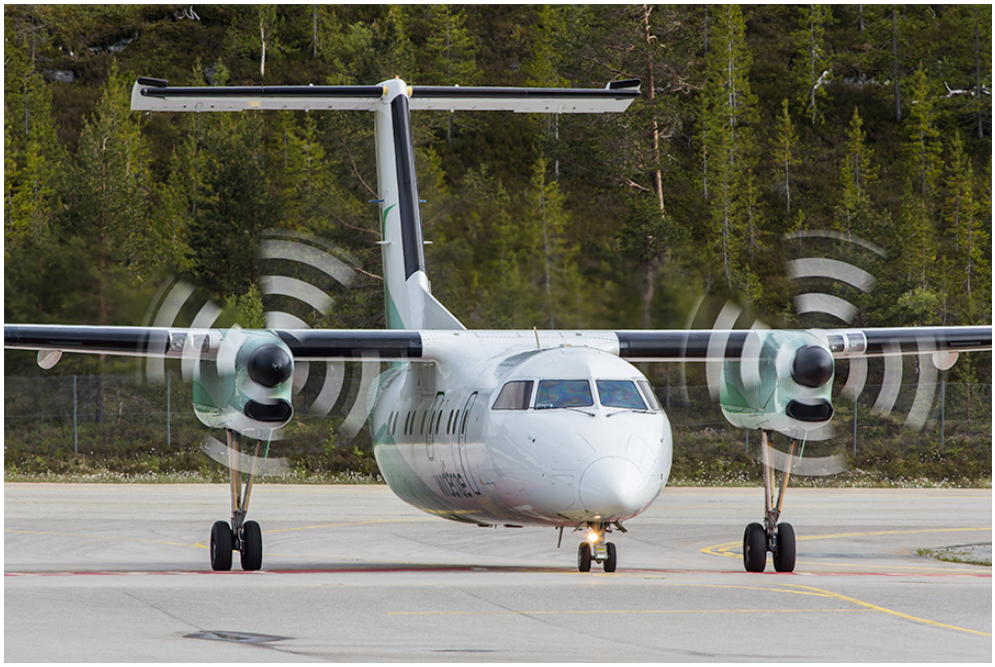
5. Added Value and Accessibility

A challenge identified by a report from Trafikanalys centres on accessibility and the associated added value of electric aviation in the Nordic countries (Trafikanalys, 2020). The report stresses the risk of limited socio-economic and monetary gains in terms of accessibility as travellers, in many scenarios, are unlikely to gain a lot of time by choosing an electric airplane over a train or an (electric) car. It is further highlighted that the replacement of conventional airplanes by electric ones will also imply longer travel times for those passengers. Disregarding long-term environmental implications and focusing primarily on aspects of accessibility and time gains in this context, the report finds that primarily routes that pass over "geographical obstacles" such as large bodies of water or mountains could generate a benefit for the population groups and regions in question (Trafikanalys, 2020).

5.1. Possible Policy Instruments: Added Value and Accessibility

Policy instruments relevant to this specific challenge overlap with instruments identified in the context of other challenges, e.g.:

- The early electrification of aviation through the establishment of regional testbeds and the further exploration of regional use cases (*FAIR Final Report – How to Accelerate the Implementation of Electric Regional Aviation*, 2022).
- An evaluation of possible routes and accessibility in the context of a research study can help to clarify the added value of the introduction of electric aviation solutions.



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6. Electric Airplane Technology

Most technology related concerns in the reviewed literature are associated with the battery of electric aircrafts. Challenges in this regard can be divided into five (partly interrelated) areas of concern, relating to the battery's

(1) weight,
(2) energy density,
(3) price,
(4) charging time, and its
(5) consequential operability in different weather conditions, on different routes or in different circumstances.

The heavy weight as well as the limited energy density, hence the amount of energy stored in a given system, are currently affecting electric airplanes' range, limiting their operation to regional flights between 200km and 400km (*FAIR Final Report – How to Accelerate the Implementation of Electric Regional Aviation*, 2022). The limitations brought about by the weight and density of the battery are particularly important to be considered in hybrid solutions where the additional weight of a battery will further affect the range of the aircraft (Trafikanalys, 2020). Batteries' weight will hence need to be reduced and energy density increased to allow for medium or long-haul flights of electric or hybrid aircrafts in the future. Today's lithium-ion batteries' energy density is expected to be increased to 400-450Wh/kg around 2025 (FAIR Project Consortium, 2021). The main hope of the industry at the moment, however, appears to be on the further development of "solid state" batteries which will have an energy density of potentially more than 650Wh/kg (Avinor et al., 2020).

