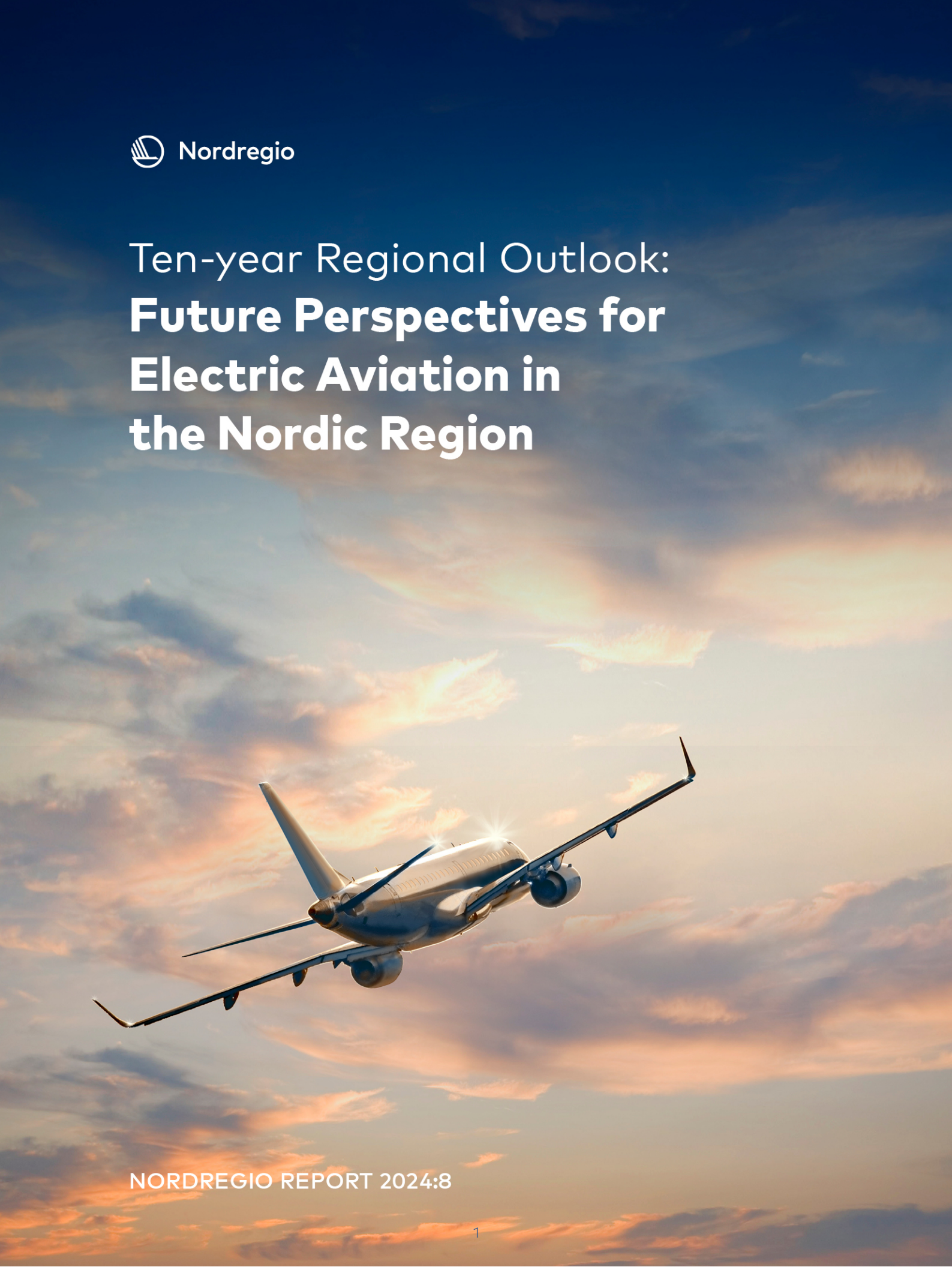
Nordregio

Ten-year Regional Outlook: **Future Perspectives for Electric Aviation in the Nordic Region**



NORDREGIO REPORT 2024:8

Authors

Rebecca Cavicchia, Nordregio

Jonas Kačkus Tybjerg, Nordregio

Hilma Salonen, Nordregio

Maja Brynteson, Nordregio

Nicola Wendt-Lucas, Nordregio

Sæunn Gísladóttir, University of Akureyri Research Centre

Hjalti Jóhannesson, University of Akureyri Research Centre

Contents

Summary 4

Sammanfattning 7

1. Introduction 9
- Background 10
- Structure of the report 11

2. Methodological choices 12
- Research design 12
- Case study selection 13
- The ten-year scenario approach 15
- Methodological limitations 17

3. Ten-year Future Scenarios for Electric Aviation. A Nordic Perspective 18
- Denmark. Copenhagen – Bornholm 19
- Finland. Kuusamo – Kajaani – Oulu 31
- Sweden. Skellefteå – Oulu 41
- Iceland. Akureyri – Reykjavik 54
- Norway. Bodø – Leknes 64

4. Impacts of Electric Aviation in Nordic Regional Contexts 79
- Political impacts 79
- Economic impacts 80
- Social impacts 82
- Technological impacts 84
- Environmental impacts 84
- Concluding thoughts about impacts of electric aviation on the Nordic region 85

5. Nordic Learnings for Electric Aviation and Concluding Remarks 87
- Key challenges and open questions for the implementation of electric aviation 87
- Looking ahead 88

References 90

Appendixes 102
- 1. Driving Forces of the Danish Case (Copenhagen-Bornholm) 102
- 2. Driving Forces of the Norwegian Case (Leknes-Bodø) 104
- 3. Driving Forces of the Icelandic Case (Akureyri – Reykjavík) 106
- 4. Driving Forces of the Finnish Case (Oulu-Kajaani-Kuusamo) 108
- 5. Driving Forces of the Swedish Case (Skellefteå – Oulu) 109

About this publication 111

Wing of an airplane flying above Oresund Bridge between Denmark and Sweden
Photo: iStock

Summary

Electric aviation has gained momentum in the Nordic region since the first certification of an electric aircraft in the European Union in 2020. Given its unique geographical features and strong commitment to climate-neutral transport, the Nordic region represents an ideal testing ground for electric aviation. In five to ten years from now, electric aviation has the potential to become reality, so it is crucial to explore which factors may affect its implementation and how regional development may be impacted.

Against this background, the objective of the "Electric Aviation and the Effects on the Nordic Region" project is to present a ten-year future scenario for electric aviation in the Nordic region. To that end, the project explores future scenarios for five selected Nordic routes and identifies the key driving forces behind that transformative shift, while exploring both the positive and negative impacts that electric aviation may bring about. The future scenarios were developed through focus group discussions conducted with key stakeholders from each of the five Nordic countries.

The main findings of the study show that electric aviation is generally perceived positively in the various Nordic countries with some relevant contextual differences.

- In Denmark, electric aviation, among other sustainable alternatives, is primarily viewed as a pathway to achieving ambitious national climate targets.
- Finland emphasises the potential of electric aviation for connecting remote regions, as well as stimulating regional development in areas that have fallen behind.
- Iceland sees electric aviation as a potential avenue for cheaper travel options compared to conventional flights, as well as improved ability to access services from remote locations.
- The greatest potential in Norway lies in reducing emissions and improving accessibility by overcoming geographical barriers.
- Sweden, in particular Skellefteå, shows a strong commitment to electric aviation, presenting significant opportunities for linking remote northern areas.

Even though the general attitude towards electric aviation seems to be positive, scepticism emerged, especially in the Danish and Finnish case. In all the cases, the social acceptance of the new technology, the unanswered questions about the future ticket price as well as the uncertainty around who will be the investors to kick-off the new technology emerged as primary reasons for scepticism.

Furthermore, the future scenarios suggest that a high level of support from local and national governing bodies is required in order to make electric aviation a viable air transport mode in the Nordic region. Factors such as incentives, taxation policies, technological advancements, regulatory frameworks and social trust were identified as pivotal elements in this transformation.

While the possible impacts of electric aviation are manifold, the most prominent are:

- enhancing the green Nordic image
- increasing the political commitment to financial regulations and incentives
- new opportunities for tourism, business and flight routes
- increased access to public services and
- reduction in emissions in the operational phase.

The dominant driving forces for such implementation include:

- strong political will and commitment
- the goal of achieving fossil-free transport and
- variations in demographics and workforce skills in different areas of the Nordic region.

Those insights are intended not only to inform decision-makers, but also to provide nuanced observations from each Nordic country and explore future pathways towards a sustainable and more integrated Nordic region in line with the vision of the Nordic Council of Ministers 2030 (Nordic Council of Ministers, 2023).

Sammanfattning

Elflyg har tagit fart i Norden sedan den första certifieringen av ett elflygplan i Europeiska unionen 2020. Med sina unika geografiska egenskaper och sitt starka engagemang för klimatneutrala transporter utgör Norden ett idealiskt testområde för elflyg. Om fem till tio år har elflyg potential att bli verklighet, så det är avgörande att undersöka vilka faktorer som kan påverka dess genomförande samt hur regional utveckling kan påverkas.

Mot denna bakgrund är målet med projektet " Electric Aviation and the Effects on the Nordic Region" att presentera ett tioårigt framtidsscenario för elektriskt flyg i Norden. För detta ändamål utforskar projektet framtidsscenarier för fem utvalda nordiska rutter och identifierar de viktigaste drivkrafterna bakom denna transformativa förändring, samt de positiva och negativa effekterna som elflyg kan medföra. Framtidsscenarierna utvecklades genom fokusgruppsdiskussioner med centrala intressenter från samtliga fem nordiska länder.

De viktigaste resultaten i studien visar att elflyg generellt uppfattas positivt i de nordiska länderna, med vissa relevanta kontextuella skillnader.

- I Danmark ses elflyg, bland andra hållbara alternativ, främst som en väg för att uppnå ambitiösa nationella klimatmål.
- Finland betonar elflygets potential att förbinda avlägsna regioner och stimulera regional utveckling i områden som har hamnat på efterkälken.
- Island ser elflyg som en potentiell väg till billigare resealternativ jämfört med konventionella flyg, samt förbättrade möjligheter att få tillgång till tjänster från avlägsna platser.
- Den största potentialen i Norge ligger i att minska utsläppen och förbättra tillgängligheten genom att övervinna geografiska hinder.
- Sverige, i synnerhet Skellefteå, visar ett starkt engagemang för elflyg, vilket ger betydande möjligheter att knyta samman avlägsna nordliga områden.

Trots att den allmänna inställningen till elflyg verkar vara positiv framkom skepsis, särskilt i de danska och finska studierna. I samtliga studier framstod den sociala acceptansen för den nya tekniken, de obesvarade frågorna om det framtida biljettpriset samt osäkerhet kring vilka investerare som kommer att driva den teknologiska utvecklingen som de främsta anledningarna till skepsis.

Dessutom tyder framtidsscenarierna på att det krävs en hög nivå av stöd från lokala och nationella styrande organ för att göra elflyg till ett livskraftigt lufttransportsätt i Norden. Faktorer som incitament, skattepolitik, tekniska framsteg, regelverk och socialt förtroende identifierades som avgörandei denna omvandling.

De möjliga effekterna av elflyg är många, men de mest framträdande är:

- förstärka bilden av det gröna Norden
- öka det politiska engagemanget för finansiella regler och incitament
- nya möjligheter för turism, affärsverksamhet och flygrutter
- ökad tillgång till offentliga tjänster och
- minskade utsläpp under driftsfasen.

De dominerande drivkrafterna för ett sådant genomförande är bland annat:

- stark politisk vilja och engagemang
- målet att uppnå fossilfria transporter och
- variationer i demografi och arbetskraftens kompetens i olika delar av Norden.

Dessa insikter är inte bara avsedda att informera beslutsfattare, utan också att ge nyanserade observationer från varje nordiskt land och utforska framtida vägar mot en hållbar och mer integrerad nordisk region i linje med Nordiska ministerrådets vision för 2030 (Nordiska ministerrådet, 2023).

Aerial photo of Allinge in Denmark – half an hour's drive from Bornholm Airport.
Photo: iStock

1. Introduction

This report aims to explore possible future scenarios for electric aviation in the five Nordic countries. Based on five selected regional contexts, the analysis delves into key context-specific driving forces affecting the future implementation of electric aviation. Furthermore, the analysis addresses the possible impacts, benefits and drawbacks of the implementation of electric aviation in the various regional contexts. Special emphasis is placed on evaluating the capacity of electric aviation to enhance connectivity between urban and rural areas. The report explores the potential benefits that may arise in terms of regional development, particularly in more remote areas, underscoring the role that electric aviation can play in fostering improved accessibility and development opportunities for such regions in line with the vision of the Nordic Council of Ministers 2030 (Nordic Council of Ministers, 2023).

Background

Electric aviation has witnessed rapid development, with the European Union Aviation Safety Agency (EASA) certifying the first electric aircraft in June 2020 (EASA, 2020). Aircraft manufacturers and airline operators are increasingly optimistic that electric airplanes will be deployed on certain routes within five to ten years.

Electric aviation encompasses various aircraft types powered by electric engines, using battery or hydrogen storage systems. Battery-driven electric aircraft are considered most promising for the Nordic countries in the coming decades and challenges – including battery energy density, charging time, mineral extraction and safety issues – are being addressed through ongoing innovation and investment (Wendt-Lucas, 2023). Electrification of aviation promises environmental and climate benefits, in particular lower CO2 emissions and reduced local pollutants and noise (Adu-Gyamfi & Good, 2022). The widespread adoption of electric aviation can aid in the attainment of carbon reduction goals and ease compliance with blend-in requirements.

The Nordic region, with its many islands, extensive coastlines and remote areas, is considered an ideal testing ground for electric aviation. There are numerous short-distance routes with limited passenger volumes in this region and many such routes are currently subsidised as public service obligation (PSO) routes by national authorities (Löfving et al., 2023). Additionally, renewable energy sources account for a high share of electricity production in the Nordic region, further augmenting the potential advantages of implementing electric aviation. The Nordic countries are collectively committed to climate-neutral transport in line with the Paris Agreement and aim to pioneer the deployment of electric aircraft (Löfving et al., 2023). Iceland is actively working to electrify its domestic aircraft fleet, while Norway and Sweden have set targets for electric short-haul flights. Electric aviation initiatives are expanding across the region, with notable examples in Norway, Denmark and Sweden.

Routes under 400 kilometres are considered the initial target market for electric aircraft in the Nordic region (Heart Aerospace, n.d.). In addition, shorter routes under 200 kilometres, particularly in sparsely populated areas, are under consideration. Norway, which has a significant number of such routes, is considered likely to benefit the most from electric aviation. Iceland, Sweden, Denmark and Finland also have substantial potential for electric aviation on specific routes (Nordregio, 2022).

In ten years from now, electric aviation can become reality in the Nordic countries. Several development programmes are underway and Nordic countries are an ideal test bed for electric aircraft for several reasons, including their commitment to environmental sustainability, access to green energy, geographical characteristics and accessibility issues in many rural areas (Löfving et al., 2023). Nevertheless, numerous critical factors ranging from technological issues, social acceptance and

political commitment through to economic sustainability and the required regulations (Wendt-Lucas, 2023) need to be considered.

Against that background, the case studies explored in this report aim to answer the following questions by considering a ten-year future scenario:

- What are the key driving forces for the future implementation of electric aviation in Nordic regions?
- What kind of positive or negative impacts might the implementation of electric aviation have at the regional level in the next ten years?

Structure of the report

The report is structured as follows. Section 2 describes the adopted research design, methods and limitations of the research. Section 3 explores the ten-year future scenarios for electric aviation through the five selected case studies. Section 4 delves into the possible future impacts that the implementation of electric aviation might have in the selected regional contexts. Finally, section 5 offers some concluding reflections and Nordic learnings.

Aerial photo of Bodø Airport in Norway
Photo: Kent Wang, CC BY-SA 2.0 via Wikimedia Commons

2. Methodological choices

Research design

The regional case studies use a combination of qualitative methods and are based on a two-step research design:

- Desk research: this initial phase involved comprehensive examination of previously published reports within the scope of this project, as well as relevant grey and academic literature, local policies, relevant documents and media articles. The primary objective was to provide a holistic overview of regional factors critical to the prospective integration of electric aviation. Those factors encompass geographical characteristics, the state of transport and energy infrastructure, the regional economy and the landscape of policies and initiatives pertaining to electric aviation.
- Ten-year scenario development: in the second phase, a ten-year scenario was drawn up by forming focused discussion groups for each of the five selected case studies. Those discussion groups typically comprised four to seven key stakeholders in electric aviation and related fields within their respective regions. Participants included regional development experts, representatives

from regional and local authorities, other relevant local actors, aviation specialists and experts in the field of energy. The objective of this phase was to extrapolate and envision the trajectory of electric aviation over the course of the next decade, informed by the insights and expertise of those diverse stakeholders.

Case study selection

A comprehensive approach integrating both quantitative and qualitative data was used to select the case study routes in the five Nordic countries. The initial phase was based on the outcomes of the accessibility study conducted within the project framework (Nordregio, 2022). That study used key indicators such as a route length not exceeding 200-400 km, urban-rural connections and travel time benefits provided by electric aviation in comparison to alternative modes of transport, including both public transport and cars. In this way, about 200 routes resulted as potentially beneficial for implementing electric aviation.

To enhance and complement the quantitative findings from the accessibility study, consultations were held with the project's reference group, regional experts and Nordic Energy Research.[1] Those discussions aimed to provide additional insight and perspectives with regard to selection of case study routes.

The selection of the case studies was guided by the overarching objectives of broad geographical representation, identification of routes with diverse regional potential and exploration of the connections between urban hubs and more remote and rural areas.

Based on the above, the following routes were selected:

- Copenhagen-Bornholm (Denmark)
- Kuusamo-Kajaani-Oulu (Finland)
- Leknes-Bodø (Norway)
- Akureyri-Reykjavík (Iceland)
- Skellefteå-Oulu (Sweden)

The study is limited in scope to a ten-year horizon, with a specific emphasis on shorter routes, ideally with a distance of approximately 200 kilometres or less and not exceeding 400 kilometres. Additionally, the study concentrates on aircraft models accommodating up to 30 seats. For a detailed overview of the aircraft model employed in this study, see Table 1.

1. Nordic Energy Research is a platform for cooperative energy research and policy development under the auspices of the Nordic Council of Ministers.

Time frame of the case study	Ten years into the future (~2033)
Example aircraft[2]	ES – 30 HEART Aerospace
Assumed max. distance	200 km (max. 400 km)
Operating cost[3]	15-22% cheaper than conventional airplanes - reduction in oil and fuel expenses - no (or lower) CO2 quotas But - high initial costs/ unclear ownership costs - higher weight: higher landing fees
Ticket price	Difficult to evaluate: lower operating costs vs. lower passenger volume Likely to be lower than for a conventional flight
Assumed passenger capacity	19–30 seats
Emissions	Could be more than 60% lower than for conventional flights (depending on the covered distance and lifetime). There is no clear advantage compared to land-based modes of transport (Baumeister et al., 2020)
Speed	300km/h (vs. 900 km/h for conventional airplanes) (other sources: 30% slower than conventional airplanes)
Energy consumption	570 Kw/h per 200 km and 19 passengers
Source of propulsion power	**Batteries.** Fuel cells and hybrid solutions may be accepted in individual use cases (this needs to be specified; hybrid solutions might affect the data provided in this table)

Table 1: Aircraft model employed for this study (Heart Aerospace).

2. https://heartaerospace.com/es-30/
3. https://liu.diva-portal.org/smash/get/diva2:1631695/FULLTEXT01.pdf

The ten-year scenario approach

As described in Porter (1985), a scenario is "an internally consistent view of what the future might turn out to be – not a forecast, but one possible outcome". Scenario planning uses scenarios in order to explore and describe possible future conditions. The aim of scenario planning is to offer a holistic perspective of the interconnected advantages and disadvantages of potential futures.

Within the framework of this project, a ten-year future scenario approach was developed to identify the key driving forces in the selected regions that may potentially influence the future implementation of electric aviation. The concept of driving forces is central to scenario planning. A driving force can be both an enabler and a hurdle to a specific change (Edgar et al., 2013). Furthermore, the scenario planning focused on possible impacts of electric aviation in the region. The term "impacts" is taken in this research project as referring to the possible effects – in terms of regional, economic and technological development, service accessibility and social implications – that electric aviation may have in different Nordic regional contexts.

In order to develop the future scenarios, focus group discussions were conducted for each case study with four to seven participants. The steps involved were as follows:

1. Identification of key driving forces (desk research)

- Key forces that drive or hinder the development and future of electric aviation in the region were identified.
- The concept of a PESTEL analysis was used to place the identified key driving forces into six overarching categories:
- Political: this refers to the influence of political will and government policies on electric aviation.
- Economic: this includes factors like economic growth and regional development.
- Social: demographic trends, cultural attitudes, social values and lifestyle changes fall under this category.
- Technological: this involves assessing the impact of technological development on electric aviation. It includes factors such as innovation, research and development, automation and the pace of technological change.
- Environmental: environmental factors focus on ecological and environmental aspects. That includes considerations like climate change, sustainability and environmental regulations.
- Legal: legal factors involve the impact of laws and regulations on electric aviation.

PESTEL analysis, which is commonly used in business development, is a useful tool in research to examine systematically and understand the external factors that may impact the subject being studied. It is an analytical approach based on certain contextual variables that can outline existing and future scenarios. Its purpose is to identify which variables may be relevant to the occurrence of those scenarios (Cordova-Pozo & Rouwette, 2023).

2. Ranking of key driving forces. Before the focus group discussion took place, participants were asked to rank the identified driving forces according to two main factors: the probability of their occurrence in the next ten years and their level of significance for electric aviation. The probability of occurrence refers to the likelihood or chance that a specific event or outcome will happen. The level of significance in this context refers to the critical importance or influence of a specific driving force in terms of facilitating the realisation of electric aviation. In essence, it measures the pivotal role played by a particular factor in making electric aviation reality

3. Focus group. The focus group discussions were conducted either online via Teams or in person and lasted approximately two hours. It should be noted that in some of the focus groups the process of ranking the driving forces occurred beforehand, rather than during the session itself. That ranking process was facilitated by using Mentimeter, an audience engagement platform that enables real-time surveys and collection of feedback. During the sessions, participants were asked to individually rank the driving forces, providing reasons for their choices, and engage in discussion with their fellow participants to explore each topic in greater detail. Additionally, participants were encouraged to brainstorm and propose potential additional driving forces, as well as to reflect on the potential impacts that the adoption of electric aviation might have on the region.

4. Description and interpretation of the scenarios. Based on the focus group discussions, a future scenario for electric aviation was developed for each of the regional contexts analysed.

Methodological limitations

Focus group discussions are recognised as a valuable tool for gaining in-depth insight into social issues (O.Nyumba et al., 2018). Nevertheless, it is crucial to acknowledge certain methodological limitations. Several levels of bias, limitations and challenges warrant consideration:

Discussion biases:

- The participants across different focus group discussions had varying levels of expertise, potentially influencing the results. Certain topics might have been given more in-depth consideration based on the participants' diverse backgrounds.
- Given the wide-ranging levels of knowledge about electric aviation among participants, there is a risk of dominance bias. Less expert participants may be less inclined to express their opinions, potentially skewing the overall perspective.
- The desire for group harmony may deter individuals from expressing diverse or conflicting views and ideas. That dynamic could limit the range of perspectives presented during the discussions.

Interpretation of the results:

As the data from the focus groups are rooted in personal opinions and anticipation of future events, researchers must approach the interpretation with extreme caution. It is important to note that this study does not aim to predict future developments in electric aviation, but rather to construct scenarios or hypotheses about what the future might hold in this field.

Limited generalisability:

The study deliberately selected a specific set of cases based on predefined parameters. Consequently, caution should be applied when attempting to generalise the results to other routes, as some insights are closely tied to the unique characteristics of the specific cases and may not be universally applicable.

In light of those considerations, meticulous attention to the potential biases and limitations is essential to ensure the reliability and validity of the insights derived from focus group discussions.

Aerial view of Akureyri Airport in Iceland
Photo: iStock

3. Ten-year Future Scenarios for Electric Aviation. A Nordic Perspective

In this chapter, five future scenarios addressing the ten-year horizon of electric aviation will be presented. The background of the specific country and route, such as geography, economy, local policies, current transport infrastructure, accessibility of public services and energy infrastructure, will first be discussed for each case. Next the key driving forces, categorised according to the PESTEL analysis, will be presented. Finally, interim conclusions will be drawn for each of the cases.

Denmark. Copenhagen – Bornholm

Copenhagen – Bornholm	
Distance between the airports	141 km
Travel time by electric airplane[4]	approx. 22 min

Table 2: Distance and travel time between the airports.

The Danish case study on the impacts of electric aviation is unique in comparison to the other Nordic regions because of the location concerned. Denmark has a significantly smaller geographical area than the other Nordic countries and is therefore significantly more urbanised and more densely populated. In order to satisfy the methodological requirement of this study for an urban-rural connection, a route over water was considered most suitable, leading to selection of the connection between Copenhagen and the island of Bornholm.

That route connects two distinct areas of Denmark with airports situated 141 km apart from each other: the densely populated Danish capital Copenhagen and the island of Bornholm, which is considered a rural area in the proximity of Copenhagen (Nordregio, 2022). According to preliminary calculations, the flight would take approximately 22 minutes by electric airplane. The existing flight route between those two destinations is operated by the Danish airline DAT three to eight times per day, depending on the day of the week and the season of the year (Bornholms Lufthavn, 2023). While there are no bridges or tunnels connecting the island to mainland Sweden or Denmark, there are regular "Bornholmslinjen" ferries that connect Bornholm to Ystad in Sweden, Køge in Denmark and Sassnitz in Germany (Tomiola, 2023). Passengers travelling between Bornholm and Copenhagen by ferry usually use the route between Bornholm and Ystad and then take the bus or travel by car to Copenhagen. Bornholm is rapidly transitioning to a green island, with high support for sustainable means of transport (Municipality of Bornholm, 2018). Given those factors, the flight route between the island of Bornholm and Copenhagen lends itself to being studied.

In short, while there are existing connections on the route between Bornholm and Copenhagen, the case study will provide a unique perspective of the possible impacts that electric aviation might have, should it be implemented on this route.

4. Table 1: Aircraft model employed for this study.

As this case study will primarily investigate the impact of electric aviation on regional development on the island of Bornholm, most of the following text focuses on the Danish Island of Bornholm rather than the capital city of Copenhagen. However, transport and other administrative links between the two locations will be taken into consideration.

Regional context

Geography and demography

Bornholm is a Danish island located in the Baltic Sea, to the east of the Danish mainland. With an area of 588 km², Bornholm is Denmark's fifth largest island. The island lies about 180km east of Copenhagen by sea and 37 km from the Swedish mainland (Melskens, 2017).

As at January 2022, Bornholm had 39,552 inhabitants. Since 1990, the population has decreased by 13.5% percent from about 45,800. However, the regional authority, the Municipality of Bornholm, expects the island's population to grow again slightly over the coming ten years and estimates a total population of 40,470 in 2033 (Municipality of Bornholm, 2022). The previous reduction in population has been linked to causes including young people leaving the island in pursuit of careers elsewhere, reflecting demographic changes that have also been observed in other rural parts of the Nordic region (Bogason, 2020). About two-thirds of the local population today live in towns while the remaining inhabitants live in rural areas. Bornholm's largest town is Rønne, located on the island's west coast; other towns are Hasle, Sandvig, Allinge, Gudhjem, Svaneke and Nexø.

The average age of the island's population is 48 years. That is more than ten years above the average age in Copenhagen (Admin Stat Danimarca, 2023). The largest age groups on the island are the group aged between 56 and 64 (17%) and the group aged between 66 and 74 (16%) (Admin Stat Danimarca, 2023). As at March 2023, Bornholm had an unemployment rate of 3.0%, compared to 3.5% in Copenhagen (Statistics Denmark, 2023). However, the overall income level in Bornholm is about 20% lower than the national average (Statistics Denmark, 2022). Housing is less expensive on the island than elsewhere in Denmark due to lower demand (Bogason, 2020).

Regional economy

Historically, the main income-generating activities in Bornholm have been fishing, agriculture and the machinery industry. Many of Bornholm's farmers engaged in pig or dairy farming in the past. However, in line with the island's "Bright Green Island" policy, which will be outlined in the next section, the agricultural sector has been shifting its focus towards organic, small-scale farming over the past years (Bogason, 2020). The manufacturing of craft products also has a long-standing tradition on the

island, especially in the fields of glass blowing and ceramics, while other materials such as wood and textiles also play a role in the artisanal production of local artefacts (Royal Danish Academy, 2017). Bornholm has also attracted many Danish and international artists over the past decades and has become known for its local art museum (Tomiola, 2020).

Sustainable tourism has been identified as an important future source of income for the local population (Broegaard, 2022; Destination Bornholm ApS, 2023; Szromek, 2019). Various sustainable concepts have been evolving over the past years in the gastronomy sector and the tourism sector as a whole on the island (ibid). Furthermore, Bornholm's "Energy Island" project is set to generate new sources of income, including new job opportunities for the local population, such as in the field of sustainable offshore engineering (Energy Island Bornholm, 2023). The project is expected not only to turn the island into a hub for green energy generation, but also for research and further development in that field (Baltic Energy Island, 2023). The establishment of such new green jobs can help to attract more people to the island, strengthen the local employment sector and economy and potentially improve the island's old-age dependency ratio.

Regional policies and initiatives relevant to electric aviation

Over the past years, Bornholm has strengthened its regional and international reputation as a sustainable community and tourist destination, with ambitious goals on carbon neutrality and the introduction of sustainable solutions across all sectors. Bornholm's ambitious strategy is called "Bright Green Island" and has gained recognition, with the island being awarded the European Union's "RESponsible Island Prize" in 2020, for example. The prize recognises Bornholm's cross-sectoral approach to sustainability and local renewable energy production systems (European Commission, 2020).

The "Bright Green Island" strategy was developed under the leadership of the local municipal council and launched in 2018 (Nordregio, 2019). The vision describes eight overarching goals which are intended to support the island's transition towards a carbon-neutral society (Municipality of Bornholm, 2018). Those goals include achieving carbon-neutral energy production in 2025, being fossil-free by 2040 and recycling or reusing all waste by 2032 (ibid). On the path to meeting its objectives, the island of Bornholm today bases all of the island's district heating and electricity production on renewable energy sources, using wind, solar, biogas, wood chips and wheat straw. Local energy production covers 60% of local consumption (Destination Bornholm ApS, 2022). With its aim of phasing out all fossil fuels by 2040, the island will have to transition towards the electrification of its transport sector in the coming years. Presently, the Danish airline DAT compensates its emissions through the planting of trees (Destination Bornholm ApS, 2023).

In line with its sustainability goals, Bornholm is currently in the process of becoming the world's first "energy island". That process is described in more detail under the section "Energy infrastructure" and comprises Bornholm's future role as an energy hub for energy produced in offshore wind parks in the Baltic Sea.

Transport infrastructure

The airport in Rønne is Bornholm's only airport. Routes served to and from Rønne Airport include Copenhagen, Aalborg, Billund and Sonderbørg, all of which are in Denmark. Apart from those regular flights, the airport is also open to general aviation from all of Europe (see Figure 2). Figure 1 shows the total number of passengers arriving at and departing from the airport, with an average of 6,760 passengers arriving per month on the island in 2022.

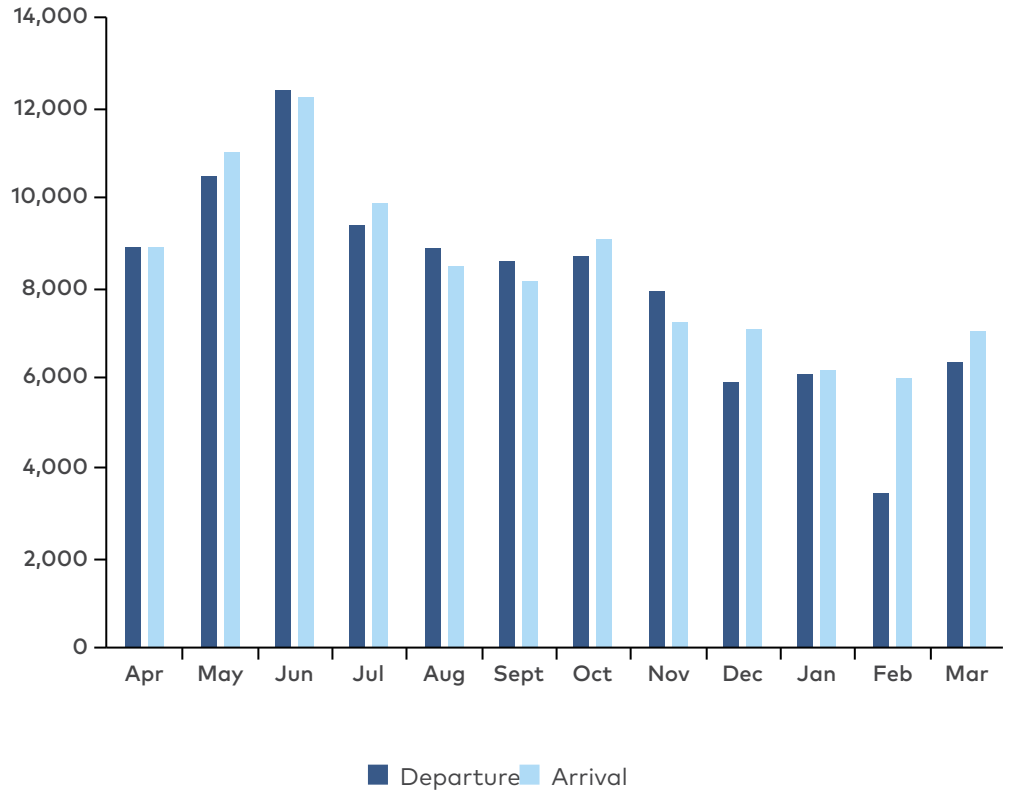


Figure 1: Number of passengers arriving at and departing from Bornholm Airport in 2022 and 2023
Source: Trafikstyrelsen, 2023

As mentioned above, the island can also be reached by sea. The ferry company "Bornholmslinjen" connects the island with Ystad in Sweden, Køge in Denmark and Sassnitz in Germany (Tomiola, 2023). Moreover, Christiansø, which lies 10 km northeast of Bornholm, is connected by a ferry service that runs between Gudhjem and the island of Christiansø (ibid). The connection between Ystad and Rønne is the most frequently used route with about five ferry departures per harbour per day, while there are only one to two departures from Køge and Sassnitz (Bornholmslinjen, 2023). In April 2023, a new vessel called "Express 5" began serving the route between Ystad and Rønne. The world's largest fast ferry can carry up to 1,600 passengers, as well as 450 cars (Herin, 2023). The ferry's four 16-cylinder engines are of the dual-fuel type, which means that both the engines and the vessel are capable of using alternative fuels (Bornholmslinjen, 2023). Sustainability was hence considered in the design and development of the ferry. However, it cannot be seen as a low-emission or zero-emission transport solution. There are no bridges or tunnels connecting the island with the mainland. On the island itself, a good network of streets connects the various towns and villages, ports and the airport.

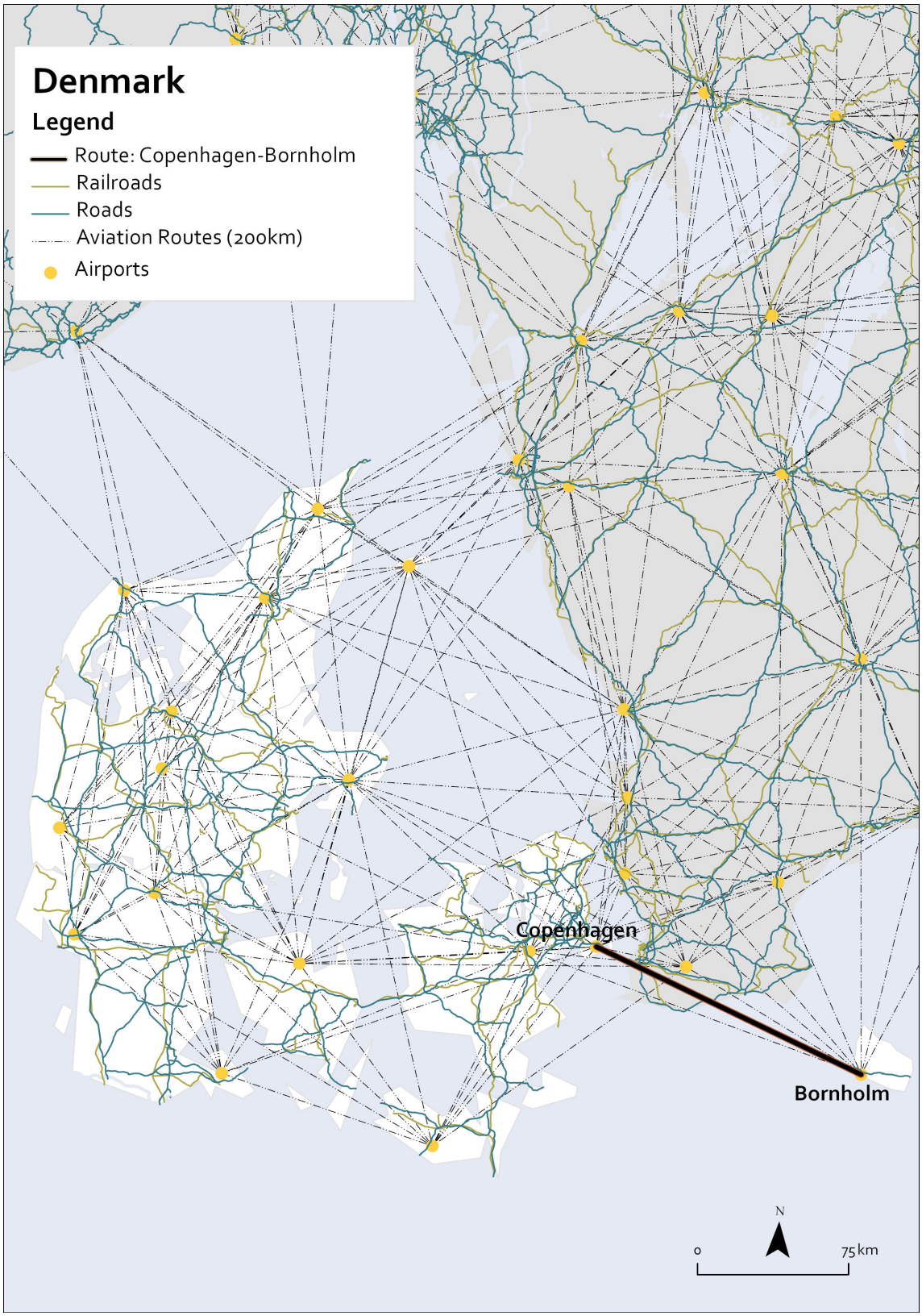


Figure 2: Danish route and regional transport infrastructure

Source: Nordregio

Accessibility of care facilities, education, work and other public services

There is one hospital on Bornholm, situated in Rønne. Bornholm is considered one of five health clusters in the Capital Region of Copenhagen. As at 2022, the hospital had about 600 employees (Bornholms Hospital, 2022, 2023b). The hospital offers services including a maternity ward, an anaesthesiology department, a surgery department, an oncology section and a mental health unit (Bornholms Hospital, 2023a). If there is a lack of specialists or a patient cannot be treated at the local hospital for other reasons, patients are usually transferred to a specialist at a hospital in Copenhagen due to Bornholms Hospital's administrative link to the Capital Region of Copenhagen. That requires a referral from a local doctor. The municipality pays for the patient's transport if they are travelling to/from the nearest specialist, i.e. in Copenhagen, and have not opted to continue their treatment in one of the other Danish hospitals outside the Capital Region (Municipality of Bornholm, 2023b). Furthermore, travel expenses are only covered if the patient takes the cheapest travel option, namely the bus from Rønne to Copenhagen via the ferry to Ystad in Sweden, which takes over three hours. The municipality only covers the costs of other means of transport, i.e. flights, if the health condition of the patient does not allow for travel by bus (and ferry) (ibid).

Besides the hospital, in 2018, there were about twelve medical surgeries across the island as well as eleven dental practices (Tomiola, 2018). Access to healthcare facilities on the island is therefore relatively good. However, hospitals in Copenhagen offer a wider range of specialist care, so patient trips between Bornholm and the Danish capital are a regular occurrence. In 2021, there were about 40,000 single trips between Bornholm and Copenhagen, "often for just a brief medical consultation or check-up" (VOPD Project Consortium, 2021).

There are several educational facilities on the island of Bornholm. For children under the age of six, Bornholm offers 17 daycare facilities. Furthermore, the island is home to six primary schools, two special-needs schools and one lower secondary school (Municipality of Bornholm, 2023a). In addition, there are seven private schools and one upper secondary school (Business Centre Bornholm, 2023). There are also several institutions offering vocational and academic qualifications. For instance, the Copenhagen Business Academy, University College Copenhagen and Bornholm's Health and Nursing School offer study programmes ranging from pedagogy and nursing through to finance (Bornholms Sundheds- og Sygeplejeskole, 2023; Copenhagen Business Academy, 2023; University College Copenhagen, 2023). The local municipality has worked in recent years on establishing more upper secondary educational programmes to retain young people and also attract young people to the island (Bogason, 2020).

Energy infrastructure

Bornholm's "Energy Island" project was adopted by the Danish Parliament in early 2020 and is currently set not only to boost the sustainable energy supply of the island itself, but also of some of the Baltic Sea's littoral states, including Denmark and Germany. It will further serve as a role model for other energy islands around the world (Energy Island Bornholm, 2023). Several windfarms south of Bornholm are planned to be put into operation by 2030, generating 2-3 GW of green energy (Energy Island Bornholm, 2023), which will then be delivered to a high-voltage station on Bornholm. The energy will be distributed on from there to Germany and Denmark. In spring 2023, the Danish and German transmission system operators (TSOs) concerned launched a market study for procurement of the necessary cable systems (Memija, 2023). Besides the TSOs, the Municipality of Bornholm plays an important role in the process, ensuring that the developments take place in consultation with the local population, as well as that the best interests of Bornholm's inhabitants and local businesses are considered and jobs are created (Energy Island Bornholm, 2023). The project will further enable Bornholm to become a "green refuelling station" for ships and there are plans for the establishment of a "National Centre for Green Energy" on the island (Destination Bornholm ApS, 2022).

Ten-Year Scenario for Electric Aviation

The focus group discussion was conducted online via Teams in October 2023 and took around two hours. The scenario below has been developed based on the discussion with four respondents (one from Bornholm and three from elsewhere in Denmark). The recruitment process was less dynamic than expected due to the passiveness and lack of response from contacted suitable participants located in Bornholm. While it was intended for the highest number of participants to be from Bornholm, only one was available to take part in the study.

The participants included a management-level representative from Bornholm's official travel guide "Destination Bornholm", a researcher from DTU (Technical University of Denmark), a chief consultant from "Trafikstyrelsen" (Danish Civil Aviation and Railway Authority) and a business developer from "Erhvervshus Hovedstaden" (Business House Capital) who is also involved in "Blå Bornholm" (Blue Bornholm), an association that is working on improving the environmental condition of the Baltic Sea.

Key driving forces:

Political factors

The focus group named the "Bright Green Island" vision as a pivotal force that is set to shape the trajectory of electric aviation over the next decade. Since the vision is one of several levers that have encouraged Bornholm to become greener and more sustainable, the group was convinced that local support for the vision could generate

positive incentives to implement electric aviation, thereby improving Bornholm's transport connections. The group emphasised that such innovative goals signal political support for green solutions. While acknowledging the potential influence of that vision, participants underscored the need to pay attention to other equally significant factors. A closer examination of the vision revealed a commitment to fossil-free transport, which was deemed an even more significant driving force than the "Bright Green Island" vision.

Political will and commitment, along with the aspiration to transition to fossil-free transport, are considered likely to act as a driving force. However, it was stressed that electric aviation is not the only means by which emissions could be reduced. The participants referred to alternative fuels, such as Sustainable Aviation Fuel (SAF) or hydrogen, as being potentially more cost-effective and feasible options in the Danish context. Despite highlighting the diverse means by which sustainable aviation can be achieved, the group recognised strong political intent to implement eco-friendly flights and highlighted specific goals such as all domestic flights being green by 2030. Notably, there is already agreement on an electric aviation route between Læsø and Roskilde that is expected to be operational by 2028.

The scope of Bornholm's ambition extends beyond aviation, as articulated in the "Bright Green Island" vision. The goal is for all public transport to be sustainable and for electric cars and ride sharing solutions to be incentivised. However, the focus group identified ferries as a significant contender in that context. When discussing public transport in general, the participants expressed the view that it is ferry transport that largely needs to be improved, since it is the main source of pollution. It has been argued that the actual emissions per transported passenger are much higher by ferry than by conventional airplane. In addition, more people use the ferry than travel by airplane on this route. It was also thought that electric airplanes, unlike ferries, would not be able to carry heavy cargo. Such factors might deter decision-makers from supporting electrification of airplanes. It also explains why the focus group was hesitant to be fully positive with respect to the outlook for electric aviation.

The focus group remained cautious about exclusive support for electric aviation due to doubts about political backing. As mentioned, sustainable aviation can also be achieved using other fuel types – a point that was stressed several times during the discussion. The group backed up that argument by highlighting the challenge for decision-makers in supporting one company over another, solely based on the fuel type they utilize. This poses an issue as currently there is only one airline operating between the cities in question.

Economic factors

The imperative to attract a skilled workforce is as a key catalyst, given the current flow of people commuting between the regions for work-related reasons. Nevertheless, for electric aviation to have a significant impact, the flight schedules need to be drawn up very carefully to accommodate working hours. On the other

hand, the focus group participants pointed out that Bornholm does not currently offer significant employment potential and electric aviation is not anticipated to generate a substantial increase in job prospects.

Linked to that, the drive to attract a younger demographic is a significant factor, as some groups of young people are more environmentally-aware and choose only sustainable travel options. Nevertheless, the ferry might still be more attractive to young people given that it is a cheaper option. Price is a crucial factor for young people, who are budget-conscious and typically place less importance on a shorter travel time. The group also stressed that electric aviation may not be a sufficient draw for young people, since the salaries and the housing market in Bornholm are currently unattractive. Other things being equal, other sustainable options would also be attractive to young people.

The focus group thought that the growing sustainable tourism sector is likely to continue expanding in Bornholm. As the island positions itself as a hub for sustainable tourism, efficient means of transporting visitors become crucial. Since electric aviation could facilitate that need, the growing popularity of sustainable tourism was identified as an important driver. For some participants, the prospect of trying out a new technology, such as an electric airplane, was deemed to be attractive in itself. The connection could be used by people visiting their summer house or wishing to explore the island. On the other hand, ferry services remain attractive to tourists desiring more flexibility, including the option to bring their own vehicles.

Social factors

Accessibility of healthcare was considered an important driving factor for the implementation of electric aviation, as the healthcare facilities on Bornholm are limited in comparison to Copenhagen. Currently around 20% of trips between Copenhagen and Bornholm are health-related according to one participant. When discussing conventional airplanes in particular, the group noted that there tend to be some five to six people onboard who are bound for Copenhagen due to an appointment at the hospital. If electric aviation could offer more competitive prices than the ferries, improved healthcare accessibility could be a noteworthy driver, since the state pays for the cheapest means of travel from Bornholm to Copenhagen when needed for an appointment at the hospital. In an emergency situation, the healthcare provider would have the patient transported by helicopter or airplane. The focus group reasoned that if the electric airplanes were small enough (like a helicopter), they could land directly at the hospital. In addition to better healthcare coverage, outmigration might also fall owing to the snowball effect.

Accessibility of education was not seen as a major driver, since educational possibilities are limited in Bornholm, meaning that any efforts to attract students to the island would not bear fruit**.** Conversely, the focus group considered it unlikely that students would fly often to Copenhagen to attend courses given that the ticket prices are expected to be too high for students. Students tend to prefer to live in a

college environment and are therefore more likely to move from Bornholm to Copenhagen to study and live. Given that there are already connections between Bornholm and Copenhagen, electric aviation would not offer enhanced access to education.

Technological factors

As was noted during the discussions, the evolving green energy hub is an important driving force given that the prerequisite for electric aviation is for the airplanes to be charged using green, renewable electricity. The green energy hub could facilitate that, providing that the necessary infrastructure is in place. The group was convinced that the energy produced on the island would be more than enough to charge the airplanes and provide enough electricity for further export. Another compelling factor to consider with respect to advancement of the green energy hub in Bornholm is the potential synergy with the emerging field of electric aviation, further enhancing the overall impact of sustainable development.

More flexibility in aviation was identified as an additional driving force. Since the electric airplanes are expected to be smaller than conventional airplanes, there could be more possibilities to land at airports of a different size. One participant cited the example of the waterplane, which operates between Aarhus and Copenhagen. If that plane were to run on electric fuel, not only would it be able to land on water or at small airports, but it could also minimise travel times, since the airport in Aarhus is situated fairly far outside the city. The already planned electric route for 2028 between Roskilde and Læsø that was mentioned above shows that Bornholm and Copenhagen are far from being the only possible routes that electric airplanes could operate on.

Environmental factors

Protection of local flora and fauna was considered a double-edged driving force since the impact of that factor is not clear-cut with regard to electric aviation. The lack of CO2 emissions and expected lower noise pollution during operation of the electric airplanes would clearly benefit the natural environment. However, the group questioned to what extent development of the battery might pollute the natural environment. While estimates were unknown during the focus group discussion, the participants were not optimistic in that regard. Another issue raised was the question of battery disposal after use. Due to such uncertainties, the participants questioned whether SAF would leave a smaller footprint then the electric alternative.

Legal factors

There was consensus in the focus group that the relevant rules and regulations for electric aviation will be in place in due time. However, safety and reliability take priority, so even though electric aircrafts are mostly in the test phase at the time of writing, the participants did not expect that to contribute as a negative driver. Trust in electric aircraft is difficult to predict. Nevertheless, failed tests can have ambiguous consequences for the development and perception of such types of new technologies.