Even though the price of batteries has been declining, the report from Trafikanalys notes that Heart Aerospace assumes that batteries will need to be replaced after

1,000 to 3,000 charging cycles (Trafikanalys, 2020). This is estimated to equate to intervals between one and three years, imposing further costs on those airlines aiming to integrate electric aircrafts in their fleets. Charging can also pose a challenge in terms of the time required to fully charge a battery. This might affect the turn-over of flights at airports, rendering the use of electrified solutions potentially less profitable and thus less attractive to airlines.

Another aspect mentioned in this context is the operability of electric aircrafts in different weather conditions (NewsLab, 2020). Melina From of RISE research institute notes in this context: "If electric planes can fly in our airspace, they will work in the rest of the world as well. In addition to high winds, short runways and ice formation, low temperatures can affect the battery capacity of future aircraft." (NewsLab, 2020).

Apart from issues related to the battery, other technical concerns addressed in the literature are linked to e.g., the electricity grid, necessary to supply airports with sufficient energy to charge the aircrafts. Another report highlights for instance, that the capacity of the Swedish electricity network is currently insufficient to sustain a comprehensive transition towards electric aviation and that reinforcement of the network must be addressed in a more anticipatory manner to not further delay the introduction of novel and greener technologies (Al-Ghussein Norrman & Talalasova, 2021). The ability to store energy at airports also plays a role in this respect as it could offer an alternative to the increased capacity of the power grid (Trafikanalys, 2020).

Another challenge that has been identified in the reviewed literature relates to the overall complexity of the system necessary to make zero or low emission aviation a viable alternative to current fossil fuel-based solutions. As many of the described technical challenges are interconnected, considerable investments are required to assure interoperability and the overall advancement of environment friendly aviation. The currently still relatively low Technology Readiness Level (TRL) of electric aircrafts, especially in the medium and long-haul range, can be seen as adding further inertia to the innovation process, contributing to potential investors' uncertainty.

6.1. Possible Policy Instruments: Electric Airplane Technology

Various policy instruments were identified in previous studies that can serve the further technological advancement of low or zero emission aviation:

- New and additional elements should be considered for future tender contracts such as investment tax, residual value guarantees and extended contract length (Avinor & Luftfartstilsynet, 2020).
- Nordic governments should support both national and European investment/ funding schemes for further research and development in the field of low or zero emission aviation (Avinor et al., 2020; Avinor & Luftfartstilsynet, 2020). A sustainable aviation fund should be considered as a potential source for the financing of such national schemes (Ydersbond et al., 2020).
- The individual countries should further develop and invest in specialised R&D centres and testbeds for the development, testing and implementation of zero- and low emission aviation. Clear criteria for the design of, participation in and for financing such centres and testbeds should be set (Avinor &

Luftfartstilsynet, 2020). Regional initiatives should also be considered and supported in this context.

- The establishment of suitable airspace for the creation of testbeds should be given more attention. The selected airspace should comply with the necessary safety standards (Avinor & Luftfartstilsynet, 2020).
- **Biofuel:** The government should allocate funds to enable research and development into the efficiency of large-scale production of fossil-free fuel. This should be synchronised with existing aeronautics innovation programmes (Ydersbond et al., 2020).

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7. Market Uncertainty and Investments

Regarding investments in zero and low emission aviation, there are common concerns documented in the literature around market uncertainty and lacking business models. Even though several actors estimate that electric aviation in the long-term perspective will have lower operation and investment costs than comparable fossil fuel-based aircraft, the cost is expected to be high at the start (Avinor & Luftfartstilsynet, 2020; Hellesund, 2022).

The final report of the FAIR study notes that these high investment costs can result in part from (initially) small production volumes of electric aircrafts (*FAIR Final Report – How to Accelerate the Implementation of Electric Regional Aviation*, 2022) while another report stresses the high cost of biofuel (Regeringens klimapartnerskaber, 2021). Moreover, the lack of public funding and private investments is likely to play a role in this context as does the supply of the necessary infrastructures at airports.

It is further noted that small and medium enterprises do not yet have the financial means to establish themselves on the electric aviation market, making any progress dependent on a small number of larger actors (Al-Ghussein Norrman & Talalasova, 2021; Avinor & Luftfartstilsynet, 2020). This could potentially further impact the costs of these emerging zero or low emission solutions. Also, the use of small aircraft and the implied decrease in passenger numbers along with the comparably high cost of biofuels for hybrid solutions are seen as factors which will likely diminish the profitability of low and zero emission aviation and hence the interest in potential investors in the short run. The high investment costs stemming from the need to adapt and add infrastructure is seen as an additional hurdle in this context

(*FAIR Final Report – How to Accelerate the Implementation of Electric Regional*

Aviation, 2022).

These uncertainties relating to the total of costs and the lack of predicted profitability of specific solutions affect the relevant markets. Market uncertainty does not only affect electric aviation but also the use of biofuels. Avinor & Luftfartstilsynet (2020) and Föreningen Svenskt Flyg (2018) highlight that the simultaneous emergence of several novel technologies in the field is further contributing to the prevailing uncertainty amongst investors about the wisest choice for investment and possible future returns on investment.

However, as mentioned above, other studies have also pointed to the cost reducing factors of sustainable aviation solutions which include the lower cost of the energy sources – renewably sourced electricity as opposed to fossil fuel – as well as the lower maintenance costs (Thapa et al., 2021). The overall operating cost of electric flights is hence predicted to be lower in comparison with conventional airplanes. More data is needed to predict future ticket prices for regional flights operated by electric airplanes.

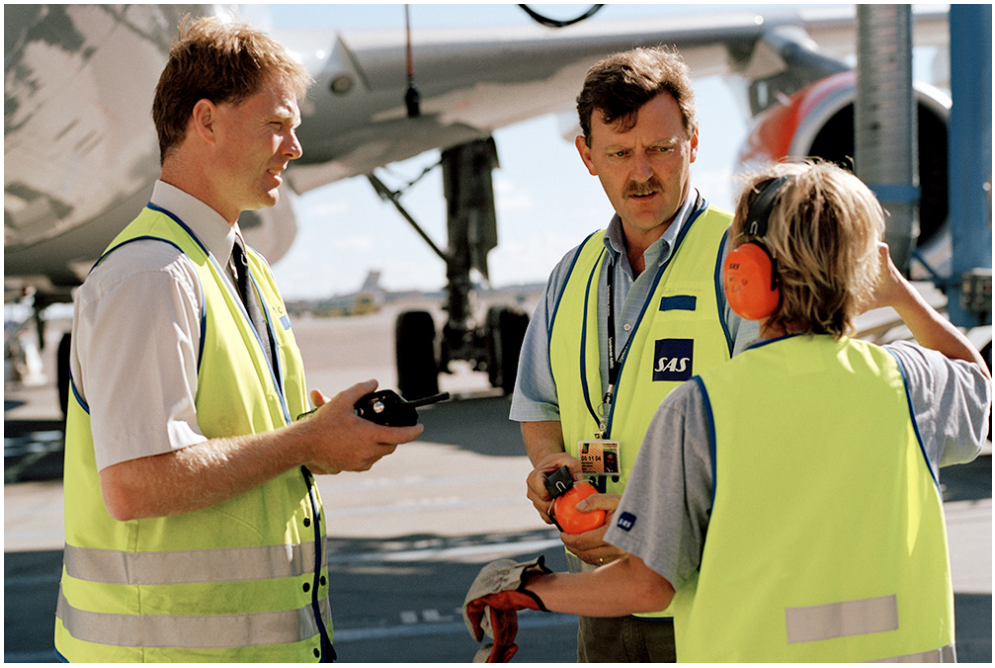
7.1. Possible Policy Instruments: Market Uncertainty and Investments

Several policy instruments are suggested in the reviewed literature that can facilitate the establishment of economically beneficial operating conditions for low and zero emission aviation.