Concluding reflections

When considering the possible electric route between Bornholm and Copenhagen, the focus group remained sceptical about the discussed drivers and applicability. One of the major doubts voiced throughout the discussion concerned the price of tickets for flights served by electric airplane. Since the route is currently served not only by conventional airplanes, but also by ferries, which are significantly cheaper, the focus group was uncertain as to whether the electric airplanes would be used extensively and whether there would therefore be sufficient incentives to commit to development of the routes. In connection to the previous point, the group was also doubtful about whether the airplanes would necessarily be electric. It was underlined that there are other types of fuels that would likewise be sustainable or easier to implement, so evaluating political commitment was equally difficult.

On the other hand, there was full agreement concerning the necessity and possibility of finding a sustainable flight solution. Bornholm, which is moving rapidly towards a sustainable future thanks to local support and tangible steps – such as development of the green energy island – is undoubtedly in need of a sustainable approach. However, whether that will involve electric aircraft or other options remains to be seen. Implementation of electric aviation along that route could make the island an even more attractive tourist destination. Furthermore, it has the potential to improve healthcare access for local residents. Overall, the focus group suggested the need for further evaluation and for more details to be addressed prior to implementation of such a route.

Finland. Kuusamo – Kajaani – Oulu

Kuusamo – Kajaani – Oulu		
Distance between the airports	Kajaani-Kuusamo	205 km
	Oulu-Kuusamo	183 km
	Oulu-Kajaani	138 km
Travel time by electric airplane	Kajaani-Kuusamo	41 min
	Oulu-Kuusamo	37 min
	Oulu-Kajaani	28 min

Table 3: Distance and travel time between the airports.

The Finnish case study concerns a triangle between the cities of Oulu, Kajaani and Kuusamo. This differs from the results of the accessibility study (Lundberg, 2022), which mainly suggests oversea connections as having the greatest potential for electric aviation in Finland. Our aim in choosing the inland connections between those three cities is to supplement the results of statistical analysis with qualitative data to see whether drivers and open questions may be revealed that would otherwise not be evident. The estimated flight time between the destinations by electric airplane is as follows: Kajaani-Kuusamo approx. 41 min, Oulu-Kuusamo approx. 37 min, Oulu-Kajaani approx. 28 min.

The cities of Oulu, Kajaani and Kuusamo were chosen after being flagged as potentially interesting cases by our expert working on aviation issues in the council of the Oulu region. The triangle formed between them has a growing number of new transport connections and people arriving for work and education (Oulu), as well as new bioindustry projects, active demand for business travel connections (Kajaani) and the busiest tourism area in the country (Kuusamo). In addition, there has been growing political interest in the region in keeping the positive impact of aviation on the regional economy on the national agenda. Such political support and local activity may suggest that there are drivers supporting electric aviation in the region that can be activated when the time is right.

Regional context

Geography and demography

Kajaani belongs to the Kainuu region, while Oulu and Kuusamo are situated in Northern Ostrobothnia (Pohjois-Pohjanmaa, 2021). There are 212,000 people and approx. 50,000 jobs within a 20 km radius of the city of Oulu and 318,000 people and 64,000 jobs within a 100 km radius (Pohjois-Pohjanmaan ELY-keskus, 2019). Kajaani has a population of 36,000, while the surrounding Kainuu region is home to 70,500 people and 27,800 jobs. The unemployment rate is relatively low but due to a decade-long trend of population decrease, companies are experiencing recruitment problems throughout the region (Kainuun liitto, 2023).

From Oulu, Kuusamo can be reached by bus several times a day, with a travel time of three hours. From Kajaani, the travel time is approximately 3.5 hours and there is only one connection outside the high tourist season. There are three daily bus connections between Oulu and Kajaani with a travel time of 2.5 hours and four train connections with a travel time of two hours.

Regional economy

The Finnish regional flight network is heavily subsidised by the state (in the amount of 40 million EUR during 2021-2023); the same also applies to the Helsinki-Kajaani connection and Kajaani Airport. In 2023, the Parliament decided to continue supporting the regional routes by providing an additional 17 million EUR until at least April 2024. Without the national subsidies, Finnair would not continue operating those routes. The route to Kajaani is the busiest of the five subsidised regional routes, even though the airplanes have a 52% passenger/capacity rate. Currently the state is hoping that regional actors will themselves find ways to make these routes financially viable. Under the previous government, the main emphasis was on reforming the railway network instead of investing in air traffic to align with national climate goals. (Holopainen, 2023; Tolpo, 2023).

The regional council of Northern Ostrobothnia conducted a study on the impact of aviation on the regional economy, with particular emphasis on the cities of Oulu, Kajaani and Kuusamo. The report states that the impact of aviation is much larger in the case of regional airports (meaning all airports other than that of Helsinki) and the more remote an area is, the greater the importance of having an airport. Indirect impacts are three times larger than the direct impacts on the regional economy. The report details that 51% (26 billion EUR) of revenue and 11,000 jobs in the impact area of the airports in Oulu, Kajaani and Kuusamo are dependent on aviation, with 59% of that business being international sales. A total of 49% of regional businesses considered on-site meetings with clients and stakeholders to be necessary, while 32% saw them as important. Furthermore, the report found that one in three companies in the region had made significant investments that rely on regular flight connections. (Council of Oulu Region et al., 2023).

The survey estimated that better connections would help 50% of companies to increase their revenue in Oulu, 48% of companies in Kajaani and 49% in Kuusamo. Of industries that would benefit the most, 97% of companies in tourism could increase their revenues, 78% of companies in the fields of entertainment and art, 70% of IT companies and 54% of companies in heavy industries and mining. (Council of Oulu Region et al., 2023).

In all three case study locations – Oulu, Kajaani (especially near Kajaani in Paltamo) and Kuusamo – there are large pulp, board or paper mills or sawmills and related transport flows. In addition, there are several bio-industry projects that are under development or have already been completed in the wider region. (Liikennevirasto, 2017).

The main economic strengths of the Oulu region are electronic industries and education (Pohjois-Pohjanmaan ELY-keskus, 2019). In a scenario developed by the Finnish Transport Infrastructure Agency, it was estimated that an increase in air traffic in the Oulu region in the future could be prompted by a) multinational enterprises establishing knowledge centres in the Oulu region, b) increased work travel by researchers due to a rise in research and development activity c) the further development of a common Nordic employment market and d) new tourism approaches making the Oulu region a more attractive destination. It is also estimated that air traffic via Oulu to Lapland will increase in the coming decades. (Herneoja et al., 2019).

As far as Kainuu is concerned, the CEO of the Association of Entrepreneurs of Kainuu commented that regular flight connections are of great importance to regional entrepreneurs. That includes local microenterprises and medium-sized companies, the mining industry, tourism and the forestry industry, which all trade internationally. (Kinnunen, 2022). In the regional plan for developing the transport systems, the region estimates that the regional economy will benefit in the future from the global growth in tourism and the development of the bioindustry, technological and mining industries. The region's strong points in terms of transport system investments are the existing infrastructure and topical knowledge about the important economic actors. Weaknesses hampering development of the current transport structure are long distances, sparse population and thin personal transport flows. Those weaknesses mean that there are considerable challenges in terms of maintaining the road network and organising public transport. The region has estimated that all possible future driving forces would require reliable flight connections to enable efficient work travel or visits by stakeholders, for example. (Kainuun liitto, 2018).

Kuusamo is the third largest travel destination in Finland owing to its status as a ski holiday destination. The number of overnight stays has increased more strongly than the national average and the travel industry of Kuusamo has set itself the goal of 185,000 air passengers by 2026. However, travel entrepreneurs have expressed concerns regarding Kuusamo Airport and the frequency of flight connections, given

that they are necessary for tourism in the area. There is also a new bio-park focused on circular economy activities in Kuusamo (Karjalainen, 2022; Karjalainen & Ukkonen, 2022; Kuusamon kaupunki, 2023; Loukkola, 2023).

Regional policies and initiatives relevant to electric aviation

The transport and logistics strategy for northern Finland of 2017 states that problems with accessibility should be managed by prioritising the transport needs of business, industry and tourism actors, as well as the Ostrobothnian coast. In the future, long-distance journeys, economic activities, industries and international cooperation are expected to focus to an increasing extent on certain "development corridors". Of the case study locations, Oulu and Kajaani are situated along those development corridors, while Kuusamo is at the heart of tourism activities. New political solutions are needed to ensure public transport in the very sparsely populated regions of northern Finland. (Liikennevirasto, 2017).

In the Northern Agenda, which was drafted by a group of stakeholders in northern Finland (regional councils, cities, universities, chambers of commerce and entrepreneurial associations), it is recommended that the new government emphasises transport connections to create a more unified Northern area, with Oulu as a key growing transport node.

Transport infrastructure

The airport network of northern Finland is relatively extensive and is of great importance for the regional economy and industries. Of the three case study locations, Kajaani Airport and Kuusamo Airport are especially important for tourism and Oulu Airport for business. (Liikennevirasto, 2017).

Oulu Airport is Finland's second busiest airport with over 630,000 passengers. (Degerman, 2023b). The airport is used to a far lesser extent for cargo traffic as most cargo is carried by road. However, the cargo carried by air is relatively valuable. (Pohjois-Pohjanmaan ELY-keskus, 2019). The 2019 national evaluation of significant transport nodes listed Oulu among important nodes for personal transport, noting that air traffic is of greater importance than rail and road traffic in this context. The importance of Oulu Airport is heightened by the fact that the distance to Helsinki is over three hours by rail or road. The Finnish Transport Infrastructure Agency (Väylävirasto) also stated that transport connections (especially between the city and the airport) and services around Oulu Airport should be improved overall given its status as an important node (Herneoja et al., 2019).

Kajaani Airport is located ten kilometres from the city centre and is managed by the state company Finavia. Kuusamo Airport is located 80 kilometres northwards. The distance between Oulu and Kajaani is 183 kilometres. Currently there are two to four flights a day between Kajaani and Helsinki and roughly 80,000 flights per year, 75%

of which are to Helsinki and almost all the rest to destinations abroad. In other words, less than 1% of passengers fly to other Finnish cities from Kajaani (via Helsinki). The reasons for flying are evenly distributed among tourism, business travel and travel for other purposes. Air cargo has been on the decrease during the past decade (Kainuun hyvinvointialue, 2023; Kainuun liitto, 2018).

As far as rail travel is concerned, the connection between the cargo station Kontiomäki near Kajaani and Oulu is among the country's busiest routes for cargo traffic, with traffic having been on the rise during the past years. Most journeys around Kajaani are made by personal car (82% of journeys, compared to the national average of 72%) and the average daily distance travelled is somewhat longer than the national average at 52 kilometres. In 2011, it was estimated that traffic is Kainuu's largest source of emissions with a share of 39%, most of which is from road traffic. Besides digitalisation, a decrease in private car journeys and support for railway traffic instead were the main aims with respect to reducing emissions (Kainuun liitto, 2018).

Passenger numbers to Kuusamo Airport have been on the increase and reached a record high in 2022 at over 110,000 passengers, representing a 57% increase compared to the previous year. Two-thirds of passengers to Kuusamo Airport are international, so a large share of flight connections consists of charter flights. (Karjalainen, 2022; Loukkola, 2023). The transport infrastructure of the selected Finnish regions is illustrated in Figure 3.

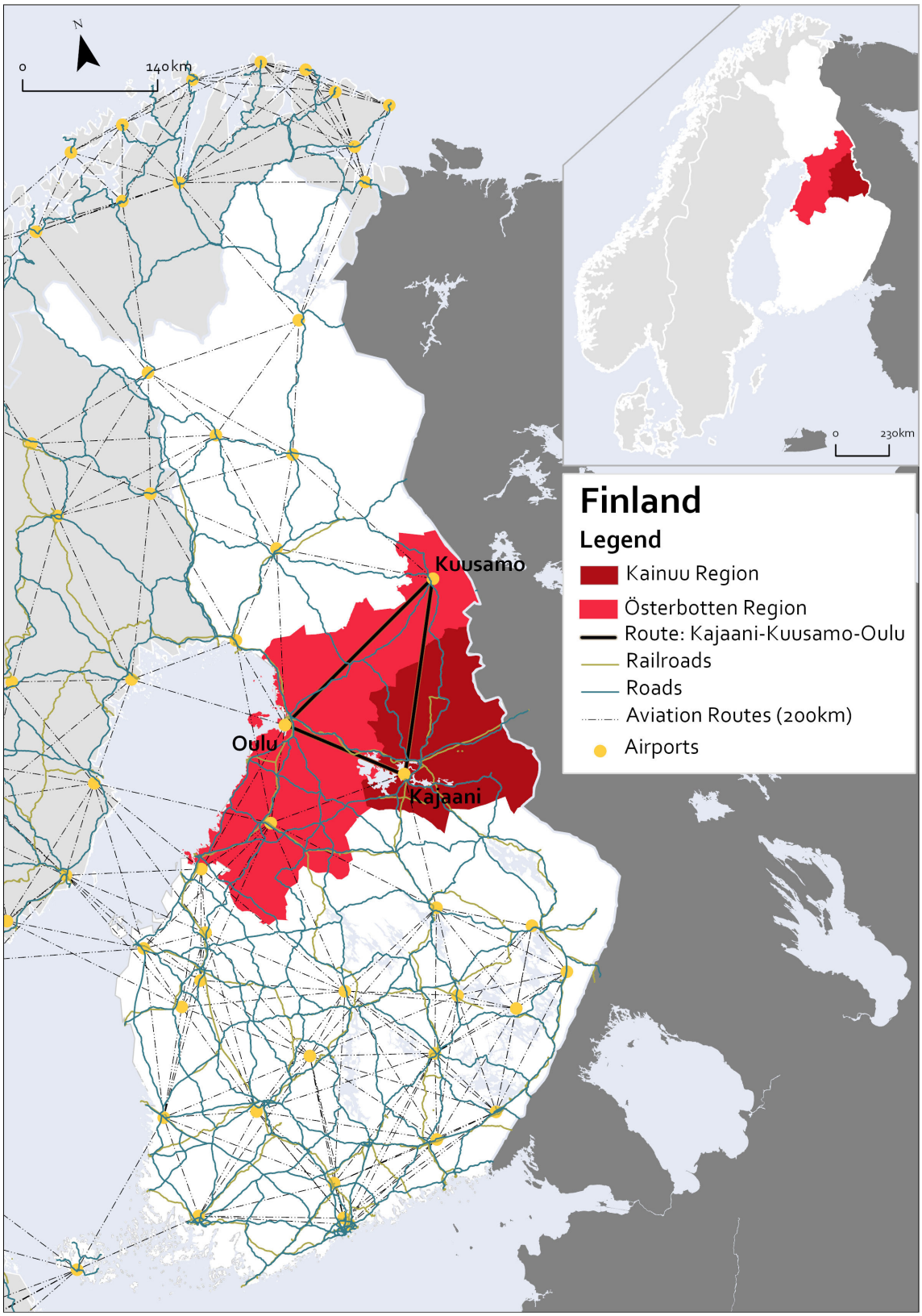


Figure 3: Finnish route and regional transport infrastructure

Source: Nordregio

Accessibility of care facilities, education, work and other public services

Compared to the Oulu region, accessibility has long been one of the core problems of the whole Kainuu region and related problems have also been on the increase. Transport infrastructure is considerably weaker than in southern Finland when it comes to road conditions, service provision (especially regarding railways) and the fragility of air traffic connections. For that reason, the smart specialisation strategy of Kainuu aims for more interregional cooperation and connections to compensate for the lack of people. (Kainuun liitto, 2020).

Energy infrastructure

Finland has a strong main grid and fewer regional bottlenecks than Norway, Denmark or Sweden. The case study regions of Northern Ostrobothnia and the Kainuu region have surplus power production. The Ostrobothnian coast also has a high share of wind power production with several completed wind parks and new ones in development, indicating reasonable potential for electric aviation in the region. The wind energy production area also extends to Kajaani and Kuusamo, making them attractive locations for electric aviation despite their relative proximity (200 km) to Oulu Airport. In addition, they are highly rural and sparsely populated regions. (Nordic Energy Research, 2023).

Ten-year scenario for electric aviation

The focus group

The focus group mainly consisted of regional experts representing the areas around the cities of Oulu and Kuusamo, as well as a representative from the Finnish public company Finavia, which is responsible for maintaining and managing the national airports. There were six participants in total. Oulu, the biggest city of the three, was also represented by the highest number of participants, with experts from Business Oulu (2) and the city of Oulu (1). An expert representing the tourism sector in Kuusamo also participated. Subsequent to the focus group discussion, an individual interview was conducted with an expert representing the council of the Oulu region who was also well informed about the situation in the city of Kajaani. The case study also gathered observations from the Seminar on Sustainable Tourism and the Circular Economy organised by the regional council of Kainuu (in Kajaani), at which this topic was likewise discussed.

Key driving forces for implementing electric aviation on the routes between Oulu, Kajaani and Kuusamo

Political factors

The political factors discussed in the group were sub-grouped under uncertainty over government subsidies, national and EU climate goals, regional development aims and better connections to Helsinki. The group began by pointing out that political support may potentially favour other ways of decreasing transport emissions in the future, such as rail traffic or – in the case of aviation – synthetic low-carbon fuels. In other words, electric aviation is presently not seen as a "silver bullet" to the same extent that it was several years ago. While the possibilities it offers are still worth considering, electric aviation may prove out to be the best available option under certain conditions.

Better connections to Helsinki were deemed an unimportant factor for electric aviation, since it would be difficult to compete with train connections here. Electric aviation could primarily be useful for inter-regional traffic or for feeding passengers from smaller cities into a bigger airplane that would then connect Kajaani and Helsinki, for example. In other words, electric aviation could help create new transport hubs in places where the transport links are rather thin at present. For example, the charter airplanes operating to Kuusamo could also feed passengers to smaller airplanes and bring them to the north or other cities to allow for more diverse options.

Instead of building new types of connections to the capital, other cities in the north were viewed as promising options for electric aviation routes from the three cities. Those could include, for example, routes from Oulu to Luleå in Sweden or Rovaniemi or even further north to destinations in northern-most Finland or Tromsø and other cities in northern Norway. A connection between Oulu and Rovaniemi could open up a wide network of new travel options. Creating a denser and more flexible flight network with lower emissions for the use of the tourism industry was repeatedly mentioned as one of the main possible early benefits of electric aviation. The future possibility to create new types of hubs means that it is sensible to invest a certain amount of money now in maintaining regional airports and airfields, since electric aviation cannot grow a functioning airport.

Furthermore, the discussion addressed the current political goals for cutting emissions. Given that all participants agreed that this factor is the single most important driver (some even went as far as to suggest that it the only significant driver) for electric aviation, there was less debate on this point.

Finally, the focus group discussed drivers – linked to the northern geography and long distances – that are currently perceived as marginal or absent, but that might be worth considering during the ten-year time span. For example, forest fire monitoring or defence requirements resulting from the current unpredictable geopolitical situation might result in new demand for smaller airplanes that are affordable to operate.

Socioeconomic factors

Here a decision was made to combine economic and sociocultural factors into socioeconomic factors, including the need to attract a skilled work force to the area, new industry projects, the potential to link the cities concerned with Skellefteå in Sweden and the role of the cities as nodes for transport, business and education. In addition, tourism was discussed.

While attracting a skilled work force is an important factor, it was not seen as an important driver for electric aviation. Instead, it was thought that businesses would benefit most from having more regular connections, thereby enabling meetings between clients and other stakeholders. The same applies to new industrial projects in the area; while they are important, it was difficult to estimate whether they would feed enough passengers to maintain a regular new transport route. In other words, while the focus groups viewed accessibility as one the main factors for business development in the region, they were unsure whether electric aviation would be the best way to support that.

Instead, tourism could be an important driver because even a relatively small decrease in price (estimated at 30-40 EUR cheaper for one trip) could be sufficient incentive for people to choose a new experience. The focus group discussed opportunities for experience tourism that electric aviation could make more accessible, such as short flights to view the Northern Lights or the summer White Nights. Current trends in travel could also favour electric aviation for reasons beyond those related to low emissions. Tourists are increasingly choosing to stay longer in one region in order to cut back on short-haul flights. Electric aviation connections could help them discover more of the wider region of northern Finland during the same stay.

Kuusamo is an important transport node for tourism, with several charter flights arriving there weekly. It could therefore also act as a significant transport node for electric aviation if charter flights were to feed passengers into smaller electric airplanes that would then serve other destinations. As Oulu is growing as an important node combining different transport modes, the possibility for a combination of train travel and electric aviation in the region might also be a potential future product. For example, there are currently too few trains arriving in Rovaniemi during the season when the leaves change colour in autumn (“ruska”) to transport all potential passengers, so such types of more targeted connections might serve the region well. However, given the current absence of such connections previously, it remains difficult to estimate how much they would be utilised. In short, the group anticipated that while new connections would represent new possibilities, the most important determining factors are price and travel time.

With respect to the connection between Kuusamo and Oulu, the group also noted that in some cases it would make more sense to increase rail traffic between Oulu and Kajaani, where a railroad exists, than to add an electric aviation route there. However, on other routes, the distances are long, so electric aviation could potentially decrease travel time. In other words, new transport routes have considerable potential to make travel links more flexible and smoother, but that fact is not enough to constitute a driver in land travel. That view applies foremost to the current situation, in which the initial investment costs are significant (especially for public actors), i.e. within a ten-year scenario, and such factors may change as the market develops.

Technological factors

Under technological factors, the group evaluated only the growing wind power production in Finland (especially Ostrobothnia) and the resulting surplus electricity. However, while the experts assumed that affordable electricity would be available for electric aviation as well, it was not viewed as a significant driver. Since operating electric aircraft is already less costly than operating conventional airplanes, that type of additional boost is not considered to be needed.

Concluding reflections

The group was more or less consistently sceptical about the future drivers for electric aviation. That was less due to the practical usability of electric airplanes than to several unanswered questions that need to be addressed before more detailed regional visions are possible. Such questions include identifying operators willing to make large investments during the cost-heavy initial phases of development or discovering new business models that would be able to find niches where electric aviation would not be in direct competition with traditional transport models (traditional aviation and railroads). Since so many market factors are currently "up in the air", a single driving force or operator may rapidly change the overall situation.

New strategic security shifts or cooperation arrangements, slower and broader trends in tourism or regular work travel flows between two cities in the Oulu-Kajaani-Kuusamo triangle, to name just a few examples, could potentially prove to be a driving force that might suddenly become significant. While regional stakeholders are waiting to see whether electric aviation will eventually impact the future development of their region, they can prepare themselves by investigating which new routes have the best prospects for future small-scale travel and by maintaining close cooperation with their colleagues in the broader Barents region. As the field is currently developing very fast, it is essential for the region to maintain openness to embracing potential new opportunities in practical and political terms.

Sweden. Skellefteå – Oulu

Skellefteå – Oulu	
Distance between the airports	215 km
Travel time by electric airplane	approx. 43 min

Table 4: Distance and travel time between the airports.

The northern regions of Sweden and Finland are currently undergoing a significant transformation, marked by substantial investments in green industries. Those regions, known for their vast territories, sparse populations, substantial industrial projects and workforce shortages, are experiencing a surge in activity. This presents both opportunities and challenges. Consequently, there is increased need for improved accessibility for companies, workers and residents, as well as well-established transport infrastructure to address that growing demand (Lapland Chamber of Commerce, 2023). Previous research has highlighted the increased need for and interest in electric aviation routes between the northern parts of Sweden and Finland. There are already cross-border collaborations, but as demand is expected to increase, more routes and transport options are needed. Electric aviation has been highlighted as a suitable transport mode for increasing access between the regions (Lundberg, 2022).

This case study explores a cross-border route between the northern parts of Sweden and Finland, namely the Skellefteå-Oulu route. That route would have a travel time of approximately 43 minutes by electric aircraft. In Sweden, several initiatives have been launched focusing on electric aviation (Ydersbond et al., 2020) and in Skellefteå work on testing and implementing electric aviation is already underway (Löfving et al., 2023). The case study will primarily focus on Sweden and the impact of electric aviation on regional development in Skellefteå, but Oulu will also be explored. Transport, infrastructure, administrative links and policies between the two locations will be taken into consideration and addressed when studying the route. Skellefteå and Oulu are separated by the Gulf of Bothnia. That gulf itself serves as a natural boundary between the two countries, with Sweden to the west and Finland to the east. There is no direct air travel route between Skellefteå and Oulu at the time of writing and there are few links connecting Skellefteå to the bordering side of Finland. Yet there is a desire to connect those two locations and increase cross-border connections for the purpose of regional development (Ericson, 2019), making it interesting to study such an electric aviation route more closely.