- Public support schemes should be established for airlines for the purchase of electric aircrafts, for instance through government loans and guarantees (Avinor & Luftfartstilsynet, 2020) or by buying the airplanes directly (Ydersbond et al., 2020).
- Emission trading schemes should receive greater political attention (Trafikanalys, 2020).
- Take-off and landing fees should be differentiated or exemptions from such fees for electric aircrafts should be considered (Avinor & Luftfartstilsynet, 2020; Trafikanalys, 2020; Ydersbond et al., 2020).
- The energy tax for electric flights or for the establishment/expansion of charging infrastructure and the overall electrification of airports should be lowered or removed (Avinor & Luftfartstilsynet, 2020; Trafikanalys, 2020; Ydersbond et al., 2020).
- A fund where different industries and other actors can contribute to in order to foster the development of low and zero emission aviation should be established (Avinor et al., 2020).
- A grant scheme for supporting the development charging infrastructure should be set up (Avinor & Luftfartstilsynet, 2020).
- Functioning models for the value chain should be advanced to foster practical implementation, commercial sustainability and hence the attraction of venture capital (Föreningen Svenskt Flyg, 2018).
- An exemption from or reduction of air passenger taxes until 2040 should be considered (Avinor & Luftfartstilsynet, 2020; Ydersbond et al., 2020).
- VAT exemption for electric aircrafts in leisure activities should be introduced. Especially as the early introduction and use of electric aircrafts is more likely in this sector (Avinor & Luftfartstilsynet, 2020). This can further contribute to the societal acceptability of electric aviation.
- Joint Nordic work towards the EU and ICAO should be fostered. This can help to create cooperation at a pan-European level to create a large enough market for

manufacturers to prioritise it. The link of the topic with the European Green Deal should be highlighted in this context (Ydersbond et al., 2020).

- **Biofuel**: State subsidies should support the design of production facilities. Production capacity to supply aviation with the fuel needed to reach the 2030 target requires an estimated investment of five billion SEK (Föreningen Svenskt Flyg, 2018).
- **Biofuel:** The Aviation Climate Fund, public funds, and passenger fees should be utilised to equalise the difference between sustainable and fossil jet fuel (Regeringens klimapartnerskaber, 2021).
- **Biofuel:** The public sector should use its purchasing power to create demand for sustainable fuels (Avinor et al., 2020).



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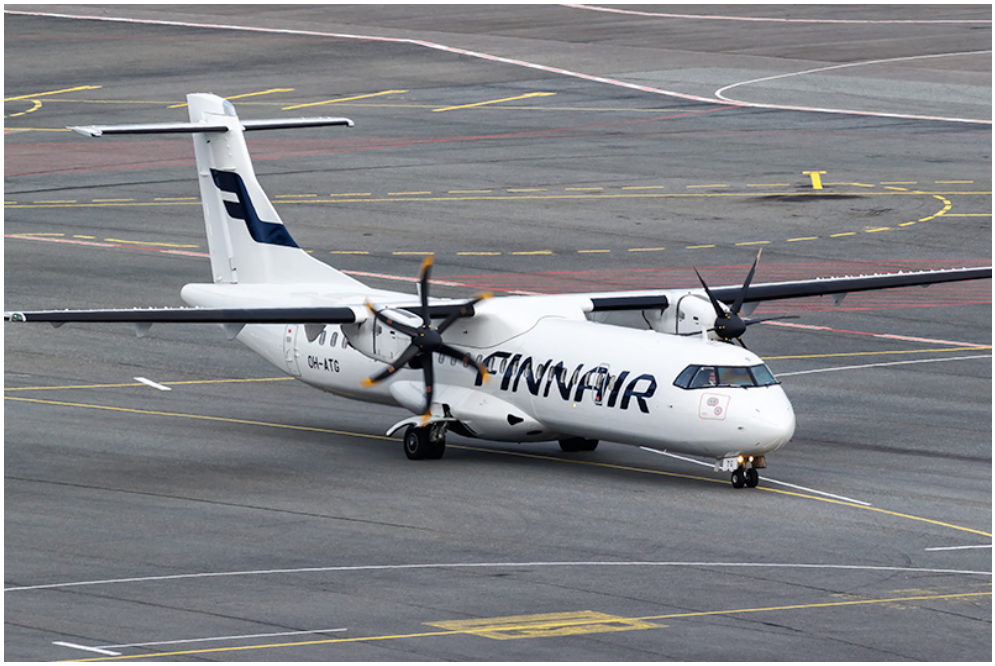
8. Regulation and Certification