Regional context

Geography and demography

Skellefteå is a city and municipality in Västerbotten County, located on the east coast in northern Sweden. With a total area of around 9,944 km², Skellefteå municipality is the eighth largest municipality in Sweden in terms of area (SCB, 2023c). Between 1995 and 2015, the population trend was negative but then reversed and the population has been increasing in the 2020s. As at the end of 2022, Skellefteå had a population of 74,402 people (SCB, 2023a). Currently, a large green industrial transition is underway in parts of northern Sweden, with Skellefteå playing an important part in that. There is a need for the municipality to grow, especially in terms of new workers for the relevant industries (Skellefteå, 2022b; Skellefteå Works, n.d.). In Skellefteå, 81.5 percent of people live in urban areas and 18.5 percent of people live outside urban areas. Furthermore, 83.8 percent of people aged 20-64 are in employment, which exceeds the national average of 79.6 percent (SCB, 2023b). The unemployment rate in Skellefteå was 4.5 percent in 2022, which is among the lowest rates in Sweden and lower than the national average of 7.2 percent (Öhlund, 2022). Among the counties, the shortage of relevant skills is most pronounced in Västerbotten. As Västerbotten is also the county with the lowest level of unemployment, it is emphasising the need for inward migration to alleviate the shortage in the county (Arbetsförmedlingen, 2023).

Oulu is a town and municipality in the Northern Ostrobothnia region and is considered to be the centre of northern Finland. Oulu has total area of 3,880 km², with a population of about 212,000 people in the city of Oulu in 2023, making it the fifth most populous city in the country. Oulu is unilingually Finnish and is located beside the Gulf of Bothnia, approximately 600 kilometres north of the capital Helsinki (Info Finland, 2023b). Oulu has a balanced gender distribution and a fairly young population with the largest age group being that of 20-29-year-olds (about 35,000 people). Oulu has a labour force of 102,841 people, with an unemployment rate of 11.8% (Business Oulu, 2022).

Regional economy

Skellefteå is an industrial municipality, whose major industries are mining, wood, metals and minerals, battery production and green energy production. In 2017, it was announced that the company Northvolt had chosen Skellefteå as the location for its planned battery factory. Northvolt is estimated to need a workforce of some 2,500-3,000 people. The expansion means that more people will be needed in the public and service sectors as well including education and healthcare and the development will give a boost to shops, restaurants, hotels, transport companies, construction work etc. That requires increased commuting from the local area and migration both nationally and internationally (Skellefteå, 2021). Skellefteå's economy is based on a

large private sector and industry accounts for a large share of the labour market in Skellefteå (Skellefteå, 2019, 2022c).

Oulu is known as a city of technology and a major hub in the field of high technology, specifically in IT and wellness technology and for telecommunications companies. Oulu is the leader in the IT/business sector in Finland and a frontrunner in the new technology and innovation sectors. Oulu is also making strides in the field of renewable energy and is involved in research and development related to sustainable energy sources, including wind energy and bioenergy. Oulu is also home to traditional industries, such as steel, paper and wood refining (Business Oulu, 2022; Oulu, n.d.).

Transport infrastructure

With a port, airport and bus stations, there are several transport options in Skellefteå. However, Skellefteå is the largest city in Sweden without passenger rail services. There is no direct train to Skellefteå. Passengers taking the train must currently change to a bus in a neighbouring municipality. However, there is a project focused on expanding the railway network in northern Sweden. The North Bothnia Line (*Norrbotniabanan*), a new railway between Umeå and Luleå (running through Skellefteå), will connect the cities along the coast of northern Sweden, enabling faster, safer and more environmentally-friendly travel and transport. Work on the North Bothnia Line is ongoing but is delayed, with the last segment of the route expected to be completed by 2030 (Trafikverket, 2022).

The Skellefteå region is in a phase of expansion, involving numerous investment projects and a strong need for good connections, including an expansion in both domestic and international air traffic (Skellefteå, n.d.). Skellefteå Airport is Västerbotten's second largest airport and is strategically located between Luleå and Umeå. The airport is owned by Skellefteå municipality and has about 300,000 passengers per year (Skellefteå Airport, n.d.). Skellefteå's location between Luleå and Umeå (i.e. between two of Norrland's largest cities) both helps and hinders the airport. The passenger base for flights to destinations that can be flown to from both Luleå and Umeå – in particular Stockholm – is shrinking. That is because the airports in Umeå and Luleå often offer a better flight schedule with more airlines and thus more flights. However, with competitive prices and better timetables, Skellefteå Airport can capture a much larger passenger market that extends geographically from Luleå to Umeå (Ericson, 2018).

Routes served to and from Skellefteå Airport include both international and national ones. There is a wish to improve connections to Finland and especially to the area on the other side of the Baltic Sea from Skellefteå. See Figure 4 for an overview of the transport infrastructure in the selected Swedish and Finnish regions. In 2018, the business community in Skellefteå was already working to try to establish both a passenger and freight route to Finland. The plans were not carried out at the time, but an air traffic route from Skellefteå to Finland is part of the vision for Skellefteå's

business community (Ericson, 2019). Northvolt's battery production in Skellefteå, for example, will create the need for both Finnish supply of materials and workforce in the near future (Lundberg, 2022). The FAIR programme investigated current air traffic patterns and connections in the northern parts of Sweden, Finland and Norway (Smedberg et al., 2022). Currently, the most common travel mode between the two destinations is by car, with an approximate road distance of 382 km, taking just under 4.5 hours (Rome2Rio, n.d.).

Oulu serves as a regional transport hub with several means of transport. The railway station is one of the busiest in Finland with railway connections to destinations throughout Finland. Several regional and long-distance buses operate and all main roads/highways meet in Oulu (Info Finland, 2023b). Oulu Airport is an international airport and the second busiest airport in Finland. In 2022, around 630,000 passengers passed through the airport (Degerman, 2023a). The airport is especially important for businesses purposes, as Oulu serves as a city of technology and university city (Finavia, 2023). There is a great demand for accessibility for companies, employees and residents and a functioning electric flight network can help meet some of that demand. Investments in cross-border flight routes could promote the movement of people and investments between the two regions (Lapland Chamber of Commerce, 2023).

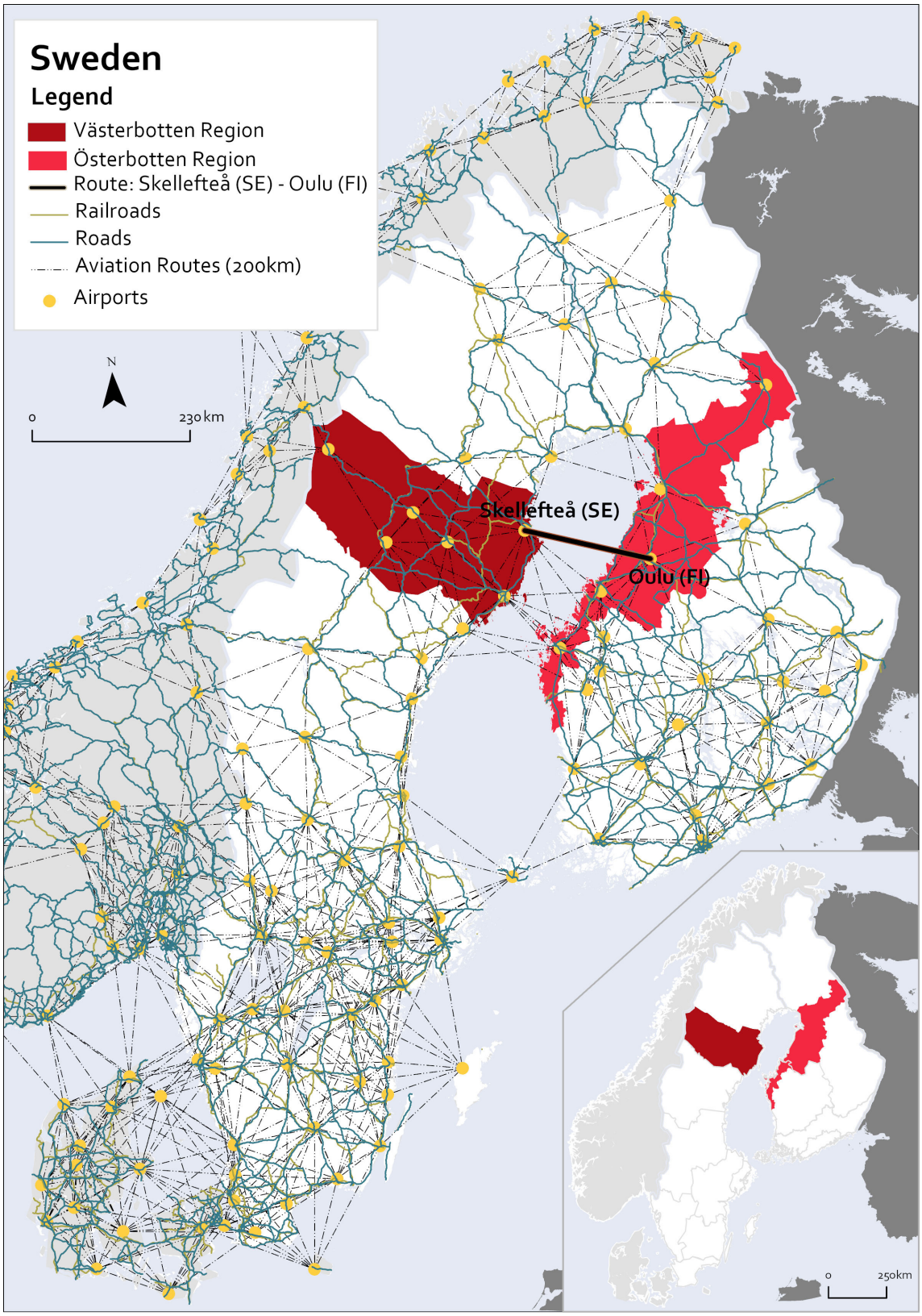


Figure 4: Swedish route and regional transport infrastructure

Source: Nordregio

Accessibility of care facilities, education, work and other public services

Skellefteå faces challenges related to accessibility of public services, an issue that is expected to become more pressing as the population grows. Skellefteå is a vast municipality with major infrastructure needs. The low population density makes access to public services difficult for some of the population living outside central hubs (Skellefteå, 2022a). With more people, the need for health, social and elderly care will also increase (Skellefteå, 2022c). There is one hospital in Skellefteå, "Skellefteå Lasarett", which is one of Västerbotten county's three emergency hospitals (Region Västerbotten, 2022). The level of education in Skellefteå is low compared to the rest of Sweden. Skellefteå is not home to a university, but Campus Skellefteå offers educational resources from Luleå University of Technology and Umeå University (Skellefteå, 2023).

Oulu offers a diverse range of education, from early basic education to university level. The higher education sector is strong given the presence of the University of Oulu and the Oulu University of Applied Sciences. (Oulu, n.d.). Oulu belongs to the health and welfare region of North Ostrobothnia (Pohde) and offers basic and high-tech healthcare opportunities. There are health centres throughout Oulu and Oulu University hospital is an innovative hospital focused on research and development (Info Finland, 2023a).

Regional policies and initiatives relevant to electric aviation

Over the past years, Skellefteå has drawn up new regional policies and strategies and launched initiatives aimed at making the municipality grow. Those strategies also cover sustainable transport, noting that Skellefteå will be a proactive hub for sustainable air traffic, an innovative leader in sustainable air traffic and a test bed for the aviation of the future (Skellefteå, 2022a). Skellefteå, together with Skellefteå Airport, has several ongoing initiatives for sustainable aircraft. One development is establishment of the "Green Flight Academy" at Skellefteå Airport, which began operating in 2022. It is a flight school initiative that will develop a climate-smart educational platform, with a large part of the training using electric aircraft charged with green electricity (Ericson, 2021a).

An initiative was launched in 2020 to make Skellefteå Airport capable of accommodating electric airplanes. Skellefteå Airport and Skellefteå Kraft (the local energy company) are responsible for the initiative, which is aimed at Skellefteå becoming a test bed for electric aviation and taking the first steps towards commercial electric aviation. That includes test activities such as take-off, landing and charging in a realistic context (Ericson, 2020, 2021b). In 2020, an investment was made to enable the charging of electric airplanes at Skellefteå Airport and in 2021 the charging structure was in place. The charging station enables 1 MW of available power for electric aviation, which is enough to fast-charge several small electric airplanes simultaneously. Part of the development of the charging structure stems

from the ELIS (*Elektrifierad Luftfart i Skellefteå)* development scheme, which aims to accelerate the commercialisation of electric aviation. ELIS is a collaboration between Skellefteå Airport, Skellefteå Kraft, Northvolt, Skellefteå Science City and EIT InnoEnergy. Skellefteå was seen as an optimal site for the initiative, as the region has a) an airport with available space b) Skellefteå Kraft, which is engaged in research into and production of renewable electricity, development and production of renewable electricity c) Northvolt with access to battery development and solutions for energy storage and d) climate-smart flight training through the Green Flight Academy (Skellefteå Airport, 2021).

One key theme in Northern Ostrobothnia's climate roadmap 2021-2030 "Towards a carbon neutral Northern Ostrobothnia" is low-emission transport. Strategies to strengthen the shift to low-emission means of transport and renewable fuels are underway (Pohjois-Pohjanmaa, 2021). Oulu Airport forms part of the Finavia airport network. Finavia has several policies and initiatives for sustainable air traffic, with the overall aim being for all of Finavia's carbon-neutral airports to reach net zero emissions in 2025. Finavia is a member of the Network for Electric Aviation (NEA) in the Nordic region and is involved in funding of the first electric aircraft in Finland (Finavia, 2022). Furthermore, the University of Oulu is also involved in research on innovation in aviation and electric and hydrogen-powered aircraft. The initiative called ALBATROS is an EU-funded research project by Horizon Europe that aims to develop a dependable model to assess and mitigate potential hazards to aviation. One section of the research focuses on the risks related to electric and hybrid-powered aviation, studying side effects on safety and survivability, as well as new airport energy systems (University of Oulu, 2023).

Energy infrastructure

In northern Sweden, the electric grid is extensive, with a high stability and consumption coverage rate and high power adequacy (Nordic Energy Research, 2023). Skellefteå Kraft is one Sweden's five largest electricity producers, producing wind and hydro power, heat and bioenergy. Its operations span large-scale power generation, electricity networks, charging infrastructure, district heating, broadband and solar energy. Recently, the Blaiken wind farm was inaugurated, whose 99 wind turbines will make it one of the largest wind farms in Europe. The goal is for its own energy production to be 100% sustainable and there is also interest in energy storage and investments in charging infrastructure (Skellefteå Kraft, n.d.). Skellefteå Airport is located close to one of the transmission projects under "*Fossilfritt övre Norrland*" (FÖN), an investment programme implemented by Svenska Kraftnät. The FÖN project works to develop power grids to electrify industries in northern Sweden. With proximity to one of the transmission projects, it extends the 400 kV transmission grid (Nordic Energy Research, 2023; Svenska Kraftnät, 2022).

In general, Finland has a strong main electric grid. Northern Ostrobothnia is a region of renewable and low-emission energy and is engaged in the development of new

energy sources (Nordic Energy Research, 2023). In fact, Northern Ostrobothnia is Finland's leading wind power producer, producing approximately 40% of the country's total wind power (Pohjois-Pohjanmaa, 2021). Oulu has surplus power production and a high share of wind power production due to the establishment of several wind parks. Wind farms throughout Oulu harness wind power for electricity generation. Solar energy adoption has also been increasing in Oulu but is not seen as important due to the rather low share of sunlight in given periods (Fingrid, 2022). The University of Oulu also focuses on research and innovation in the field of renewable energy technologies and solutions (University of Oulu, n.d.).

Ten-year scenario for electric aviation

The focus group

The focus group discussion was conducted online in September 2023 via Teams. The session lasted approximately 90 minutes and six participants attended. The focus group was mainly composed of regional experts from Skellefteå, representing both the perspectives of the local electric aviation projects and of local business and social development. Skellefteå has several initiatives focusing on electric aviation, so those experts provided knowledge of driving forces and barriers to future implementation. The stakeholders in the field of municipal development provided input on the potential impacts and effects electric aviation could have. Input from the perspective of Oulu was provided by this project's Finnish focus group.

Key driving forces for implementing electric aviation on the Skellefteå-Oulu route

Political and environmental factors

Political factors and environmental factors were often discussed together and were viewed as interlinking factors due to EU, national and regional climate goals of lowering emissions. Environmental reasons and the lowering of emissions were highlighted as the starting point for electric aviation being attractive and needed in the first place. In other words, climate goals – which are also political – are perceived as a vital driver for electric aviation. Both Skellefteå and Oulu have good access to green electricity in their respective regions, which is also an important environmental factor. It was noted that it is important to take into account the fact that there is no existing route between Skellefteå and Oulu when evaluating environmental aspects. The electric aviation route would establish a new, low-emission transport mode rather than replacing a higher-emission one.

The group agreed that political commitment is a key aspect with regard to future implementation of electric aviation. The view taken was that market forces alone are not sufficient, meaning that strong incentives are needed. There is currently strong

political support in Skellefteå for electric aviation and the group expected that commitment to remain robust. However, the high political ambition at the municipality level may not accord with the political ambition at the national level. It was noted that strong political ambition at the national level is important to create strong incentives for future implementation. It was considered important to note that this is one of several transport modes and other transport modes also need attention and development efforts.

There is political and commercial will to connect Skellefteå with northern Finland, but it was mentioned that cities other than Oulu could be more suitable. The connection to Finland was deemed important, but not to Oulu specifically, and the group reflected that it could be more useful to establish electric aviation routes to connect with smaller regions/destinations within Sweden instead.

The Swedish-Finnish cross-border route scenario brought with it some concerns, as different political factors are in place in the two countries, which could complicate the implementation of electric aviation. The political situation, driving forces, will and ambitions may differ between Skellefteå and Oulu and during a ten-year time frame the two countries may choose to approach electric aviation differently.

Economic factors

Under economic factors, the focus group's discussions centred on economic incentives, demand for labour and skills, business opportunities and reputation. Just as with political commitment, economic incentives were deemed to be highly relevant to the future implementation of electric aviation. Economic incentives from the government were seen as important to incentivise implementation, as the market will be uncertain during the initial years. Electric aviation will need large initial investments and it unsure when there will be a return on investment, with the possibility of economic losses in the initial phase.

Skellefteå needs to attract both skilled and unskilled workers for industrial investments and the related societal developments. The group noted that the relevance of this factor to electric aviation is fairly low. It was not seen as a key driving force for electric aviation as it was thought that electric aviation would be implemented regardless. Having a new transport route, with regular flights and reasonable prices, is an attractive factor for workers, who might be able to commute more readily and frequently. Yet some challenges were mentioned concerning the route. One concerned the language barrier, with Skellefteå being unilingually Swedish and Oulu being unilingually Finnish. In Skellefteå, it is beneficial to speak Swedish for numerous jobs in the public sector, such as in healthcare, care for the elderly and kindergartens. Oulu is unilingually Finnish speaking, meaning that it would be difficult to "solve" the issue of labour shortages by using Finnish labour in workplaces where Swedish is the working language rather than English and vice-versa. The group was of the view that an electric aviation transport route within northern Sweden would probably have a larger effect on the labour demand issue.

The group perceived more opportunities in the case of labour supply to industries where English may be the working language. Oulu is a university city with several businesses in the tech, energy and battery sectors, with a high-skilled labour force that could be attractive to the industries in Skellefteå. From the perspective of Oulu, the Finnish focus group noted that while a connection between Oulu-Skellefteå could naturally pose a potential threat to the Oulu region due to high-skilled workers leaving for Skellefteå, it was still smarter to think about development and cooperation in a wider context and more beneficial to focus on how a wider region may benefit than on individual cities. The group also noted that it is unlikely that the first aircraft will carry cargo as well, meaning that cargo will still need to be carried by land.

Furthermore, the group expressed the view that electric aviation could open up new business connections by enabling face-to-face meetings, with the potential to link to businesses in Oulu. However, that was not identified as a driving force for the future implementation of electric aviation, but rather as a positive outcome of it. Cooperation is facilitated by more efficient means of transport. Regional businesses and green industry projects could benefit from an electric aviation route as it would enable meetings between clients and other potential stakeholders, such as industry experts or researchers. The smaller size of the aircraft would be sufficient for that purpose. However, whether there are enough passenger demand to support the route was a concern raised by the focus group. From Oulu's perspective (contributed by the Finnish focus group), it was noted that the Finnish market for air taxis is small and it is uncertain whether there would be enough regular passengers between Oulu and Skellefteå. Hence, the route should be researched and marketed carefully.

Social factors

Social factors included the social acceptance of electric aviation, and the role electric aviation could play in accessibility of services, as well as geographical distances and alternative transport modes. In a scenario where electric aviation is a common transport mode, social acceptance and trust are key. Social acceptance was seen as a factor that will not affect the future implementation of electric aviation, but rather as a factor affecting the future utilisation of it. Passengers need to trust the solution and electric aircraft need to be seen as a travel mode that is "safe enough". If most of the population are sceptical, who will fly? Electric aviation needs a period for it to become established, i.e. to be promoted and for trust to be built in it as a safe alternative. It was mentioned that Skellefteå is already working on that issue and has strategies in place to promote and advertise electric aviation and to inform the public about its use and safety. Furthermore, it was noted that most people already understand the benefits of electric aviation, but changing habits and establishing trust takes time, which is why Skellefteå is already making efforts geared towards the future commercialisation of electric aircraft.

In addition, it was noted that the population of Skellefteå and northern Sweden in general are to a large extent used to relying on cars and the "freedom" of transport

associated with driving, which could also affect the utilisation of electric aviation. There is a habit of taking the car; the choice between flying and driving depends on the reason for the trip and whether the traveller needs a car at the destination they are traveling to. If electric aviation provides for reduced travel times, cheaper tickets, a good flight schedule with frequent and attractive flights and an easy boarding process (seamless and fast check-in, security screening etc.), then flying could be an attractive choice for the population in the future.

From Oulu's perspective, it was noted that the Oulu-Skellefteå route had largely not been discussed, as the two places were generally perceived as being too far apart. However, electric aviation could change that perception and perhaps open up new connections. Utilising electric aviation for routes across water, such as the Gulf of Bothnia, is currently seen as the most sensible use for it. However, train connections are viewed as more important in several transport plans in the area. In general, Oulu viewed the whole Swedish coast as having considerable potential for new routes and Skellefteå as being an interesting possibility, but perceived Luleå as a more logical point of contact as it is a more active transport node with more routes onto other destinations from there.

Regarding the accessibility of services, the group deemed that this factor was not likely to be a driving force for electric aviation. Furthermore, discussions centred on the point that the cross-border route would not be likely to provide benefits in this regard, since patients needing access to medical care would tend to be flown to a hospital within the country rather than to another country.

Technological and legal factors

Under technological factors, the group noted that Skellefteå strives to be and has already begun working on becoming a test bed for electric aviation. That was not seen as a driving force per se, but the infrastructure, technology and initiatives already in place serve as enabling factors for the future implementation of electric aviation.

Technological factors were described as seldom being driving forces but it was noted that they may be vital prolonging forces. Regarding electric aircraft, the focus is on developing and continuing to improve the battery technology. While it is improving, energy density remains a limiting factor for electric aircraft. Furthermore, the right kind of infrastructure at airports is needed. The necessary infrastructure for electric aviation is already present or under construction in Skellefteå. The airport infrastructure, namely the runway and the charging grid, has been updated. Skellefteå is in a phase in which action and practical testing are more necessary and valuable than further research. It is not sufficient for one airport to have all the technological factors in place, i.e. the charging grid, infrastructure, runway, routines etc.; the issue is that the destination airport also needs to have adequate technological factors and infrastructure in place. That is true whether the route is cross-border or domestic, but different countries may have different regulations and ambitions regarding electric aviation. It is therefore not possible to expand faster

than the infrastructure available to support electric aircraft. There are still some technical issues to be resolved and tested, such as finding a solution to how to remove ice on the aircraft wings during flights a problem that has been solved for fossil-fuel aircraft and more knowledge of the impact of ice and snow on electric aircraft is needed.

It was mentioned that Skellefteå, with its geographical location, harsh winters, considerable snow and low temperatures, is a good location for a test bed for electric aviation. Electric aircraft may be more vulnerable to certain weather conditions, such as extreme cold, which may affect battery performance. Testing electric aircraft under perfect weather and climate conditions can only provide limited input into electric aviation operations. Instead, testing electric aircraft under the "worst" conditions can provide much more input for future work on developing electric aircraft. A cold climate has an impact on batteries, so the cold weather in the Nordic region makes it an optimal place to pioneer electric aviation technology. Developing and testing electric aircraft there and ensuring that the technology works in those weather conditions will make it easier to export it elsewhere.

Under technological factors, legal aspects also arose during the discussion. Legislation, regulations and certification processes for new technologies were not discussed as a driving force per se but as having the potential to be both enabling and prolonging factors. For electric aircraft to operate commercially, they must be deemed highly safe and the institutions/authorities in charge need to be able to guarantee that. Certification may thus be strict, as certifying electric aircraft for commercial use on international routes requires comprehensive testing and validation to ensure safety and reliability. Air safety regulations, legislation and certification processes are decided at a high level (EU or national government) rather than by the local level on its own. Accordingly, these are key factors that will affect the future implementation of electric aviation. During the ten-year scenario, there will be a need for authorisations and legislative factors that promote electric aviation, rather than prevent it, while all safety regulations are upheld and guaranteed.

Concluding reflections

There is strong support for electric aviation in Skellefteå and several projects have been launched with the aim of establishing Skellefteå as a testbed for the future implementation and utilisation of electric aviation. Yet for electric aviation to become reality and used commercially within the next ten years, several enabling factors need to be enhanced and other inhibiting factors need to be addressed. During work on the case study, several key elements to consider in a ten-year scenario implementation arose. Electric aviation can be considered a positive opportunity that can be used to increase accessibility, both for people and businesses, and that can offer an environmentally-friendly and efficient mode of travel that overcomes mountains and seas. However, it is important to understand

that political commitment and issues of regulations and financing are important preconditions for early implementation that need to be considered closely.

A route over water, connecting the northern parts of Sweden and Finland, was viewed as attractive in the future. The question of the most beneficial cross-border route needs to be researched closely and the market needs to be studied. However, cross-border routes in the initial phase of electric aviation present certain specific challenges due to the evolving nature of electric aircraft technology and the complex regulatory and logistical issues associated with international air travel. Electric aircraft require airports that have been upgraded, with infrastructure suitable to the new type of aircraft. Establishing a reliable and standardised charging infrastructure network for electric aircraft at airports on both sides of the border is vital. However, there are no guarantees that the two countries will choose to approach electric aviation in the same way or in the same time frame and the level of ambition may vary.

Creation of an electric aviation network hub in northern Sweden was seen as beneficial to regional development. In the initial phase, electric aviation is suitable for shorter flights and the aircraft have a limited amount of passenger seats. Establishing a route connecting airports in northern Sweden within the range limitations can connect smaller/rural settlements with the larger cities in the north. Implementation of electric aviation could have positive impacts especially on cooperation and accessibility within the region of northern Sweden. All airports still need to have the necessary infrastructural upgrades, but the point was raised that it might be easier to streamline such work in the context of a domestic route, rather than a cross-border one.

Iceland. Akureyri – Reykjavik

Akureyri – Reykjavík	
Distance between the airports	250 km
Travel time by electric airplane	approx. 50 min

Table 5: Distance and travel time between the airports.

Introduction

The Akureyri-Reykjavík flight route is the most popular domestic route as it has the highest passenger numbers of all domestic flight routes (Isavia, 2022) and is therefore an interesting case study to examine. The estimated travel time by electric aircraft would be approximately 50 minutes. Flights on this route are currently operated by Icelandair. As highlighted in the report *Electric Aviation Outlook in the Nordics* (Löfving et al., 2023), Icelandair announced in 2022 that the company will support the development of a 30-seat electric airplane by Heart Aerospace to use for passenger transport in 2028. Electric aviation is therefore likely to be introduced on this domestic route within the next ten years. The route is important for access to services, including health services, and for business travel. Additionally, very few international routes are operated from Akureyri Airport so many people need to fly to Reykjavík in order to travel abroad.

Geography and demography

Akureyri is a town located in the north of Iceland. It has an area of 138 square kilometres and lies just 100 kilometres from the Arctic Circle (Guide to Iceland, n.d.). It is situated about 390 kilometres north of the capital city Reykjavík and it takes about five hours to drive between the two places. There are regular bus services between Reykjavík and Akureyri, with the route taking about six hours (Visit Akureyri, n.d.). The route includes three mountain passes and may be closed in the event of severe weather warnings and snowfall. Over the years, there have been discussions about shortening the route between Akureyri and Reykjavík and there has been support for some initiatives. For instance, a report by the University of Akureyri Research Centre in 2022 (Dagsdóttir, 2022) found that 66% of survey participants thought it was important to shorten the route by 15 kilometres around the town of Blönduós. There is therefore a possibility that the route will be shortened, which could mean increased competition between driving and flying. Furthermore, it has

historically been more expensive to drive between the two locations due to the high cost of petrol. However, with the introduction of electric cars and relatively inexpensive electricity prices in Iceland, it has become cheaper to drive than before (if driving an electric car).

Iceland is unique in that, despite having a population density of just four people for each square kilometre (World Bank, n.d.), 63% of the population – which totals just under 400,000 – lives in the greater Reykjavík region (the capital region), corresponding to approximately 243,000 people (Statistics Iceland, 2023). Some 80% of the island's population lives within the functional urban area of Reykjavík[5] (Ministry of Transport and Local Government, 2021). Akureyri is Iceland's second largest urban area (Guide to Iceland, n.d.), with a population of 20,000 as at 1 January 2023 (Statistics Iceland, 2023). There has been a steady increase in the population, with a 29% increase in the total population of Akureyri between 2000 and 2023 (Byggðastofnun, n.d.).

The average age of the population of Akureyri municipality is 38.5 years. That is only slightly higher than the Reykjavík average age, which is 38.0 years (Byggðastofnun, n.d.). In Akureyri, men account for 50.3% of inhabitants, while women account for 49.7% and other account for 0% (Byggðastofnun, n.d.). The demography of Reykjavík is similar with 51.2% men, 48.7% women and 0.1% non-binary/other. According to data from the Directorate of Labour (n.d.), the unemployment rate in Akureyri was 2.9% in 2022, compared with 4.2% in Reykjavík.

The average wage income in Akureyri was approximately 7% lower than the national figure in 2021 and was approximately 6% lower than in Reykjavík (Statistics Iceland, n.d.).

It is difficult to estimate housing prices in Akureyri in comparison with housing prices in Reykjavík. However, in 2019 Landsbankinn Bank estimated that housing prices in Akureyri were at 75% of the prices in the capital region (Sturludóttir, 2019).

Regional economy

Akureyri is the main service hub for the north of Iceland, so accessibility of the municipality is important. Historically, Akureyri has had a large fishing industry with an important port and some of the biggest Icelandic fishing companies, including Samherji, are based there (Guide to Iceland, n.d.). Strong economic sectors in northeast Iceland, where Akureyri is the most populous town, include primary materials processing, tourism and public sector jobs (SSNE, 2021). Furthermore, higher education has become a fast-growing economic sector, alongside services, in the last few years. Akureyri Hospital (SAk) is also a large employer (Guide to Iceland, n.d.).

5. Within approx. one-hour driving distance.

Transport infrastructure

Icelandair is currently the only airline to operate flights between Akureyri Airport and Reykjavík Airport. Based on information from Icelandair's booking machine, there are currently three to five flights from Akureyri to Reykjavík on weekdays, three flights on Saturdays and four flights on Sundays. The flight time is estimated to be 45 minutes.

As shown in Figure 5, the number of passengers on the Akureyri-Reykjavík flight route in 2022 was 163,586 (Isavia, 2022). The number of passengers was even higher prior to the Covid-19 pandemic at 168,212 in 2019 and 190,621 in 2018 (Isavia, 2022).

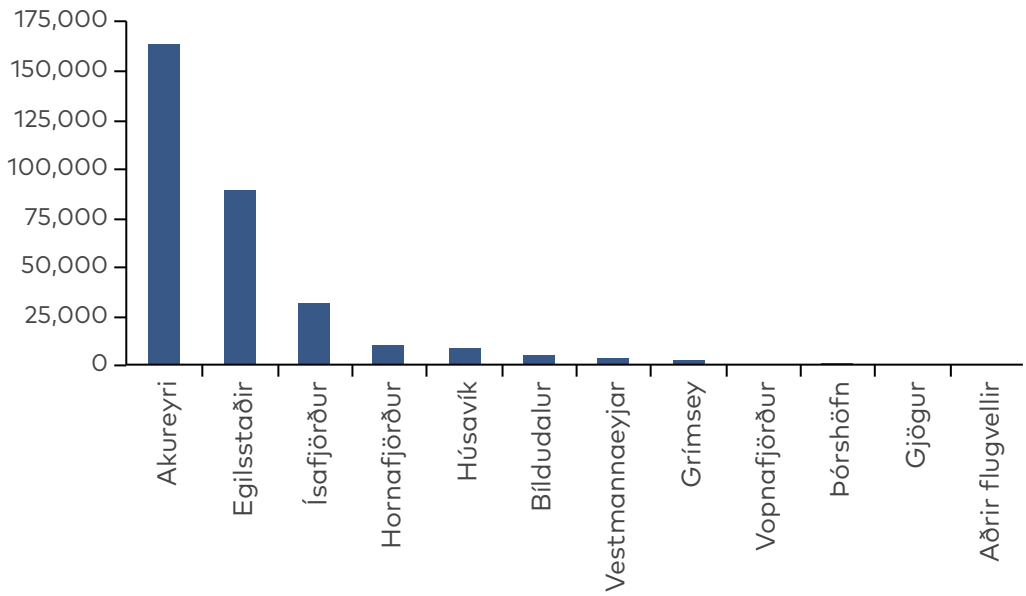


Figure 5: The number of passengers on domestic flights in 2022.
Source: Isavia, 2022

One point to consider in this case study, since it covers the next decade, is that discussions around relocating Reykjavík Airport have been ongoing for over six decades. The latest update is that the airport will remain in its current location until the year 2032 or until a new and suitable location has been found. While the City of Reykjavík is emphasising that the airport should be relocated (City of Reykjavík Department of Environment and Planning, 2022), that will not take place until another option is ready and the Minister of Infrastructure has maintained that the airport will not stop operating for some decades. (Kjarnans, 2020). If the airport were to be relocated, that might impact electric aviation as the domestic airport is currently in the centre of the city and is therefore located conveniently close to services such as the national hospital.

Akureyri Airport opened in 1954 and serves both domestic and international flights (Isavia, n.d.). The airport is 2,400 m long (Isavia, 2023). Its facilities have been under construction and, after some delays, it is anticipated that a new terminal will be ready in May 2024 (Ólafsson, 2023).

The Northeast Iceland Development Strategy 2020-2024 highlights inefficient basic services on the national roads as a threat to employment development and innovation in the region. It also points to distorted competitive conditions with regards to transport. Furthermore, the strategy mentions that the uncertainty regarding Reykjavík Airport and domestic flights is a further threat to employment development and innovation (SSNE, 2021).

There is only one currently scheduled direct flight from Akureyri Airport to a destination abroad, namely the Akureyri to London Gatwick route operated by EasyJet, which will be a scheduled service from 31 October through March 2024 (Níelsson, 2023). Previously a local airline, Niceair, had launched in summer 2022 but it filed for bankruptcy in May 2023 (Ásgeirsson, 2023). The main reason given for the bankruptcy was that Niceair lost access to the sole aircraft in its fleet and was therefore unable to continue its operations (Ritstjórn, 2023). The experience of Niceair nevertheless demonstrated that there was a market for regular direct international flights from Akureyri. EasyJet restarting international flights from Akureyri could therefore decrease demand for domestic flights to Reykjavík for people based in northern Iceland travelling abroad from Keflavik Airport. When the Northeast Iceland Development Strategy was formulated, Niceair had not begun operating and the lack of direct flights to destinations abroad from the region was noted among the weaknesses in terms of job development and innovation. An overview of the transport infrastructure in Iceland is illustrated in Figure 6.

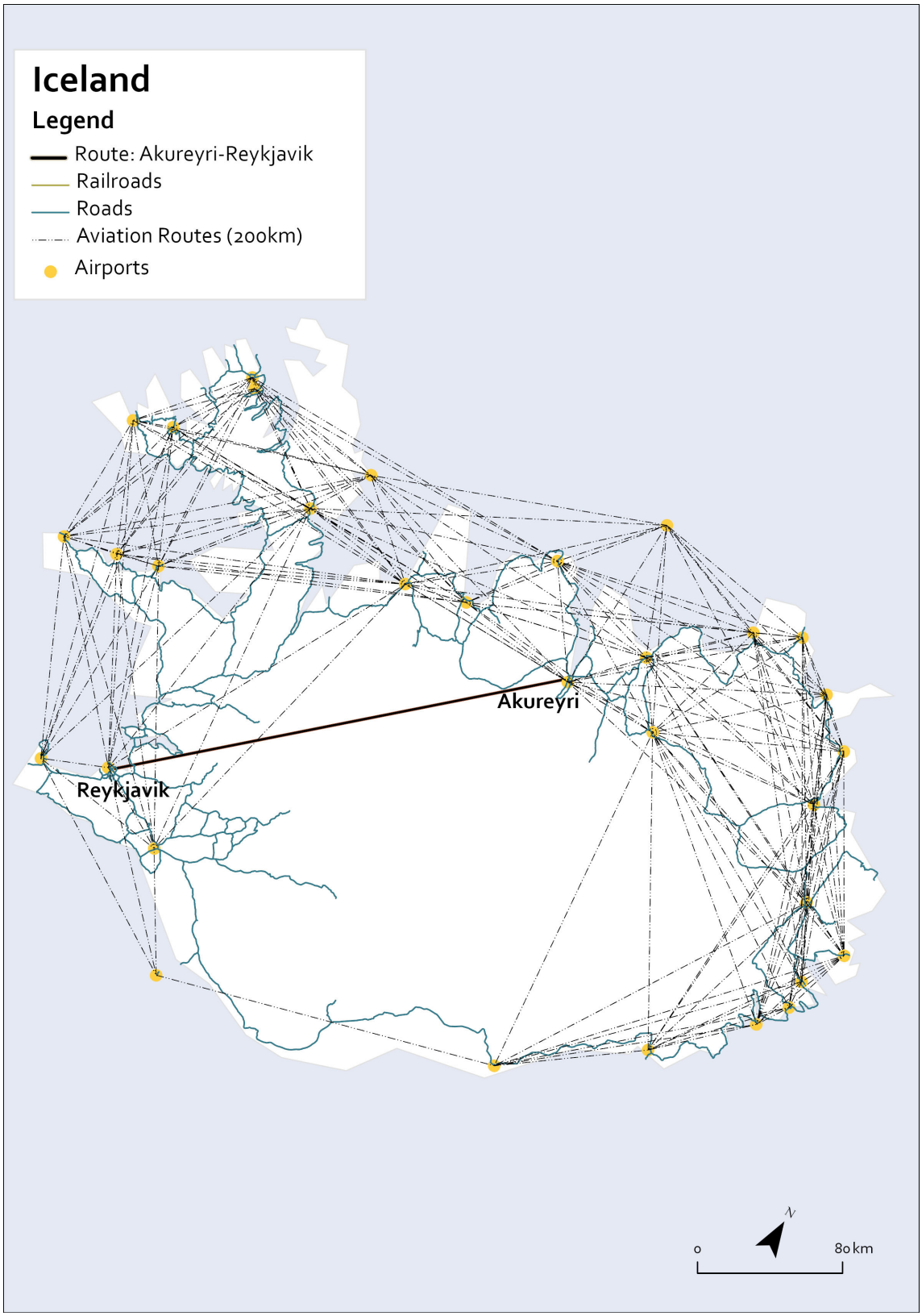


Figure 6: Icelandic route and regional transport infrastructure
Source: Nordregio

Accessibility of care facilities, education, work and other public services

Public services are concentrated in Reykjavík and its service role for all of Iceland has become progressively stronger. Public administration and, accordingly, the majority of government institutions are based in Reykjavík. The Parliament, ministries and most institutes are located there, for instance. Furthermore, all institutes of national interest with regards to culture and recreational services, for example, are located in the capital region (Jóhannesson, 2015). Nevertheless, as Akureyri is the largest town outside the capital region, its inhabitants are more privileged in terms of access to services of general interest than inhabitants in other sparsely populated regions of Iceland (Jóhannesson, 2015).

There main hospitals in the country are located in Reykjavík in Akureyri (Jóhannesson, 2015). Three universities in Iceland are based in Reykjavík, including two of the largest universities, namely the University of Iceland and the University of Reykjavík, as well as the only arts university in the country.

Akureyri is a regional centre in the northeastern area. Its hospital, for instance, has a catchment of roughly 45,000 people and also acts as the primary reserve hospital for the national hospital, Landspítali, in times of health-related crises (Editorial Team & Waller, 2020). The hospital had 960 employees in 2021 (Akureyri Hospital, 2022) and provides general and specialised healthcare. There is an emphasis on emergency services and vital specialist treatments (Ísland.is, n.d.a). In 2021 there were 111 beds at the hospital and 16,019 emergency admissions. A total of 491 children were born at the hospital in 2021 (Akureyri Hospital, 2022).

There is a primary healthcare centre in Akureyri called the Akureyri Health Clinic (Akureyri Municipality, 2023) as well as a number of dentist practices. Access to healthcare facilities in Akureyri is therefore relatively good. If a person living in Akureyri needs to seek health services in Reykjavík on the basis of a doctor's recommendation, that person can apply for reimbursement from Iceland Health for the domestic travel costs (Ísland.is, n.d.b).

There are several educational facilities in Akureyri. The municipality of Akureyri runs nine kindergartens in 12 locations and also supports one private kindergarten for children under the age of six (Akureyri Municipality, 2022c). There are ten primary schools (Akureyri Municipality, 2022b) and two secondary schools (Menntamálastofnun, n.d.).

Furthermore, Akureyri is home to the largest university outside of the capital region, the University of Akureyri. In additional, many companies have offices in Akureyri.

Nevertheless, the inhabitants of areas outside the capital region need to travel regularly to Reykjavík and its nearby towns to access services, such as specialist doctors and even regular services such as eye doctors etc. The Icelandic government therefore subsidises routes of regional airports for passengers for whom it takes more than 3.5 hours to reach necessary governmental services by public transport and where there is no air transport due to market failure (Althingi, n.d.).

Furthermore, on 1 September 2020 the government introduced a new flight discount on domestic flights, providing inhabitants living at least 270 kilometres from the capital region with a discount of 40 percent on domestic flights. The discount could be applied to up to six flight legs (3 round trips) per year starting on 1 January 2021 (Jóhannsson, 2020).

Regional policies and initiatives relevant to electric aviation

A policy on strengthening Akureyri as a regional urban centre for north and east Iceland has been developed (Ministry of Transport and Local Government, 2021).

Akureyri municipality belongs to the Association of Municipalities in Northeast Iceland, which has set out its objectives and priorities in the Northeast Iceland Development Strategy 2020-2024. The strategy highlights the electrification of domestic flights as an opportunity (SSNE, 2021). Additionally, one of the goals of the strategy is to enhance the region's infrastructure, including by ensuring provision of the amount and quality of electricity required (SSNE, 2021).

Akureyri municipality has an environmental and climate policy which is in effect from 2022 to 2030. The main objective of the policy is to reduce emissions of greenhouse gases by changing travel habits and increasing the use of domestic energy, as well as by decreasing waste and increasing recycling (Akureyri Municipality, 2022a). Akureyri municipality is one of three municipalities in Iceland that are members of the Global Covenant of Mayors for Climate & Energy (GCoM), which is a joint statement by a number of city and town mayors around the world on reducing greenhouse gas emissions, strengthening resilience to climate change, publishing statistical information on climate performance and setting targets for even better performance. By participating, the municipalities want to demonstrate that local actions can have a significant impact on a global scale. The policy includes an emphasis on the energy transition of cars in the municipality and electrification of the harbour. The municipality is also aiming to increase the use of eco-friendly energy sources produced in the municipality such as methane, biodiesel and electricity (Akureyri Municipality, 2022a).

Energy infrastructure

The Northeast Iceland Development Strategy 2020-2024 notes that the electricity transmission system in the northeast is a weakness for job development. One of the goals under the strategy is to enhance the region's infrastructure, including by ensuring provision of the amount and quality of electricity required (SSNE, 2021). The main transmission grid in Iceland is being renewed. Access to electricity in Akureyri is very good with two new and upgraded transmission lines set to power stations in northeast and east Iceland. There will be further improvement in the next few years with three new transmission lines between Akureyri and the capital region (Landsnet, 2023).

Ten-year scenario for electric aviation

The focus group

A focus group discussion was conducted in person on 14 September 2023 at Akureyri Airport. It was attended by seven participants, as well as two researchers from the University of Akureyri Research Centre. The participants in the focus group included a high-level expert in healthcare services from the hospital in Akureyri, a high-level representative from Regional Airports Iceland, airport managers from Reykjavik Airport and Akureyri Airport, a project manager for tourism in Akureyri municipality, a high-level expert from the company "Vistorka" and finally an expert in electric aviation.

Key driving forces:

Political factors

The focus group viewed the electrification of domestic flights as an opportunity and believed that there is a high chance overall that it will become reality. According to the focus group, implementation of electric aviation is tied closely to a possible political decision to reduce imports of energy and begin providing the country with domestically generated electricity. However, that requires considerable political support for infrastructure expansion and one participant noted that there is currently no funding for electric aviation in the government's transport plans for 2024-2038. Strong political support is required as there cannot be an impact without funding.

The goals of achieving carbon neutrality by 2040 and replacing fossil fuels by renewable energy sources by 2050 are perceived as a good driver for the implementation of electric flights on the Akureyri-Reykjavík route, but the group did not believe that international routes would be covered. As part of the efforts to achieve those goals, the collaboration between Icelandair and Heart Aerospace is seen as a positive development. The focus group participants would expect that the airplanes used for pilot training will be the first ones to be used more widely in the country and on the route in question. However, those driving forces all come down to the question of necessary funding, as charging facilities would need to be set up in both airports.

Economic factors

High flight ticket prices in Iceland are a strong driver to implement electric aviation in the country. The focus group recognised that Iceland has good access to reasonably priced electricity, which could result in the electric airplane tickets being more affordable. The focus group noted that the state is a significant purchaser of flight tickets for staff in the public sector, providing an additional incentive. The participants said, for example, that on average two people fly each day on behalf of Akureyri Hospital on the Akureyri-Reykjavík route. In the long run, the costs for the government of transitioning from conventional airplanes to electric aviation could be

lower since the ticket prices might fall further down the road. That would also apply to the private sector, as both the government and employees of companies need to be able to travel readily in Iceland.

Even though Iceland is rapidly electrifying cars, which could result in lower road transport costs, the focus group determined that this would not significantly impact the popularity of flying, especially between Reykjavik and Akureyri. That is due to the travel time difference on this route. An aviation expert who was present at the focus group discussion estimated that the flight time would increase by a maximum of ten minutes compared to conventional airplanes operating currently on the route. On a different note, the decision to fly or drive also depends to a great extent on the purpose of the trip, as some people prefer to travel by car to Reykjavík in order to be able to commute within the city. Nevertheless, for most people time is of utmost importance and if ticket prices were to fall due to electrification of the fleet, it would serve as an additional benefit.

There is a general disposition towards the green economy and sustainable ecotourism in Iceland, which is a stimulant for implementing electric aircraft. As mentioned before, cars and also buses are expected to transport commuters. One example includes the bus route from Keflavik Airport to the city centre or the public transport system around the Reykjavik region, which is planned to be electrified in the upcoming decade. By implementing electric aviation, Iceland could become a leading country in terms of electrifying its transport nodes. On the other hand, cruise ships, for example, would still be significant polluters, especially in Akureyri.

Social factors

The main social driving force according to the participants is the increasing need for accessibility of public services in rural areas. The ageing population requires more frequent trips to specialised doctors in the capital region. It is also just as important for such medical or public specialists to be able to have easy access to people living in the north of Iceland. As discussed earlier, a likely fall in ticket prices would result in those public services becoming cheaper both for the state and for the people requiring assistance. More frequent flights could likewise result in a higher level of access to public services.

Regarding public acceptance of electric aviation, the group believed that suitable education and introduction of new technologies could result in a positive view of electric aviation. An accident relating directly to an electrical malfunction could, however, have a negative impact on the perceived safety of the new technologies. Nevertheless, the focus group agreed that since the public authorities place great emphasis on aviation safety, the public is not likely to develop a fear of electric flights.

Technological factors

Under the technological factors, the focus group agreed that availability of the necessary infrastructure for charging batteries is crucial for successful operations.

The participants expect there to be overnight charging of batteries, but do not anticipate swappable batteries to be used in electric aircraft. Another key requirement would involve the necessary training of the airport staff. For instance, fire fighters at the airport would have to learn to adapt to different conditions, since the electric airplanes would not be powered by a combustion engine. Additional equipment and inventory would have to be stored at the airport to accommodate the new technologies.

Environmental factors

The focus group acknowledged that there is still little knowledge about the effects of environmental impacts specific to the Icelandic climate, such as cold weather, on the electric airplanes. For example, experiences with electric cars suggest that the range might be lower due to the cold weather. According to the focus group, there will be a generator in the Heart Aerospace aircraft, which is most likely to operate on the route in question. The purpose of that would be to ensure sufficient power to turn the airplane around in the event of an emergency. It is likewise expected that the airplanes will carry fuel for extraordinary situations.

Concluding reflections

The flight route between Akureyri and Reykjavik is currently operated by Icelandair. As the airline intends to cooperate with Heart Aerospace on developing an electric airplane to be used on domestic flights by 2028, the focus group considered that electric aviation is likely to become reality in the region within the next ten years. The results of the focus group discussion indicate that there is strong support for electric aviation, both because of the positive environmental impacts and because the participants believed that it could reduce the price of flying domestically thanks to access to inexpensive electricity in Iceland.

Norway. Bodø – Leknes

Leknes – Bodø	
Distance between the airports	101 km
Travel time by electric airplane	approx. 20 min
Yearly number of air passengers, Lofoten-Bodø	90,300-100,900
Expected yearly passenger growth Lofoten-Bodø in 2028-2029[6]	98,600-110,200

Table 6: Distance and travel time between the airports together with passenger numbers.