The market entry of novel technologies is usually accompanied by certification processes. Furthermore, current legal frameworks might need to be adapted as they do not yet reflect and consider the abilities and specific technical characteristics of emerging technologies. Adapting and introducing new regulations and certifications in the context of a greener aviation sector is another challenge raised in the literature. For instance, the Nordic Sustainable Aviation report mentions certification as one main barrier for the introduction of electric aviation (Ydersbond et al., 2020). The report from Avinor and Luftfartstilsynet mentions in this regard that these legal aspects need to be integrated from the beginning of any development project (Avinor & Luftfartstilsynet, 2020). This anticipatory rather than reaction-based approach shall ensure a swift market introduction without facing (too many) legal hurdles. The report that presents the Aviation in Norway Programme further explains that lengthy certification processes are especially to be expected in relation with aircraft larger than a two-engine propeller aircraft of 19 seats and 8600kg (Avinor et al., 2020). When surpassing this limit, aircrafts need to be certified according to EASA CS-25 which implies a more complex process. Regarding potential certification issues for hybrid solutions Föreningen Svenskt Flyg debates the lack of certification for some biofuel for aviation as a barrier (Föreningen Svenskt Flyg, 2018). The reports further emphasise that public financial support might be required to stem the costs of the certification process.

8.1. Possible Policy Instruments: Regulation and Certification

The outlined challenges associated with certification processes and regulations can be addressed from several angles. These approaches do not directly stem from the reviewed Nordic reports on the introduction of electric aviation but from academic and public debates around the issue area in other contexts of emerging technologies (e.g. (Forsberg, 2015)):

- Legal experts should be included in the early stages of R&D processes to identify potential legal challenges early on and to assure that these potential issues along with certification standards are considered and reflected in the design and development process.
- Public funding should provide opportunities for the development of adapted training programmes for pilots and technical personnel.
- Public support should be provided in the certification process to make the process more accessible also to smaller/younger companies.



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9. Sustainability and Human Rights

Several reports list challenges linked to sustainability and human rights (Avinor et al., 2020; Trafikanalys, 2020). For instance, the Trafikanalys report underlines that the minerals used in batteries often stem from conflict-ridden countries (Trafikanalys, 2020). In this context, the report further highlights the case of cobalt, often originating from the Republic of Congo where several studies from *inter alia* UNICEF have revealed the use of child labour in cobalt mines. However, due to technological advances the use of and need for cobalt in batteries has decreased (Randall, 2023). In addition to these human rights concerns, the possibility of recycling out-of-order batteries requires further investigation.

While most electricity in the Nordics can be labelled as sustainable, being sourced through renewable energy supplies, the Aviation in Norway report mentions that Svalbard mainly relies on coal power (Avinor et al., 2020). Regions where no sustainable energy sources are accessible or not in place yet could hence not offer a transition to low or zero emission aviation, despite the use of electric aircrafts. However, due to its distance from the mainland, the use of electric aviation to or from Svalbard will not be a concern in the foreseeable future.

In the context of biofuels, which are used in hybrid solutions, the Avinor report also discusses the origin of biofuels, referring to deforestation for the sake of biomass production which is processed for biofuel production. The report points out the opportunity cost of using biomass to produce biofuel for aviation as this resource could alternatively be used for food or feed. Additionally, the report stresses this argument in the context of land-use for biomass production (Avinor et al., 2020).

9.1. Possible Policy Instruments: Sustainability and Human Rights

Possible policy instruments that could help tackle sustainability challenges, as suggested by the literature, are the following:

- Nordic governments should further work to strengthen international sustainability measures at European and global level including the EU Emissions Trading System (EU ETS) and the Carbon Offsetting and Reduction Scheme for International Aviation (Avinor et al., 2020).
- Different public authorities should cooperate more closely on the matter of aviation and climate impacts and Transport Ministries should set clear guidelines in this context (Avinor & Luftfartstilsynet, 2020).
- Nordic governments should push for the implementation of a climate labelling system in aviation to create more incentive for manufacturers and operators (Avinor & Luftfartstilsynet, 2020).
- Governments should require their employees to conduct their business trips in the quickest and most sustainable way (Avinor & Luftfartstilsynet, 2020).
- Country councils should introduce emission-based assessment criteria in future tenders or other requirements for zero discharge or a defined maximum discharge. A subsidy scheme could be established to cover potential additional costs (Avinor & Luftfartstilsynet, 2020).
- Regional development opportunities should be enhanced beyond regional business development, e.g. through the integration of electric aviation in a region's spatial planning. This can be done by exploring, for instance, how electric aviation might affect the built environment through noise levels and support the local production of sustainable energy (*FAIR Final Report – How to Accelerate the Implementation of Electric Regional Aviation*, 2022).

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10. Operational Security

While implicit in many challenges listed under "Technology", the reports from Avinor and Luftfartstilsynet, Transportøkonomisk Institutt as well as Trafikanalys list a couple of potential operational security challenges in their publications that might require distinct attention (Avinor & Luftfartstilsynet, 2020; Brevik Wangsness et al., 2021; Trafikanalys, 2020). While Avinor's and Luftfartstilsynet's as well as Transportøkonomisk institutt's reports point to safety requirements as one aspect to be considered both in the design, development, and certification of electric aircrafts and their propulsion systems, the Trafikanalys report offers more detail on the topic. As primary risk in relation to the electric aircraft's battery, the report mentions "thermal runaway" a condition of uncontrolled release of cellular energy which can lead to hard-to-extinguish fires (Trafikanalys, 2020). Thermal runaway is usually caused by overcharging, overheating, or short-circuiting. The report further discusses the risk of toxic gases which can be released from batteries. Most operational safety and security risks currently discussed in the relevant literature are hence associated with the battery in electric aircrafts.

10.1. Possible Policy Instruments: Operational Security

Many of the possible measures regarding persisting operational security challenges need to be addressed on a R&D level. For further information, see challenge 1.5. Technology and the associated policy instruments.

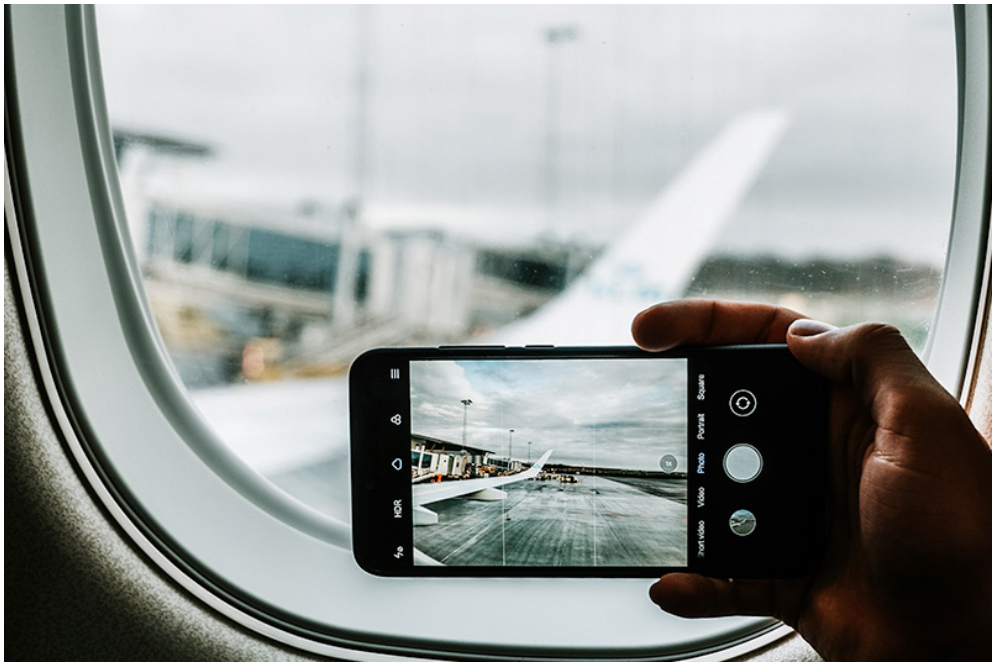

Photo: Unsplash.com

11. Societal Acceptability

The societal acceptability of electric aviation as well as related hybrid solutions has been addressed by a few reports reviewed for this chapter. The report Nordic Sustainable Aviation (Ydersbond et al., 2020) as well as the report from Transportokonomsik institutt (2021) underline, for instance, that several passengers might be sceptical towards flying in an electric aircraft due to the novelty of the technology. The Nordic Sustainable Aviation report suggests that this scepticism might be overcome through , for example, cheaper ticket prices (Ydersbond et al., 2020). The Transportokonomisk institutt's report names trusted security certification schemes to tackle the lack of potential costumers' trust. Transportokonomsik institutt's report (2021) also discusses the possibility of an increase in air passengers as sustainable travel alternatives become more available as this means of transportation might speak to a different target group. Public scepticism towards new technology and the associate lack of trust and acceptance has been widely discussed in the relevant academic literature and might need to be explored further in the context of low or zero emission aviation in the Nordic countries (see e.g. (Granić & Marangunić, 2019; Marangunić & Granić, 2015)).