Norway, and especially northern Norway, is very interesting to study for the purpose of exploring the potential implementation of electric aviation in the future. Previous studies conducted within the framework of this project (Löfving et al., 2023) have already emphasised the nation's ambitious goals to achieve climate neutrality at the national level. Furthermore, various Green Aviation programmes are in place, in collaboration with key partners such as Avinor,[7] the Luftfartstilsynet,[8] Norsk Industri[9] and SINTEF.[10]

Several factors create ideal conditions for electric aircraft within Norway. The extensive short-haul network, rapid electrification of the car fleet and the transition to electric ferries all contribute to the country's suitability for electric aviation (Valmot, 2021). Notably, Norway's significant internal tourism and domestic flights further enhance the appeal of electric aviation. Within Europe, routes like Oslo-Trondheim, Oslo-Bergen and Oslo-Stavanger rank in the top 20 for passenger traffic (OECD, 2022).

6. *Osloeconomics, Norconsult, & Nord Universitet. (2022). Forslag til offentlig kjøp av regionale flyruter. Statistics Norway. (2022a). Befolkningsframskrivinger for kommunene 2022.*
7. Avinor AS is a state-owned company that operates most of the civil airports in Norway.
8. Luftfartstilsynet is Norway's national aviation authority.
9. Norsk Industri is the largest national association in the Norwegian Confederation of Business and Industry (NHO).
10. SINTEF is a technical research institute in Norway.

The geographical characteristics of Norway also render it a compelling case study. There are vast distances between many of the country's locations, particularly in the northern regions, where the lack of cost-effective and efficient public transport often makes flying the sole viable option for reaching certain destinations. Nonetheless, it is worth noting that the majority of internal flights are in areas where lower-emission alternatives are available (Andersen, 2022).

This case study report focuses on the possible future route for electric aviation between Leknes, located on the Lofoten Islands, and Bodø. The calculated flight time of that route by electric airplane would be around 20 minutes.

Geography and demography

The selected route connects the airports of Bodø and Leknes, located in the administrative region (*Fylkeskommune)* of Nordland, in northern Norway. Bodø is located on the mainland and is the administrative centre and largest municipality in the region (with a population of 53,259 as at 2023) (Statistics Norway, 2023), while Leknes is the most populated settlement in the Lofoten Islands and is part of the municipality of Vestvågøy (11566 people as at 2022) (Statistics Norway, 2022b). Avinor, a state-owned Norwegian company under the auspices of the Ministry of Transport and Communication, is responsible for the two airports concerned. The route is a public procurement route.

It is noteworthy that while Bodø Airport is categorised as an urban airport, in line with the urban-rural typology outlined in Nordregio's accessibility study (Nordregio, 2022), Leknes Airport is classified as rural. That distinction has significant implications for the potential of electric aviation to connect remote areas in this region effectively.

Currently, passengers travelling between Leknes and Bodø have three transport options: a flight operated by Widerøe (approximately 1.3 hours), a ferry ride (approximately 5.3 hours) and a bus journey (approximately 9 hours).

From a geographical perspective, the county of Nordland is a predominantly mountainous area, characterised by rugged coastlines with several fjords and islands that are among the least densely populated areas in Norway. Nordland has a total population of 240,345 and a population density of 6.7 people/km^2 (Statistics Norway, 2023). About 25,000 people live on the Lofoten Islands and slightly fewer than 4,000 live in the centre of Leknes (Statistics Norway, 2022b).

A central demographic aspect of northern Norway is its ageing population pattern (Statistics Norway, 2022a). That is a crucial issue, because especially from a labour market perspective more rural municipalities need to retain young people and have a skilled work force. Nevertheless, it should be noted that the county of Nordland had the lowest national unemployment rate at 1.7% as at March 2023. In some of the regional centres (in particular Bodø) there has been a significant population increase,

due both to internal and international migration. Outmigration involves young women in particular, who mainly move south to the capital (Teräs et al., 2020a). In general, however, a combination of low birth rates and decreasing immigration over the past few years (minus 65% between 2012 and 2019) has led to a decreasing population overall in northern Norway, with the exception of the centres of Bodø, Tromsø and Alta. All those centres have a strong public sector and university campuses, which contribute to attracting young people and a skilled labour force (Teräs et al., 2020a). On average, northern Norway's population is older than the national average. According to population forecasts, it can be expected that over a 30-year horizon over half the population in northern Norway will be in the 20-6 age group, supporting a growing elderly population.

Regional economy

The main economic sectors in Nordland have traditionally centred around agriculture and fishing. Nordland is Norway's largest fish farming county, with 65% of exports from northern Norway coming from there. Engineering, food and metal production are the industrial sectors with the highest number of employees (23, 29 and 12 percent respectively, in 2019) (Thorsnæs, 2023). The presence of Bodø Havn (port of Bodø) further makes the area an important facilitator for business, industry, maritime logistics and transport of people and goods. Of particular relevance to this project is the fact that Nordland produces 10% of Norway's electrical power (15 Twh) and is the second largest hydropower producer in Norway (Nordland Fylkeskommune, n.d.).

For centuries, fishing has been the main economic activity on the Lofoten Islands as well. There are high exports of cod and stockfish, in particular to Italy, Portugal and the United Kingdom. In the centre of Leknes, in particular, the wool industry, fish processing, mechanical workshops and the oil industry also play an important role. In addition, the port of Leknes is an important stopping point for cruise ships.

Bodø is also an important university hub, and has the crucial role of attracting young skilled people in the context of an ageing population.

It is also important to point out that Norway in general and Nordland in particular are highly attractive tourist destinations. As reported by OECD (2020), tourism accounts for 3.6% of the national GDP and Nordland has many attractive destinations, with Bodø and Lofoten Islands standing out in particular.

The two destinations concerned, Bodø and the Lofoten Islands, are titled sustainable tourism destinations. That refers to a national certification scheme under which that title is granted to destinations that have committed to working systematically towards more sustainable tourism development, preserving local communities and cultural heritage and reducing the environmental footprint of tourism (Global Sustainable Tourism Council, 2018). As will be described further in the next sections, the establishment of electric aviation in a hub like Bodø may have a strategic

function for tourism purposes, but may also enhance access to services from the Lofoten Islands.

Regional policies and initiatives relevant to electric aviation

Several projects and initiatives are underway to make the electrification of aviation reality in Norway (see status report, page 39). As mentioned, northern Norway, thanks to its geography, regional development conditions and short-haul network, lends itself to the implementation of electric aviation. The Norwegian airline Widerøe, which is working to implement electric airplanes on its routes, has its main office in Bodø and has set itself the goal of electrifying the short routes that today are operated by its Dash 8-fleet.

Widerøe is investing heavily in electrifying the fleet by 2030. It has established the subsidiary Widerøe Zero, which will work towards introduction of electric aircraft to Norway, in Bodø. The strategic director of Widerøe believes that Bodø is one of the most relevant cities for establishment of electric aviation (Wiik, 2022).

By 2030, a new airport should be operative in Bodø (Karp, 2022) and infrastructure will be built for both hybrid (partially hydrogen) and fully electric aircraft, even though there is still uncertainty as to what infrastructure is required at the airport and how the energy supply to the aircraft should be designed. The new airport in Bodø is considered to be a great initiative to boost both local and regional development. The initiative is indeed called "new city – new airport" and involves not only replacement of the former airport by the new one, but also an urban settlement that is almost the size of the existing town.

In the further work on development of the new Bodø airport, it will be necessary to analyse the impact that ground infrastructure and charging will have on range, resources, time and accessibility at the airports. It is assumed that it will be feasible to fly electrically between Bodø and all current domestic destinations, apart from Oslo, Bergen and Trondheim, by as early as 2040 (Wiik, 2022).

Even if the energy requirement for aircraft operation is reduced in total, electrification of aviation will contribute to an increase in the need for electrical energy at airports. Until 2040 the power requirement for charging aircraft is the primary challenge, as the energy requirement is manageable. Good control systems for power peaks, in combination with, for example, local energy packages can help solve those challenges (Avinor, 2019).

The Lofoten Islands are also committed to reducing emissions and electrification of aviation. In the Climate and Energy Plan of the municipality of Vestvågøy, the main objective is to lay down a strategic plan to reduce greenhouse gas emissions in the municipality by 50% by 2031, taking 2019 emissions as the baseline (Vestvågøy Kommune, 2022). The plan includes a specific section on energy and electrification, where it is emphasised that the aim is to go from being an energy consumer to being

an energy producer (while also encouraging a greater energy mix), with power producers and Lofoten municipalities as development partners.

An important dilemma in the Lofoten Islands is the fact that climate and environmental goals may be in conflict with other goals for the municipality and for society. The most pertinent example of that is the growth in tourism, which results in increased air and ship traffic. That also entails increased emissions, consumption of limited resources and loss of natural areas and biological diversity (Kristoffersen, et al., 2018).

In order to tackle those challenges, various initiatives are in place. First, the Lofoten Islands are part of a cooperation arrangement between Lofotkraft,[11] Lofoten Council and Destination Lofoten (Lofoten, n.d.) , called "Lofoten – The Green Islands 2030", which gives broad attention to energy use and emissions and works to find solutions for people to be able to travel to Lofoten and travel around the islands with minimal impact on the natural environment (Olsen, 2022). "Lofoten – The Green Islands 2030" is intended to be a ten-year growth strategy for the Lofoten Islands that aligns with regional, national and international climate goals and ensures green and sustainable growth for the municipalities on the islands. The strategy has a section on low-emission aviation with the aim for Lofoten to become a pilot region for zero-emission air traffic (Lofotrådet et al., 2022). Second, Bodø Airport Development, Energi i Nord[12] and "Lofoten – The Green Islands 2030" have joined forces to establish northern Norway as a testing ground for new technology in green aviation. In this respect, and in collaboration with the aforementioned partners, a new project called "Climate-neutral regional aviation in the Nordic areas" has been launched, which addresses the question of how northern Norway can make a positive contribution to the green shift. The project, which started in October 2022, comes under the scope of the Artic 2030 programme and is funded by Troms and Finnmark County Municipality.

Transport infrastructure

Northern Norway poses significant challenges in terms of establishing reliable transport infrastructure due to its geographical and climatic conditions, low population densities and extensive distances. The region's vulnerability is evident during winter when certain roads, as highlighted in a study by Teräs et al. (2020), are frequently closed. Recent years, such as 2019/2020, have seen record instances of road closures, a trend exacerbated by climate change.

Bodø, which forms the northern terminus of the Nordland Line, marks the end of the Vy (Norwegian State Railways) network. Passengers travelling further north often

11. ofotkraft is an electric company that manages the electric network in Lofoten.
12. Energi i Nord is a cluster with members from the entire energy sector and from all of northern Norway.

change to connecting buses in the nearby town of Fauske to reach Narvik. From Narvik, a railway extends into Sweden and is integrated with the Swedish rail network.

The Lofoten Islands are linked via the European road E10, which features a network of bridges and undersea tunnels. That roadway extends northward, connecting to the city of Luleå in northern Sweden. Furthermore, the E10 road facilitates the connection of Lofoten's larger islands to mainland Norway via the Lofast road connection, inaugurated in December 2007.

The inherent difficulties arising from northern Norway's geographical and climatic constraints have led to the development of an extensive short-haul network of flight routes served to and from numerous regional airports (see Figure 7). In this region, 25 airports and one helipad, accounting for nearly half of Avinor's airports in the country, serve 9% of the population. The prevalence of islands and fjords makes sea routes an effective mode of transport in many areas, resulting in widespread passenger routes along the coast. Collectively, passenger boats traverse 4.4 kilometres per person in northern Norway, surpassing other regions by a considerable margin.

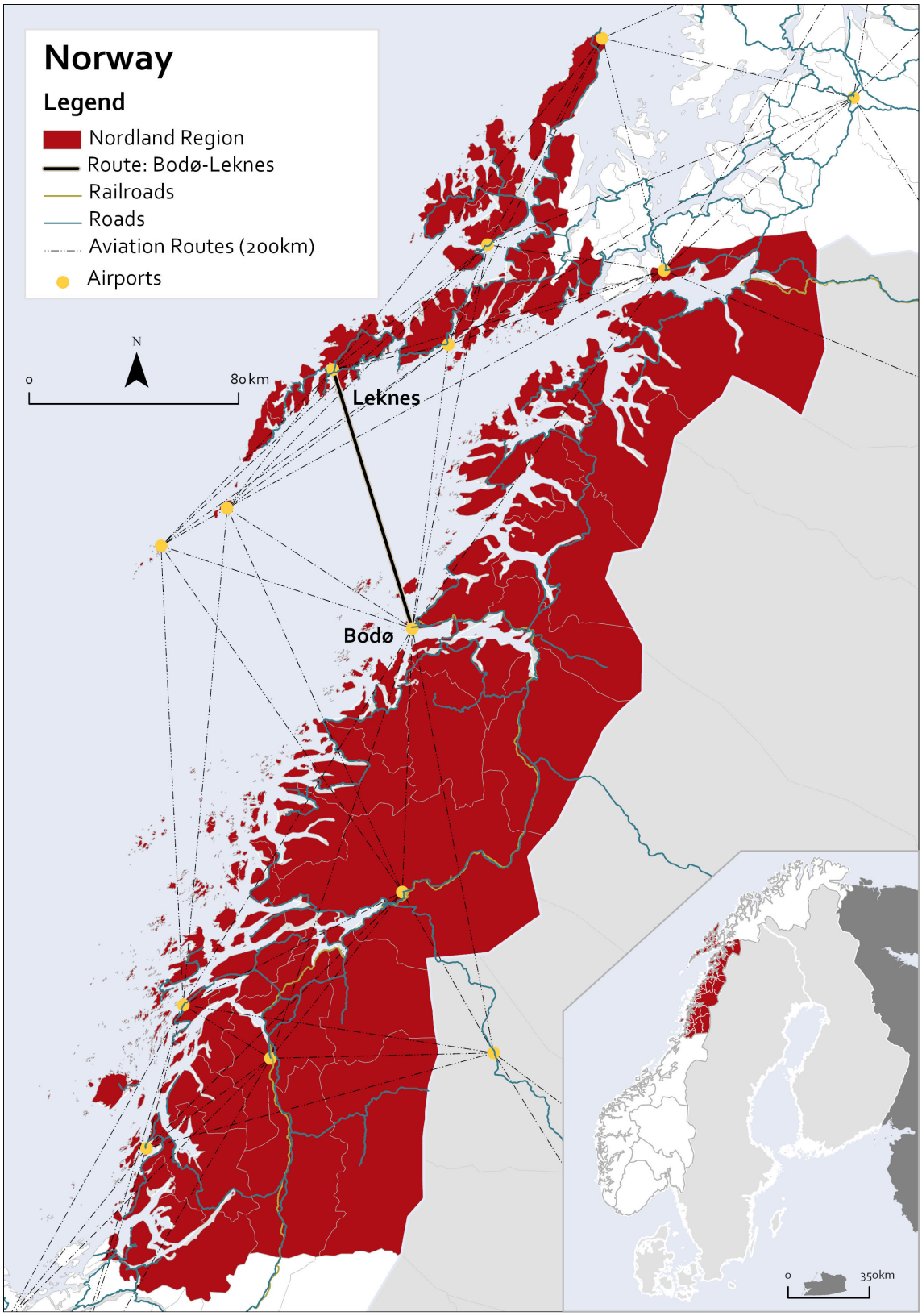


Figure 7: Norwegian route and regional transport infrastructure
Source: Nordregio

Bodø and Leknes each have an airport managed by Avinor. At present, Bodø Airport has non-stop passenger flights scheduled to 15 domestic destinations (Helsinki is thNorwegian route and regional transport infrastructuree only international destination to which there is a direct flight) (Flight Connections, n.d.). Bodø is also an important hub for connections to the Lofoten islands. Such connections are crucial for tourism especially, given that tourism is one of the main economic activities on the islands.

Leknes Airport is a small airport with domestic flights only. At present, there are three domestic flights from Leknes, to Bodø, Bergen and Tromsø. The majority of the flights are to Bodø (about seven per day) with connections to other destinations. Between 98,600 and 110,200 people per year are expected to travel between Bodø and Leknes in 2028-2029, versus the 90,300 to 100,900 passengers today (Osloeconomics et al., 2022). That very high route demand is related to the distinctive geographical conditions of the Lofoten Islands, with air travel being the only viable option in many cases.

Accessibility of care facilities, education, work and other public services

One important aspect of northern Norway is that the distance and travel time between towns and villages can be challenging and highly time-consuming. In some of the largest and less dense rural areas, it might be difficult to access basic services such as banks, postal services and hospitals.

Aviation in northern Norway is also important for medical treatment. In certain communities, residents have to travel for over four hours to reach the nearest hospital. Some of these locations have a fleet of medical helicopters and small airplanes (Teräs et al., 2020). That indicates the crucial role that electric aviation could play in in the region.

When it comes to education, Nord University in Bodø is the second largest university in northern Norway, with 11,ooo students and some 180 programmes in both academic and vocational fields, including aquaculture, sociology, business, nursing and teacher training. In the northeast of the Lofoten Islands, Nord University has a site with four master's programmes. Better education possibilities might be an important reason for outmigration from Lofoten.

Energy infrastructure

In northern Norway, the national grid is extensive but a distinction should be made between ordinary and dry years. Indeed, as noted (Nordic Energy Research, 2023), the national grid has the potential to increase the power supply by a total of 2,200 MW in an ordinary year. However, that level cannot be reached in dry years, so new power production should be incentivised. Increased energy production and smart

technologies will be needed in the coming years too given the growing electrification trends in several industries in Nordland and will be pivotal to mitigating future risks related to energy security.

Ten-year scenario for electric aviation

The focus group

The focus group discussion was conducted online via Teams in August 2023 and took approximately two hours. The focus group meeting was attended by four participants in addition to the researcher moderating the discussion. The participants included a project manager and business developer for green aviation in the municipality of Bodø, a project manager at Lofokraft Muligheter AS,[13] with expertise in business development and societal issues within the framework of energy and renewable energy, a management-level representative from Bodø's region development company (BRUS) and Bodø's airport development company (BLU[14], as well as a consultant at KPB AS[15] working as a business development and project manager for study into green aviation.

Key driving forces for implementing electric aviation on the Bodø-Leknes route

Political factors

Political commitment will play a pivotal role in making electric aviation reality within the next decade. Despite potential disagreements and polarisation on climate measures, the focus group unanimously recognised the significance of that factor. Furthermore, that commitment is expected to remain robust in the near future as well, given the current high level of political attention to electric aviation at local, regional and national levels.[16]

In Norway, achieving the established climate goals necessitates a shift towards more environmentally-friendly aviation. Notably, in the Lofoten Islands, the "Green Islands" plan outlines a comprehensive strategy for 2030 that encompasses green aviation. Similarly, in Bodø, it is imperative and expected that the newly elected (in September 2023) municipal government take on long-term responsibilities for promoting green aviation. The expectation is that politicians at the municipal and county level will set

13. Lofokraft Muligheter AS is a company owned by the six municipalities in the Lofoten Islands and operates as a fibre and energy provider with a strong commitment to a climate-friendly energy system. Together with the Lofoten Council and Destination Lofoten, Lofotkraft participates in the "Lofoten – The Green Islands 2030" programme.
14. Bodø Lufthavantvikling AS. The company plays a strategic role in facilitating the establishment of new direct routes to and from Bodø Airport, while simultaneously enhancing value creation in activities linked to the current airport.
15. Company dedicated to building future solutions for businesses.
16. The Norwegian goal is to reduce CO2 emissions by 50-55% before 2030 and by 90-95% percent by 2050 (Norwegian Government, 2023).

goals that are as high as possible. In fact, as pointed out by one of the participants, route operators will only receive licences if they commit to achieving climate neutrality, highlighting the growing emphasis on sustainability in aviation.

In the Lofoten Islands, the establishment of more sustainable transport connections has already been set out and voted on unanimously by all the municipalities. While the consensus on this matter is indeed significant, it is worth noting that local communities may not have the ultimate authority, as aviation incentives and subsidies primarily originate at the national level – with Public Service Obligation route services funded by the Ministry for Transport and Communication (International Transport Forum, 2018). However, it is noteworthy that the national government is already placing great emphasis on ensuring that public routes, such as the one between Bodø and Lofoten, adhere to low-emission standards.

Economic factors

While attracting young people to the region is crucial, given the ageing population and outmigration trends, the significance of that factor for electric aviation is relatively low as it is considered that electric aviation will become reality in the near future regardless. On the other hand, the focus group considered attracting young people to the region a crucial factor to foster economic growth and to support technological development in order to reach the climate goals set.

Tourism is a fundamental pillar of Nordland's regional economy and its trajectory has far-reaching implications, particularly in the context of promoting sustainability. The focus group took the view that the tourism industry's decision to showcase the region and its offerings as environmentally sustainable can significantly influence the path towards adoption of electric aviation. Moreover, the regulatory landscape within the tourism sector plays a pivotal role in shaping its environmental impact. By 2025, there is a growing imperative for tourist destinations to report actively on the climate footprint from tourism activities. Such reporting encompasses various aspects, including the means by which tourists access the destination in question. For a location like the Lofoten Islands, that aspect is of major significance. The Lofoten Islands are at a critical juncture in their journey towards sustainability and the way aviation is integrated into their broader sustainability framework holds the key to addressing that challenge. If the Lofoten Islands fail to adopt greener aviation solutions, it might become challenging to claim that the entire journey to Lofoten is an environmentally sustainable one. Hence choices made within the tourism and aviation sectors are closely interlinked.

The shift from fossil fuel-driven aviation to eco-friendly alternatives poses complex challenges regarding environmental taxation and the financial sustainability of the aviation sector. While adoption of green technologies will mean companies pay lower environmental taxes, participants expressed uncertainty about the relevance of that factor as a driving force for the implementation of electric aviation. In the Nordland region, Widerøe holds a quasi-monopoly on regional routes. In light of anticipated increases in environmental levies on fossil fuel-based aviation, it may be more pragmatic for it to invest in overhauling its entire aircraft fleet to avoid the financial

strain of those taxes. In that sense, reduced environmental taxes may be highly significant for the implementation of electric aviation. Nevertheless, the participants in the discussion generally expressed uncertainty about that nuanced relationship.

It was emphasised that substantial national environmental taxes play a pivotal role in spurring the development and adoption of eco-friendly technologies that reduce environmental harm. However, it is essential to recognise that elevated taxes on air travel between destinations can also lead to a reduction in the aviation industry's revenues. That is chiefly because higher taxes dissuade people from taking flights, resulting in lower passenger numbers for airlines and subsequent declines in their income. Achieving a delicate equilibrium between advancing environmental sustainability and safeguarding the economic well-being of the aviation sector is crucial. Given that the aviation industry is already contending with modest revenues and narrow profit margins, imposing hefty taxes may compound its financial challenges.

Economic incentives could be highly relevant for the implementation of electric aviation in the next ten years. It is therefore important for the national government to provide subsidies to incentivise the adoption of environmentally-friendly aviation technology. That is especially important because the market might not naturally transition to greener technology without such support, especially in the initial years. The lack or insufficiency of such incentives could stifle green aviation initiatives. There was consensus among the participants that the prospect of weak incentives is fairly unlikely, given how high green aviation is on the political agenda and how important it is with regard to meeting the environmental targets in the region. The focus group likewise acknowledged that even with enough incentives, economic losses should be expected in the initial phase, although that is not expected to have a strong impact on the implementation process.

Social factors

Social acceptance was found to be a crucial factor that can either propel or impede the adoption of electric aviation. Scepticism among the public is evident, with reservations about the safety and feasibility of the new technology. A noteworthy example of such scepticism can be seen in the case of the introduction of a hydrogen-powered ferry from Bodø to Lofoten starting in 2025. People are questioning the safety and reliability of the technology in question and it is reasonable to expect a similar, if not greater, level of scepticism for electric aviation. However, it is important to note that there are generational differences in this regard. Younger people are generally more receptive to the concept of electric aviation, recognising its sustainability and adaptability benefits. They see opportunities where others may see challenges. In a broader context, it is not uncommon for social acceptance to be a stumbling block for new technologies, as seen with the initial scepticism surrounding electric cars. Learning from past transitions involving new technologies, it is clear that a certain period of building trust and familiarity is essential in order for the technology to establish itself. It is not enough to have the technology and the necessary legislation in place; a trust-building

phase is equally critical. The challenge is to find ways to expedite that trust-building process and reduce the time required for social acceptance.

Outmigration, though a prevalent trend, was not regarded as a highly influential factor with respect to the potential adoption of electric aviation. As will be discussed in the section on impacts, participants in the Norwegian case study were more inclined to view electric aviation as a possible way to help counteract outmigration, rather than viewing outmigration as being beneficial to its implementation.

The need to enhance access to healthcare and education facilities was identified by the focus group as a factor of moderate importance with regard to the implementation of electric aviation. That medium level of significance stems from its broader implications for commuting in general. During the focus group discussions, it became evident that improving access to those critical facilities is one of the most challenging tasks within the scope of globalisation. The dwindling population in various areas of the region compounds that challenge. While Bodø is expected to experience growth due to globalisation, ensuring access to healthcare and education remains a considerable challenge. It is crucial for the region to address such issues effectively in order to create an appealing society that attracts new residents. That necessitates financial investment and attention by municipalities, regional authorities and national bodies. Another perspective worth considering is that of not only enhancing accessibility for the benefit of end-users of healthcare and education facilities, but also for the people working there. The focus group participants expect those facilities to commit increasingly to ethical and sustainable practices, potentially driving demand for more eco-friendly commuting options. That shift is expected to open the doors to a broader pool of commuters. That is particularly important for the Lofoten Islands, where – to meet the demand for skilled and talented workers – businesses and communities will have to place greater emphasis on sustainability goals and climate footprint reporting.