11.1. Possible Policy Instruments: Societal Acceptability

Several reports offer potential policy instruments that can help to address challenges related to the societal acceptability of low and zero emission aviation:

- Relevant actors should develop and implement a communications strategy (Avinor & Luftfartstilsynet, 2020).
- Cheaper tickets should be offered as significant number of passengers could be sceptical to electric aircrafts as the technology is new (yet green costumers might be willing to pay a higher price) (Ydersbond et al., 2020).
- Trusted security certification schemes should be utilised to strengthen passengers' trust (Brevik Wangsness et al., 2021).

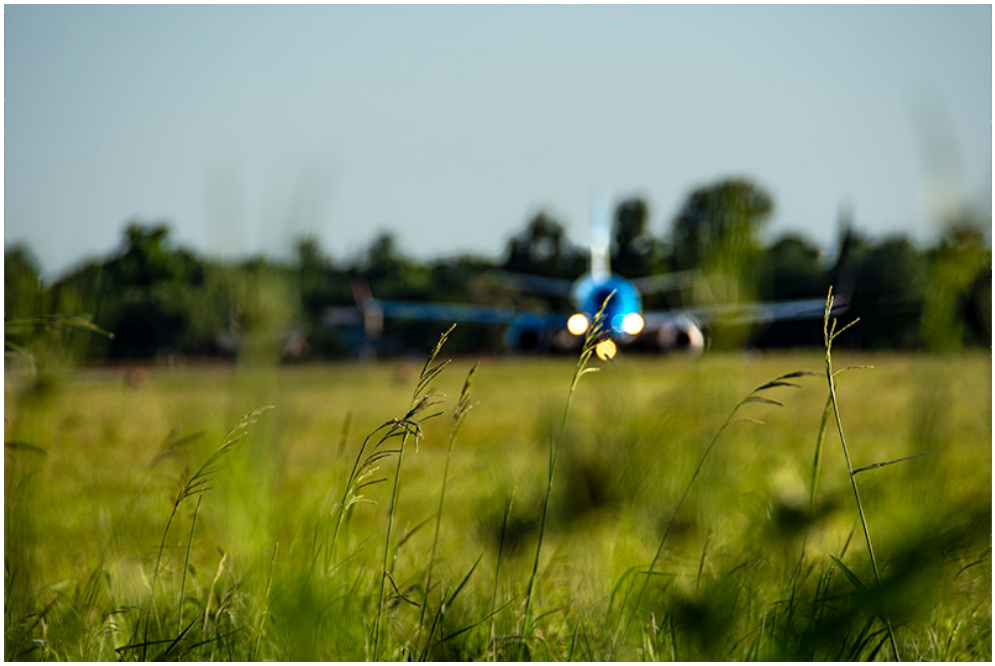

Photo: iStock

12. Concluding Remarks: Next Steps for Electric Aviation in the Nordic Countries

Technological advancement is a route to making electric aviation and hence the decarbonisation of aviation a reality in the Nordic countries and beyond. However, with many emerging technologies, electric aviation also has a number of challenges in its train. This literature review provided an overview of the main points identified by publications with a Nordic focus that will need to be addressed to smoothen the transition towards lower and zero-emission solutions in the transport sector. These include technical, political but also legal aspects. Many of the identified challenges revolve around the underlying technology, mainly the batteries and charging systems used, which may have implications both for the practical layout of future airports as well as the operational security and profitability of electric airplanes. Other arguments touch upon the legal, environmental, and societal dimensions of electric aviation, ranging from certification processes, to over sustainably sourced resources used in batteries as well as the need for more research on the societal acceptability of electric aircraft.

To frame the path forward, this working paper aggregated policy recommendations from the relevant literature and reports that may help to tackle the listed challenges. This overview brings out the relevance of improved cross-border cooperation and co-ordination on a political level to strengthen the potential that electric aviation brings for regional development and the reduction of greenhouse gas emissions in the Nordic countries. There are several tools that could be used in this context, such as the formulation of common political visions for the transport sector, adapted energy taxes and the financial and political support for research and development projects in the field of zero- and low emission aviation.

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