Technological factors

Increased energy consumption and the need for higher energy production are crucial points and are the factors of greatest significance for electric aviation. The transition to electric aircraft necessitates a substantial increase in energy production. While electric aviation serves as a cleaner alternative to fossil fuels, the question arises as to where that additional power will be sourced from. Will it be wind energy, potentially on new land? The political complexities involved are evident, as heightened energy consumption triggers the need for expanded production, and the expansion of production may lead to socio-political challenges in terms of public acceptance.

The upgrade of airport infrastructure for electric aviation was unanimously recognised as a matter of major importance for the successful implementation of electric aviation. The consensus was that such upgrades are not only expected but imperative for the transition. In the case of the Lofoten Islands, that transition would likely involve enhancing the existing airport infrastructure. In Bodø, such upgrades would align with the development of a new airport, underscoring the commitment to preparing the necessary infrastructure to support electric aviation. Similarly, the capacity for charging and the grid infrastructure were considered to be of the greatest significance.

As noted by one of the participants, several notable hurdles need to be overcome in the field of electric aviation, particularly in the technical domain. One major technical challenge revolves around the energy density and energy-to-weight ratio of batteries. That critical aspect plays a pivotal role in the feasibility and performance of electric aircraft. Additionally, traditional fossil fuel-based airplanes employ a method of de-icing their wings during flight by diverting hot air from the engines to the wings. Electric airplanes cannot employ that method, introducing specific technical challenges that need to be addressed.

The certification process by aviation authorities, both at the national and international levels, is another critical element. To operate commercially, electric airplanes must meet stringent safety standards and be proven to be as safe or even safer than existing aircraft. The authorities must have absolute confidence in the safety and technical capabilities of electric airplanes. That extends beyond simply getting such aircraft off the ground with battery power. Unlike conventional aircraft that become lighter as they burn fuel during a flight, electric aircraft maintain a consistent weight due to their battery load. As a result, they land with a significant weight, presenting unique challenges for the structural integrity of the aircraft and the landing gear. That characteristic makes the certification process for electric aircraft especially challenging.

Environmental factors

Currently the region's grid is predominantly powered by nearly 100% renewable energy sources. That significantly shapes the potential and relevance of electric aviation in the region. The availability of clean and sustainable electricity plays a pivotal role in determining the importance of electric aviation. Supposing the region's electricity source were primarily linked to higher emissions, the electrification of aviation would inherently be of less significance, given that the overall environmental impact of electric aviation would be reduced under such circumstances. In essence, the region's current reliance on 100% renewable energy enhances the significance of electric aviation, highlighting its potential for environmental and sustainability benefits.

Legal factors

Mandatory emission reduction requirements, whether at the EU, national or regional level, are of considerable importance for electric aviation, but some key points need to be taken into consideration. The likelihood of those requirements being established is high, but their effectiveness hinges on certain conditions. Individually set emission targets by single countries, like Norway, would have minimal impact on the aviation industry. To enact substantial change, a coordinated effort is needed on a broader scale. If emission reduction targets are established at the EU-wide or global level, it would catalyse investment in the development of electric aviation by the aircraft manufacturing industry. The ripple effect of EU-level requirements is profound. It extends to various aspects of the aviation industry, including the advancement of clean energy storage solutions like green hydrogen and sustainable aviation fuels. Furthermore, it influences the development of aircraft technology and operations. In essence, EU-wide mandates have a cascading effect on the entire ecosystem, propelling the industry towards greater sustainability and cleaner practices.

Concluding reflections

Northern Norway, especially the Bodø to Leknes route, is quickly becoming a key player in the adoption of electric aviation. That shift is due to several important factors that lend the region to sustainable air travel.

Foremost among those factors is the region's geographical characteristics, which play a significant part in the viability of electric aviation on the Bodø to Leknes route. The very long distances between many locations, coupled with the limited availability of efficient public transport alternatives, make electric aircraft a convincing solution for addressing the challenges associated with reaching otherwise remote and isolated destinations. Notably, these geographic characteristics have established aviation as the primary mode of transport in the region. That potential for electric aviation renders the region more attractive to the international aviation industry, as well as making local policy makers more committed to the new technology.

Moreover, the region's access to clean and sustainable energy sources stands out as a critical catalyst for electric aviation. That availability guarantees that the energy needed for such initiatives adheres to sustainable principles and aligns with the region's ambitious climate objectives. Insights from the focus group discussions underscore the crucial role of legislation and incentives as influential driving forces in implementing electric aviation. While technological advancements are undeniably vital, the legal and regulatory framework, combined with incentives, will play an equally pivotal role in bringing electric aviation to fruition.

The focus group discussions highlighted concerns about the social acceptance of the new technology and the need for robust technological development to support electric aviation fully. Although electric aviation holds great promise, it faces substantial technical and regulatory challenges that must be addressed in order for

it to become a commercially viable and safe mode of air travel. Notwithstanding those challenges, the focus group participants remain optimistic; they firmly support and advocate the potential of electric aviation and believe that it will become reality within the next decade.

Panoramic view of the city of Oulu in Finland seen from the air
Photo: iStock

4. Impacts of Electric Aviation in Nordic Regional Contexts

After clarifying all major driving forces in each case study, this section delves into possible impacts that the future implementation of electric aviation could have on the Nordic region. Those impacts were identified through discussions in the focus groups and organised according to the following topics: political, environmental, social, technological and economic impacts. Naturally, some of these impacts may overlap, but our goal is to highlight the variety of areas in which electric aviation may have a direct or indirect effect.

Political impacts

For every major transition on the market, political decisions and impacts should be taken into consideration. Electric aviation may have highly positive impacts on the political landscape in the Nordic region. For green islands such as Bornholm, electric aviation can assist efforts to become an even more sustainable area and help the local government reach the goals of the "Bright Green Island" vision. Additionally, implementation of a sustainable means to reach Bornholm using fossil-free

transport would be a firm step in the right direction for the Green Energy Island initiative and the green energy hub in a broader sense. Similarly, in the case of the Lofoten Islands in Norway, electric aviation could play a strong part in helping the national government reach its climate goals which are high on the agenda by incentivising further reduction in emissions.

In general, since the Nordic region is known as a forerunner in sustainable solutions or, more precisely, electricity produced from renewable sources, such new implementation of green innovations would to a greater extent facilitate development of the common green Nordic image. Being a pioneer in sustainable transport solutions can raise the attractiveness of the region and generate positive national and international visibility. Electric aviation is a clear sign that a region is working on solutions to reach the climate goals. Electric aviation would likewise accelerate individual countries' goals of having green domestic or international modes of transport. While that could be achieved by using SAF (sustainable aviation fuel) or hydrogen fuels and may not necessarily involve the routes presented in this study, a sustainable transition would have a positive impact on domestic political goals as well as on the United Nation's Sustainable Development Goals (UN SDGs) (Aviation Benefits Beyond Borders, n.d.).

Moreover, due to electric aviation likely being used in the future for journeys between smaller airports and rural areas, it could potentially affect the way we view traditional borders and routes across them. Making regions more interconnected and open to new types of cooperation in rural areas, the Barents region, the High North and Bothnian Bay could have significant social, economic and political implications. Finally, electric aviation is set to drive political forces to step up their commitment to promoting financial regulations and incentives. As governments aim to reach climate goals, they may introduce emission reduction mandates and incentives for green aviation. The European Union could play a pivotal role in fostering such changes, making it attractive for aircraft manufacturers to invest in electric aviation.

Economic impacts

As mentioned above, new financial incentives could be introduced and would therefore be a direct impact of the introduction of electric aircraft. Based on the implementation of electric aviation, the governments could impose taxes on non-sustainable fuel types or reduce taxes on green flights by creating an incentive to choose the environmentally sustainable options. While the question of whether the ticket prices would fall or rise is contested and still unanswered, the Icelandic focus group remains the most confident that the prices would be substantially lower. By contrast, the Danish focus group suggested that prices would rise significantly because of the smaller passenger capacity of the airplanes.

Municipalities in the northern parts of the region, such as in northern Sweden, could benefit from promising opportunities for new electric aviation routes. Those new routes could lead to the creation of transport hubs in the north with new financial benefits for the areas. On a different note, because of the lower noise level of electric aircraft, the housing prices around airports might increase, especially in places where the airport is located close to the city, such as in Copenhagen. However, such impacts would only be tangible when most of the fleet becomes electric. Similarly in Iceland, electric aviation could impact the debate on whether to relocate Reykjavik Airport further outside the city, since noise pollution would decrease. The impact would therefore have indirect financial consequences.

The debate on economic impacts revolved to a significant extent around the tourism sector, which emerged as an important topic during the focus group discussions. The most influential and important impact concerning tourism is the ability of electric aviation to open up the possibility for new destinations. Small airports located in rural areas can accommodate electric aircraft due to their compact size. Electric aviation could therefore offer tourists the possibility of more remote vacation destinations in the northern parts of Norway, Sweden or Finland or in Iceland, to which the journey would otherwise be significantly longer. Likewise, more remote areas could benefit in terms of tourism if those local areas put enough effort into business development. Product portfolios in tourism often only include locations and services of a particular region, but if there will be a closer network of flight connections in the future, it would be wise to begin thinking in terms of a wider region and offer a broader range of tourism destinations. Quick tourism trips around a remote area could be expected in such case.

By offering sustainable travel options, tourist destinations could enhance their sustainable tourism label, such as in the case of the Lofoten Islands. They could additionally attract environmentally-aware people, who would otherwise be unable to reach certain areas. Nevertheless, as mentioned above, ticket prices are an essential variable for the success of such vision. If the implementation of electric aviation proves successful, the region could expect more frequent flights with smaller airplanes and cheaper tickets, carrying tourists to unexplored parts of the north. Some participants envisaged an opportunity for tourist agencies to offer flights to holiday destinations by electric aircraft, which could function as a selling point. There would undoubtedly be further opportunities to develop tourism.

In the case of Iceland, currently most domestic flight routes connect towns to Reykjavík (a regional hub) but do not connect towns outside of Reykjavík with one another. Lower operating costs and a higher flight frequency using smaller airplanes could lead to flight connections to the Westfjords and the east. It is currently very expensive to fly via the Reykjavík hub from Akureyri to those areas. Therefore, if electric aviation would offer lower ticket prices, as is expected in the case of Iceland, such issues could be overcome.

Another aspect of economic impacts includes commercial development, facilitated by electric aviation. Since some areas, especially in secluded regions, lack skilled workers, electric aviation could facilitate their transport. Presuming a higher flight frequency once electric aviation has been implemented, there could be higher mobility of skilled workers. There is a fairly high possibility that companies would fly their workers in and hence pay for their tickets. In that case, the issue of prices would still be significant, but would pose a lesser concern.

New business opportunities could also emerge due to electric aviation. New flight connections enabled by electric aviation could bring forth many new opportunities for business activity and interregional cooperation, lowering the threshold for engaging in new business ventures between regions. While preparing for electric aviation routes, there could be new cooperation possibilities between regions and businesses, in the scope of which new product models could be built or new potential services piloted, e.g. for tourism. Electric aviation could thus impact the attractiveness of a given area and provide another industrial boost to local industries and businesses.

To give an example, when considering cross-border possibilities between Sweden and Finland, the availability of electric flights on the route between Skellefteå-Oulu would enable some geographical challenges to be overcome, such as the constraints posed by the Gulf of Bothnia. That would have a positive impact on connectivity among enterprises and businesses. Improved east-west connections may introduce new actors and cooperation to business life in the destinations. Other participants noted that Kajaani and Oulu in Finland might profit in particular from new business opportunities provided by electric aviation.

Social impacts

Electric aviation may have several important benefits for the welfare of Nordic citizens. One of the significant improvements is linked to healthcare accessibility, as observed in several of the case studies. Because of more frequent flights, possibly cheaper prices and even the probable development of an electric helicopter further down the line (as mentioned in the Danish case), the connectivity between rural and urban areas would increase. In the case of Bornholm, where the practice is for the state to compensate journeys for those needing to visit the hospital in Copenhagen, an agreement would be needed with the operators and healthcare providers about the details of such transport. Healthcare accessibility could increase in other Nordic areas, where connections are not as well developed, such as in Iceland or the north of Sweden due to large distances between settlements. New possibilities for cooperation between hospitals could also arise, as the hospitals would be better connected.

Another probable impact relates to the accessibility of education in the Nordic region, as is seen in most of the case studies. For example, in Denmark, electric aviation is unlikely to be a factor that attracts students to the given areas, but teachers living in Sjæland might be willing to fly and teach in Bornholm. Such journeys could be made once or twice per week for a specific subject or a programme that is being (partly or fully) taught in Bornholm higher education institutions. That would also imply that the university would pay for these tickets.

Other specialists working in the public sector would have easier access to clients in rural areas and the clients would likewise have improved access to the services that they require. Such an instance was underlined in Iceland but is also evident in other cases. However, when considering this impact, the cross-border connection between Oulu and Skellefteå should be excluded, as the focus group did not see the need for patients to travel between countries for public services. However, electric aviation connections within the north of Sweden, where the distances are large, could have a beneficial impact on the accessibility of public services. A regional hub in northern Sweden for electric aviation could connect more rural settlements to important services, such as specialist healthcare in Skellefteå or Umeå, that may be lacking in the local area.

However, the extent to which accessibility could rise still depends on the electric aviation routes and costs. If the routes provide more flexibility, easy access to public services and the prices are affordable, then it may have an impact on healthcare, educational opportunities and other public services for the people of the Nordic region.

In line with social impacts, electric aviation might also influence demographic developments, which could then have an effect on other categories of impacts. For instance, electric aviation is likely to enhance the region's appeal to younger people and students. The presence of aviation services is vital for geographically distant areas. It could make the region more attractive, particularly for those interested in environmental sustainability and younger generations seeking opportunities. Notably, electric aviation might attract a certain group of climate-conscious young people to choose the electric airplane instead of a polluting ferry or car to travel between two areas.

Furthermore, by attracting students and creating attractive jobs, electric aviation could potentially counteract outmigration. It might facilitate more flexible travel options and potentially reduce the impact of outmigration from less populated Nordic cities. Thus electric aviation can function as a force of attraction to facilitate in-migration. However, several participants noted that this should be treated with caution since it is seen as an unlikely development in the near future.

Technological impacts

Electric aviation may additionally be looked to as a source of inspiration for further development of technology and upgrading of aviation infrastructure. The implementation of electric aviation would involve upgrading airports to accommodate new requirements such as charging stations, better public transport (connectivity) with cities, possibly even new departure terminals and a larger parking area. Further, electrification of the aviation industry could open more doors to the development of other technologies such as electric drones (which could deliver packages and/or be flown by people) and electric helicopters (which could support windmills, oil rigs and other innovative solutions). However, the possibility of such developments should be assessed by experts.

Environmental impacts

One of the primary and most direct benefits of electric aviation is the substantial reduction in emissions, especially during flight operation. This aligns with the climate goals set out in the Nordic region and individual states while pursuing sustainability efforts. Furthermore, the limited infrastructure requirements for electric aviation, such as short runways due to the size of the airplanes, would have a reduced impact on biodiversity compared to conventional and larger aircraft. The use of electric airplanes between destinations could potentially result in an increase in cargo (mainly for light loads) being transported by airplanes. That would mean a decreasing number of lorries on the roads and would contribute to passenger, cyclist and pedestrian safety. The focus groups had little doubt about the beneficial environmental effects that implementation of electric aviation could have on the region. However, some participants voiced their concerns about pollution during the production phase of the battery. Similarly, several participants were concerned about disposal of the battery at the end of its lifetime.

It should also be noted that considerations related to potential environmental impacts were not always strictly related to electric aircraft. Indeed, numerous participants emphasised the importance of considering a diverse range of low-carbon and hybrid alternatives, such as low-carbon fuels, rather than concentrating solely on electric aviation. Narrowing the focus too much could potentially isolate development of the field, hindering innovation. Such comments should be considered when further assessing the implementation of electric aircraft.

Concluding thoughts about impacts of electric aviation on the Nordic region

As described above, electric aviation can have a variety of impacts on the Nordic region. It is difficult to pinpoint the precise scale of such impacts, but each focus group identified particular impacts for the given country. In Denmark, the focus group stressed the positive impact that electric aviation might have by supporting the green transition on the island of Bornholm. In addition, the participants highlighted the importance of stable connections, resulting in improved access to mainland Denmark, as another key impact. The Finnish focus group underlined the effects that electric aviation could have on businesses in the region. By facilitating closer cooperation between industries in the various destinations, electric aviation could help the region discover new business opportunities. In the case of Iceland, the discussion focused on better accessibility, assuming that electric aviation results in increased flight frequency, lower airplane ticket prices and/or number of airports in domestic aviation. Electric flights could enable people to reach both necessary services and remote areas without journeys taking several hours. Similarly, in the Norwegian case, key impacts included good accessibility from Bodø to the Lofoten islands, which could counter outmigration and provide easier access to services. Moreover, it would significantly contribute to the sustainable tourism label of the Norwegian region, which could further boost tourist interest. Finally, the Swedish case highlighted a variety of possible impacts; creating a regional electric aviation hub could create better accessibility within the north of Sweden, connecting people to services and offering better business opportunities.

The introduction of electric aviation in the Nordic region was generally viewed positively, with expectations of improved sustainability, accessibility and economic opportunities. The unique characteristics highlighted by each focus group underscore the need for a tailored approach to leverage the full spectrum of benefits in each country. As the Nordic region heads towards this transformative shift, continued collaboration, assessment of potential challenges and strategic planning will be essential to maximise the positive impacts of electric aviation in the Nordic countries.

Political impacts:	• Support for green initiatives, such as the "Bright Green Island" vision. • Contribution to a common green Nordic image. • Potential redefinition of traditional borders and routes. • Driving political commitment to financial regulations and incentives. • Contribution to meeting the national climate goals under the Paris Agreement.
Economic impacts:	• Introduction of new financial incentives and taxes (e.g. levying of taxes on non-sustainable fuel types). • Opportunities for new routes and transport hubs. • Potential impact on housing prices and airport locations. • Ability to offer new destinations, especially in remote areas. • Potential for tourism business development. • Enhancement of sustainable tourism labels. • Attraction of environmentally-aware tourists. • Possibility of increased mobility of skilled workers. • Emergence of new business opportunities and interregional cooperation.
Social impacts:	• Improved access to healthcare and education. • Increased connectivity between rural and urban areas. • Potential for enhanced cooperation between hospitals. • Impacts on public services, depending on routes and costs. • Influence on the region's appeal to younger people and students. • Attraction of climate-conscious individuals to electric aviation. • Potential to counteract outmigration and facilitate in-migration.
Technological impacts:	• Inspiration for the development of technology and aviation infrastructure. • Upgrades to airports, including charging stations and better connectivity.
Environmental impacts:	• Reduction of emissions in the operational phase. • Alignment with climate goals and sustainability efforts. • Limited infrastructure requirements and reduced impact on biodiversity. • Potential increase in cargo transport, reducing road traffic. • Pollution during battery production and disposal.

Table 7: Overview of possible impacts of electric aviation. Ten-year scenario.

Aerial photo of Kajaani Airport i Finland.
Photo: Finavia

5. Nordic Learnings for Electric Aviation and Concluding Remarks

The move towards electric aviation marks a significant shift in the trajectory of air travel, promising a more environmentally-friendly way to fly. In the Nordic region – which is known for its commitment to protecting the environment and embracing new technologies – challenges and open questions, as well as multiple ways of overcoming the challenges in question, have to be considered for the future implementation of electric aviation.

Key challenges and open questions for the implementation of electric aviation

Need for continuous technological advancement. This is perhaps the most tangible of the emerging barriers. Challenges like defrosting electric aircraft and maintaining a constant weight throughout flights remain unresolved.

Establishment of new regional connections. As efforts are made to address the technological challenges hindering electric aviation, it is crucial to consider various

modes of transport when establishing new connections between regions. That is particularly relevant to cargo transport, where factors like weight and size may continue to favour lorries or ferries over air transport.

Airport infrastructure upgrades. As the Nordic countries head towards the transition to electric aviation, upgrading airport infrastructure is identified as a common imperative. Despite varying developmental phases, the Swedish region explored in the report seems to be leading the way, highlighting the need for improvements at airports, including facilities and services that cater to the specific needs of electric airplanes.

Strength of regulations and social trust. Anticipated scepticism during the initial phase of introduction of the new technology calls for a solid foundation of regulations and public confidence for seamless operations. The social acceptance of electric airplanes is found to be a critical factor influencing their popularity. Stakeholders must grapple with questions of trust among commuters, addressing these concerns as prerequisites for the successful integration of electric airplanes into the Nordic region's transport system.

Incentives and affordability. Other unanswered questions and challenges that require attention include the pivotal issue of incentives. That is driven by decision-makers' commitment to electric aviation and influenced by migration trends, market dynamics and geographical boundaries. Moreover, the practical matter of ticket prices raises questions about affordability and accessibility for different demographics, further underscoring the need for careful consideration. As showcased by the Danish route Copenhagen-Bornholm, existing transport solutions, even if more polluting, might still appear more viable, as considerably cheaper.

Looking ahead

The analysis developed in this report has shown that for electric aviation to overcome the above-mentioned barriers and be at the forefront of the Nordic transport landscape, a multifaceted approach is essential, requiring strong support from both local and national governing bodies.

Key regulatory frameworks centred around taxation and incentives play a pivotal role, shaping the trajectory of the future electric aviation industry. In this situation, where it appears crucial to identify strong actors to take a clear initiative on the issue, pioneering regions as well as the national states or private actors could make a difference. Regions, being familiar with their own characteristics and specific needs, are well-advised to adopt a proactive stance towards this emerging development. It is in their best interest to advocate for routes that are most compatible with the requirements and opportunities presented by this new mode of transport. In this respect, the case study routes chosen for this report seem to support the findings from the *Accessibility study for electric aviation* (Lundberg, 2022). Indeed, the routes

crossing geographical obstacles and bodies of water appear to be the most competitive during the very early stages of introduction of electric aviation. They would provide the type of a novel benefit especially related to increased geographical accessibility, emission reduction and time saving that could justify the heavy initial investments.

Moreover, exploring alternative sustainable fuels, such as hydrogen or sustainable aviation fuel (SAF), adds another layer to the discussion. Those options indeed present potential advantages in terms of sustainability, cost-effectiveness and ease of implementation compared to fully electric solutions.

The Nordic countries exhibit varying attitudes towards the future of electric aviation. While Norway and Iceland embrace electric aircraft optimistically, Sweden is moderately positive and Denmark and Finland are taking a cautious stance. Despite those differences, electric aviation was found to be a significant opportunity to forge new synergies for regional cooperation, fostering sustainability in the field of travel and potentially elevating regional collaboration and cohesion.

References

Admin Stat Danimarca. (2023). *Age classes by gender, Province of BYEN KØBENHAVN, old-age index and average age of residents* [dataset]. https://ugeo.urbistat.com/AdminStat/en/dk/demografia/eta/byen-k-benhavn/1/3

Adu-Gyamfi, B. A., & Good, C. (2022). Electric aviation: A review of concepts and enabling technologies. *Transportation Engineering*, *9*, 100134. https://doi.org/10.1016/j.treng.2022.100134

Akureyri Hospital. (2022). *Ársskýrsla 2021*. https://assets.ctfassets.net

Akureyri Municipality. (2022a). *Umhverfis- og loftslagsstefna Akureyrarbæjar 2022-2030*. https://akureyri.is/static/research/files/umhverfis-og-loftlagsstefnan-mai-2022pdf

Akureyri Municipality. (2022b). *Grunnskólar á Akureyri*. https://www.akureyri.is/is/thjonusta/menntun/grunnskolar

Akureyri Municipality. (2022c). *Leikskólar*. https://www.akureyri.is/is/thjonusta/menntun/leikskolar

Akureyri Municipality. (2023). *Healthcare Services*. https://www.akureyri.is/en/services/moving-to-akureyri/healthcare-services

Althingi. (n.d.). *Þingskjal nr. 148/2017-2018. Svar samgöngu- og sveitarstjórnarráðherra við fyrirspurn frá Bjarna Jónssyni um stefnu stjórnvalda um innanlandsflug*. https://www.althingi.is/altext/148/s/0297.html

Andersen, I. V. (2022). (Don't) be ashamed during take-off and landing: Negotiations of flight shame in the Norwegian public debate. *Journal of Sustainable Tourism*, 1–21. https://doi.org/10.1080/09669582.2022.2127745

Arbetsförmedlingen. (2023). *Regionala utsikter våren 2023 – Utvecklingen på arbetsmarknaden 2023-2024*. https://arbetsformedlingen.se/download

Ásgeirsson, V. Ö. (2023, May 19). Niceair gjaldþrota. *Vísir*. https://www.visir.is/g/20232417582d/niceair-gjald-throta

Aviation Benefits Beyond Borders. (n.d.). *Sustainable Development Goals and Aviation*. Aviation Benefits. https://aviationbenefits.org/un-sustainable-development-goals/sustainable-development-goals-and-aviation/

Avinor. (2019). *BODØ LUFTHAVN. Skisseprosjekt NLBO. TEKNISK BESKRIVELSE*. https://avinor.no/contentassets/0b930b8661324994bb899d7d12552e06/teknisk-beskrivelse.pdf

Baltic Energy Island. (2023, February 20). Sådan bliver energiøen en vækstmotor. *Balticenergyisland*. https://balticenergyisland.com/da/sadan-bliver-energioen-en-vaekstmotor/

Baumeister, S., Leung, A., & Ryley, T. (2020). The emission reduction potentials of First Generation Electric Aircraft (FGEA) in Finland. *Journal of Transport Geography*, *85*, 102730. https://doi.org/10.1016/j.jtrangeo.2020.102730

Bogason, Á. (2020). *BORNHOLM IN DENMARK: Turning sustainable development into attractive business*.

Bornholms Hospital. (2022). *Sundhedsklynge Bornholm*. https://www.bornholmshospital.dk/om-hospitalet/sundhedsklynge_bornholm

Bornholms Hospital. (2023a). *Afdelinger og afsnit*. https://www.bornholmshospital.dk/afdelinger-og-afsnit

Bornholms Hospital. (2023b). *Overordnet organisation*. https://www.bornholmshospital.dk/om-hospitalet/organisation

Bornholms Hospital. (n.d.). *Nøgletal*. https://www.bornholmshospital.dk/om-hospitalet/organisation

Bornholms Lufthavn. (2023). *Flytider*. https://www.bornholms-lufthavn.dk/passager/flytider

Bornholms Sundheds- og Sygeplejeskole. (2023). *Forside—Bornholms Sundheds- og Sygeplejeskole*. https://bhsund.dk/

Bornholmslinjen. (2023). *Discover Bornholmslinjen*. https://www.bornholmslinjen.com/

Broegaard, R. B. (2022). Rural destination development contributions by outdoor tourism actors: A Bornholm case study. *Tourism Geographies*, *24*(4–5), 794–814. https://doi.org/10.1080/14616688.2020.1795708

Business Center Bornholm. (2023). *Børnepasning og skoler på Bornholm*. https://xn--nstestopbornholm-uob.dk/boernepasning-og-skoler-paa-bornholm/

Business Oulu. (2022). *Oulu, Finland. Accessed on 23 August 2023* [dataset]. https://www.investinoulu.com/community-profile.html

Byggðastofnun. (n.d.). *Íbúafjöldi sveitarfélaga og byggðakjarna Þann 1. Janúar 2023 (Sveitarfélög 2023)* [dataset]. https://www.byggdastofnun.is/is/utgefid-efni/maelabord/ibuafjoldi-1-januar

City of Reykjavík Department of Environment and Planning. (2022). *Reykjavik 2040 Municipal Plan, memorandum (IS) (Green Segment)*. https://reykjavik.is/sites/default/files

Copenhagen Business Academy. (2023). *Copenhagen Business Academy Bornholm*. https://www.cphbusiness.dk/english

Cordova-Pozo, K., & Rouwette, E. A. J. A. (2023). Types of scenario planning and their effectiveness: A review of reviews. *Futures*, *149*, 103153. https://doi.org/10.1016/j.futures.2023.103153

Council of Oulu Region, Council of Kainuu, & Naturpolis. (2023). *Lentoliikenteen aluetaloudelliset vaikutukset*.

Dagsdóttir, E. B. (2022). *Innviðir á Norðurlandi Eystra. Niðurstöður netkönnunar RHA í September 2022*. Rannsóknamiðstöð Háskólans á Akureyri. https://www.rha.is/static/extras/images/innvidir_pdfurvinnsla144.pdf

Degerman, R. (2023a, January 16). Air traffic picked up in Oulu and Kuusamo – northern airports boosted by tourists. *Yle News*. https://www.emeoutlookmag.com/company-profiles

Degerman, R. (2023b, January 16). Lentoliikenne piristyi Oulussa ja Kuusamossa – pohjoisen kenttiä vilkastuttivat matkailijat. *Yle News*. https://yle.fi/a/74-20013127

Destination Bornholm ApS. (2022, March 3). *Bornholm is a green energy island*. https://bornholm.info/en/bornholm-is-a-green-energy-island/

Destination Bornholm ApS. (2023). *How to spend a sustainable holiday on Bornholm*. https://bornholm.info/en/sustainable-holiday/

Directorate of Labour. (n.d.). *Greining á atvinnuleysi eftir bakgrunni. Eftir sveitarfélögum – ármeðaltöl* [dataset]. https://view.officeapps.live.com

EASA. (2020). *EASA certifies electric aircraft, first type certification for fully electric plane world-wide*. https://www.easa.europa.eu/en

Edgar, B., Abouzeedan, A., Hedner, T., Maack, K., & Lundqvist, M. (2013). Using scenario planning in regional development context: The challenges and opportunities. *World Journal of Science, Technology and Sustainable Development*, *10*(2), 103–122.

Editorial Team, & Waller, C. (2020, March 15). Akureyri Hospital: High Class Healthcare. *EME Outlook*. https://www.emeoutlookmag.com/company-profiles

Energy Island Bornholm. (2023). *Energy Island Bornholm*. https://www.energiobornholm.dk/en

Ericson, S. (2018, March 3). Skellefteå Airport växer mest – men varför? *Flyg24Nyheter*. https://flyg24nyheter.com/2018/03/03/skelleftea-airport-vaxer-mest-men-varfor/

Ericson, S. (2019, September 1). Finsk flyglinje från Skellefteå? *Flyg24Nyheter*. https://flyg24nyheter.com/2019/01/09/finsk-flyglinje-fran-skelleftea/

Ericson, S. (2020, June 17). Skellefteå satsar på elflyg. *Flyg24Nyheter*. https://flyg24nyheter.com/2020/06/17/skelleftea-satsar-pa-el-flyg/

Ericson, S. (2021a, July 6). Flygskola med elflygplan kommer till Skellefteå. *Flyg24Nyheter*. https://flyg24nyheter.com/2021/06/07/flygskola-med-elflygplan-kommer-till-skelleftea/

Ericson, S. (2021b, August 7). Skellefteå utvecklar teststräcka för vertikalstartande flygtrafik. *Flyg24Nyheter*. https://flyg24nyheter.com/2021/07/08/skelleftea-utvecklar-teststracka-for-vertikalstartande-flygtrafik/

European Commission. (2020). *Three islands receive EU Prize for innovative renewable energy solutions*. https://research-and-innovation.ec.europa.eu/news

Finavia. (2022). *Annual and Responsibility report*. https://www.finavia.fi/sites/default/files/documents/Finavia_Annual-and-responsibility_report_2022

Finavia. (2023, April 17). *Oulu Airport turns 70 – regular scheduled flights started the year the airport was opened.* https://www.finavia.fi/en/newsroom/2023/oulu-airport-turns-70-regular-scheduled-flights-started-year-airport-was-opened

Fingrid. (2022). *Main grid development plan 2022-2031*. https://www.fingrid.fi/globalassets/dokumentit/en/customers/grid-connection/fingrid-main-grid-development-plan-2022-2031.pdf

Flight Connections. (n.d.). *Flights from Bodø*. Flight Connections. https://www.flightconnections.com/flights-from-bod%C3%B8-boo

Global Sustainable Tourism Council. (2018). *Innovation Norway Sustainable Destination Standard is Now a GSTC-Recognized Standard*. https://www.gstcouncil.org/innovation-norway-sustainable-destination-standard-is-now-a-gstc-recognized-standard/

Guide to Iceland. (n.d.). *Akureyri Travel Guide*. https://guidetoiceland.is/travel-iceland/drive/akureyri

Heart Aerospace. (n.d.). *ES-30 Tech Specs*. https://heartaerospace.com/es-30/

Herin, P. (2023, April 29). Nu kastar världens största snabbfärja loss från Skåne. *Dagens Industri*. https://www.di.se/nyheter/nu-kastar-varldens-storsta-snabbfarja-loss-fran-skane/

Herneoja, A., Valli, R., Salanne, I., Metsäranta, H., & Pesonen, H. (2019). *Valtakunnalliset liikenteelliset solmut ja niiden merkitys yhteistyön kannalta*. Väylävirasto Trafikledsverket. https://www.doria.fi/handle/10024/167708

Holopainen, H. (2023, February 20). Jatko varmistui: Maakuntakenttien lennot jatkuvat ensi vuoden huhtikuulle. *Yle News*. https://yle.fi/a/74-20023153

Info Finland. (2023a). *Health in Oulu*. https://www.infofinland.fi/en/oulu/health-in-oulu

Info Finland. (2023b). *Information about Oulu*. https://www.infofinland.fi/en/oulu/information-about-oulu#heading-9d3bec4e-f5e3-47c5-9280-e2d984b83509

International Transport Forum. (2018). *Government Support. Measures for Domestic Air Connectivity*. https://www.itf-oecd.org/sites/default/files/docs/domestic-air-connectivity_0.pdf

Isavia. (2022). *Flugtölur 2022* [dataset]. https://www.isavia.is/media/1/isavia-flugtolur-2022.pdf

Isavia. (2023). *Akureyri Airport – International Gateway*. https://www.isavia.is/media/1/isavia-flugtolur-2022.pdf

Isavia. (n.d.). *Um Akureyrarflugvöll*. https://www.isavia.is/akureyrarflugvollur/um-akureyrarflugvoll

Ísland.is. (n.d.a). *About Akureyri Hospital*. https://island.is/en/o/sak/about-sak

Ísland.is. (n.d.b). *Greiðsluþátttaka vegna ferðakostnaðar innanlands*. https://island.is/greidsluthatttaka-ferdakostnadur-innanlands

Jóhannesson, H. (2015). Provision and Development of SGI at the Edge: The Case of Iceland. *Services of General Interest and Territorial Cohesion. European Perspectives and National Insights*, 167–186.

Jóhannsson, R. (2020, January 31). Niðurgreiðsla á innanlandsflugi hefst í haust. *RÚV*. https://www.ruv.is/frettir/innlent/nidurgreidsla-a-innanlandsflugi-hefst-i-haust

Kainuun hyvinvointialue. (2023). *Wellbeing services county of Kainuu*. https://hyvinvointialue.kainuu.fi/

Kainuun liitto. (2020). *Kainuun älykkään erikoistumisen strategia 2021-2027*. Association of Kainuu. https://kainuunliitto.fi/assets/uploads/2021/09/Alykkaan-erikoistumisen-strategia-julkaisupohjalla.pdf

Kainuun liitto. (2018). *Kainuun liikennejärjestelmäsuunnitelma*. https://kainuunliitto.fi/kaavoitus-ja-liikenne/liikennejarjestelma/

Kainuun liitto. (2023). *Kainuu lukuina*. https://kainuunliitto.fi/tietopalvelut/tilastot/

Karjalainen, E. (2022, February 14). Kuusamon matkailussa ennätysvuosi. *Yle News*. https://yle.fi/a/3-12316419

Karjalainen, E., & Ukkonen, R. (2022, February 8). Koillismaan matkailuväki huolestui Kuusamon lentoyhteyksien tulevaisuudesta. *Yle News*. https://yle.fi/a/3-12559314

Karp, A. (2022). *Norway's New Bodø Airport To Open By 2030*.

Kinnunen, H. (2022, September 6). Maakuntakenttien kaupungit iloitsevat, että Finnair alkaa taas lentää reittejä – toimivia jatkoyhteyksiä on kaivattu. *Yle News*. https://yle.fi/a/3-12610832

Kjarnans, R. (2020, June 20). Segir að Reykjavíkurflugvöllur verði ekki lagður af fyrr en eftir „einhverja áratugi". *Kjarninn*. https://kjarninn.is/frettir

Kristoffersen, B., Walnum, H., & Hansen, K. A. (2018). *Forprosjekt Forkommune Lofoten 2030*. https://ni-backup.ams3.digitaloceanspaces.com/lofotradet/projects

Kuusamon kaupunki. (2023). *Projektit ja hankkeet*. https://www.kuusamo.fi/kaupunki-ja-hallinto/projektit-ja-hankkeet/kuusamon-biopuisto/

Landsnet. (2023). *Kerfisáætlun Landsnets 2023-2032. Langtímaáætlun um þróun flutningskerfis raforku, drög*.

Lapland Chamber of Commerce. (2023). *Setting the steps for accelerating the green transition in the Northern region*. https://lapland.chamber.fi/wp/wp-content/uploads/2023

Liikennevirasto. (2017). *Pohjois-Suomen liikenne- ja logistiikkastrategia*. https://www.pohjois-pohjanmaa.fi/wp-content/uploads/2023/01/Pohjois-Suomen_liikenne-ja_logistiikkastrategia_15-11-2017.pdf

Lofoten. (n.d.). *Lofoten*. Visit Lofoten. https://visitlofoten.com/en

Lofotrådet, Destination Lofoten, & Lofokraft. (2022). *De Grønne Øyene 2030*. https://degronneoyene.no/Veikart_LofotenDG%C3%98_feb22_sisu%20%281%29.pdf

Löfving, L., Salonen, H., & Gísladóttir, S. (2023). *Electric Aviation Outlook in the Nordics*. Nordregio. https://doi.org/10.6027/WP2023:4.1403-2511

Loukkola, P. (2023, January 19). Kuusamon lentokenttä teki uuden matkustajaennätyksen – määrä ylitti ennen korona-aikaa tehdyn aiemman ennätyksen. *Yle News*. https://yle.fi/a/74-20013622

Lundberg, T. (2022). *Accessibility study for electric aviation*. Nordregio. https://nordregio.org/publications/accessibility-study-for-electric-aviation/

Melskens, S. (2017, July 28). Facts about Bornholm. *Destination Bornholm*. https://bornholm.info/en/fakta-om-bornholm/

Memija, A. (2023, May 5). Germany, Denmark probe market for Bornholm Energy Island cable connection(s). *Offshore Energy*. https://www.offshore-energy.biz/germany-denmark-probe-market-for-bornholm-energy-island-cable-connections/

Menntamálastofnun. (n.d.). *Listi yfir skóla*. https://mms.is/listi-yfir-skola

Ministry of Transport and Local Government. (2021). *Svæðisbundið hlutverk Akureyrar Skýrsla starfshóps*. https://www.rha.is/static/extras/images/starfshopur_skyrsla_akureyri_svaedisbundid-hlutverk12.pdf

Municipality of Bornholm. (2018). *Bright Green Island Visionen*. http://www.brightgreenisland.dk/Sider/default.aspx

Municipality of Bornholm. (2022). *Tal & Fakta Befolkningsprognose 2022-2033*. http://www.brk.dk/Om-Kommunen/tal-og-fakta/sider/befolkningsprognose.aspx

Municipality of Bornholm. (2023a). *Folkeskoler på Bornholm*. http://www.brk.dk/Borger/Familie-boern-unge/Skoler/sider/folkeskoler.aspx

Municipality of Bornholm. (2023b). *Patienttransport*. http://www.brk.dk/Borger/sundhedsygdom/Transport/Sider/Transport.aspx

Níelsson, G. (2023, May 25). EasyJet hefur áætlunarflug til Akureyrar. *Vikublaðið*. https://www.vikubladid.is/is/frettir/easyjet-hefur-aaetlunarflug-til-akureyrar

Nordic Council of Ministers. (2023). *THE NORDIC REGION – a sustainable and integrated region? Our Vision 2030 – Status Report 2023*. Nordic Council of Ministers. https://doi.org/10.6027/politiknord2023-728

Nordic Energy Research. (2023). *Overview of Electricity and Energy Capacity for the Establishment of Electric Aviation Routes in the Nordic Region*. Nordregio. https://doi.org/10.6027/WP2023:5.1403-2511

Nordland Fylkeskommune. (n.d.). *Nordland, a rich Region*. https://www.nfk.no/om-fylkeskommunen/engelsk-informasjon/#business-trade-and-innovation

Nordregio. (2022). *Accessibility study for electric aviation*. https://storymaps.arcgis.com/stories/3b35687163744e69a6966b5b9fad976e

Nordregio. (2019, December 11). *Bornholm – a path to sustainability, Denmark*. Nordregio Projects. https://nordregioprojects.org/blog/2019/11/12/bright-green-island-bornholm-in-denmark/

OECD. (2020). *OECD Tourism Trends and Policies 2020-Norway*. https://www.oecd-ilibrary.org/sites/1db86220-en/index.html

OECD. (2022). Norway. Tourism in the economy and outlook for recovery. In *OECD Tourism Trends and Policies*. https://www.oecd-ilibrary.org

Öhlund, A. (2022, June 5). Västerbotten lägst arbetslöshet i Sverige – 3 000 lediga jobb i Skellefteå. *SVT Nyheter*. https://www.svt.se/nyheter/lokalt/vasterbotten/rekordlag-arbetsloshet-i-skelleftea-inte-haft-sa-laga-siffror-pa-manga-ar

Ólafsson, Á. (2023, September 2). Byggingu flugstöðvar á Akureyrarflugvelli hefur seinkað um níu mánuði. *RÚV*. https://www.ruv.is/frettir/innlent/2023-02-09-byggingu-flugstodvar-a-akureyrarflugvelli-hefur-seinkad-um-niu-manudi

Olsen, L. J. (2022). *Nord-Norge tar europeisk posisjon innen grønn luftfart*. https://degronneoyene.no/artikler/nord-norge-tar-europeisk-posisjon-innen-gronn-luftfart

O.Nyumba, T., Wilson, K., Derrick, C. J., & Mukherjee, N. (2018). The use of focus group discussion methodology: Insights from two decades of application in conservation. *Methods in Ecology and Evolution*, *9*(1), 20–32. https://doi.org/10.1111/2041-210X.12860

Osloeconomics, Norconsult, & Nord Universitet. (2022). *Forslag til offentlig kjøp av regionale flyruter*.

Oulu. (n.d.). *Oulu information*. https://www.ouka.fi/en

Pohjois-Pohjanmaa. (2021). *Northern Ostrobothnia Climate Roadmap 2021-2023: Towards a carbon neutral Northern Ostrobothnia*. https://www.pohjois-pohjanmaa.fi/wp-content/uploads/2021/04/Northern-Ostrobothnia-Climate-Road-Map-2021_2030_A63eng.pdf

Pohjois-Pohjanmaan ELY-keskus. (2019). *Oulun lentoaseman liikenneyhteyksien skenaariotarkastelu 2040*. https://www.ely-keskus.fi/documents/

Porter, M. (1985). *Creating and sustaining superior performance*.

Region Västerbotten. (2022). *Skellefteå Lasarett*. https://www.regionvasterbotten.se/vara-sjukhus/skelleftea-lasarett

Ritstjórn. (2023, May 4). Niceair stöðvar starfsemina. *Viðskiptablaðið*. https://vb.is/frettir/niceair-stodvar-starfsemina/

Rome2Rio. (n.d.). *Skellefteå to Oulu*. https://www.rome2rio.com/map/Skellefte%C3%A5/Oulu#r/Drive/s/0

Royal Danish Academy. (2017, September 20). Bornholm Becomes the First World Craft Region in Europe. *Royal Danish Academy*. https://royaldanishacademy.com/news/bornholm-bliver-forste-world-craft-region

Samtök sveitarfélaga og atvinnuþróunar á Norðurlandi eystra SSNE. (2021). *Sóknaráætlun Norðurlands eystra*. https://www.ssne.is/static/files/Arsthing/2021/12.0-soknaraaetlun-2020-2024-endurskodun-2021.pdf

SCB. (2023a). *Folkmängd i riket, län och kommuner 31 december 2022 och befolkningsförändringar 2022* [dataset]. https://www.scb.se/hitta-statistik

SCB. (2023b). *Kommuner i siffror* [dataset]. https://kommunsiffror.scb.se/?id1=2482&id2=null

SCB. (2023c). *Land- och vattenareal per den 1 januari efter region och arealtyp. År 2012 – 2023* [dataset]. https://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__MI__MI0802/Areal2012NN/

Skellefteå. (2019). *Näringslivspolitisk program 2019-2022*. https://skelleftea.se/download

Skellefteå. (2022a). *Skellefteå 2030 – Strategi för hållbar samhällsomvandling*. https://skelleftea.se/download

Skellefteå. (2021). *Batterifabriken: Helhetsförändring i samhället*. https://skelleftea.se/platsen/naringsliv/naringsliv/stories

Skellefteå. (2022b). *Gröna förutsättningar skapar unika tillväxtmöjligheter*. https://skelleftea.se/platsen/naringsliv/naringsliv/stories

Skellefteå. (2022c). *Tillväxtscenario*. https://skelleftea.se/2030/startsida/tillvaxtscenario

Skellefteå. (2023). *Karriär och kompetens – studera*. https://skelleftea.se/platsen/flytta-hit/flytta-hit/karriar-och-kompetens/studera

Skellefteå. (n.d.). *Resor och transporter*. https://skelleftea.se/invanare/startsida/trafik-och-samhallsutveckling/resor-och-transporter

Skellefteå Airport. (2021). *Sveriges kraftigaste elförsörjning för luftfart invigd på Skellefteå Airport*. https://skellefteaairport.se/sveriges-kraftigaste-elforsorjning-for-luftfart-invigd-pa-skelleftea-airport/

Skellefteå Airport. (n.d.). *Om Skellefteå Airport*. https://skellefteaairport.se/om-flygplatsen/#hitta-hit

Skellefteå Kraft. (n.d.). *We are focused on a sustainable future*. https://www.skekraft.se/english_pages/

Skellefteå Works. (n.d.). *Prognos: Så här många bor i Skellefteå 2030, 2035 och 2040*. https://skellefteaworks.se/sa-har-manga-bor-i-skelleftea-2030-2035-och-2040/

Smedberg, A., Norberg, I., Oja, S., Carlson, H.-P., & Rognerud, K. F. (2022). *Electric aviation 2022. Regional prerequisites for electrical aviation*. BioFuel Region and MidtSkandia. https://www.kvarken.org/wp-content/uploads/2022/06/FAIR_Regional_Rapport

Statistics Denmark. (2022). *StatBank Denmark -Labour and Income* [dataset]. https://www.statbank.dk/statbank5a/default.asp?w=1920

Statistics Denmark. (2023). *Statistikbanken—Unemployment* [dataset]. https://www.statbank.dk/AUP01

Statistics Iceland. (2023, September 3). *Mesta fjölgun íbúa frá upphafi*. https://hagstofa.is/utgafur/frettasafn/mannfjoldi/mannfjoldinn-1-januar-2023/

Statistics Iceland. (n.d.). *Tekjur eftir sveitarfélögum og kyni 1990-2021 – Sveitarfélagaskipan 1. Janúar 2022* [dataset]. https://px.hagstofa.is/pxis/pxweb/is/Samfelag/Samfelag__launogtekjur__3_tekjur__1_tekjur_skattframtol/TEK01002.px/table/tableViewLayout1/

Statistics Norway. (2022a). *Befolkningsframskrivinger for kommunene 2022*. https://www.ssb.no/en/befolkning/befolkningsframskrivinger/artikler

Statistics Norway. (2022b). *Population and land area in urban settlements*. https://www.ssb.no/en/befolkning/folketall/statistikk/tettsteders-befolkning-og-areal

Statistics Norway. (2023). *Population and area, by region, contents and year*. https://www.ssb.no/en/statbank/table/11342/

Sturludóttir, R. H. (2019, July 11). Fasteignaverð á Akureyri 75% af verði í RVK. *RÚV*. https://www.ruv.is/frettir/innlent/fasteignaverd-a-akureyri-75-af-verdi-i-rvk

Svenska Kraftnät. (2022, April 25). *FÖN – programmet som ska leverera el till industrierna i norr på rekordtid*. https://www.svk.se/utveckling-av-kraftsystemet/transmissionsnatet

Szromek, A. R. (2019). An Analytical Model of Tourist Destination Development and Characteristics of the Development Stages: Example of the Island of Bornholm. *Sustainability*, *11*(24), 6989. https://doi.org/10.3390/su11246989

Teräs, J., Nygård, Vigdis, Myhr,Sindre, & Karlstad, Stig. (2020a). *Kunnskapsgrunnlag/områdeanalyse NORDLAND, TROMS OG FINNMARK, SAPMI*. https://norceresearch.brage.unit.no/norceresearch-xmlui/bitstream/handle

Teräs, J., Nygård, Vigdis, Myhr,Sindre, & Karlstad, Stig. (2020b). *Kunnskapsgrunnlag/områdeanalyse NORDLAND, TROMS OG FINNMARK, SAPMI*. https://norceresearch.brage.unit.no/norceresearch-xmlui/bitstream/handle

The Norwegian Government. (2023). *Klimaendringer og norsk klimapolitikk*. https://www.regjeringen.no/no/tema/klima-og-miljo

Thorsnæs, G. (2023). *Økonomi og næringsliv i Nordland i Store norske leksikon*. https://snl.no/%C3%98konomi_og_n%C3%A6ringsliv_i_Nordland

Tolpo, A. (2023, January 30). MOT selvitti: Puolityhjät koneet lentävät maakuntiin

valtion piikkiin ministeri kehottaa pohtimaan kannattavuutta tukiaisten sijaan. *Yle News*. https://yle.fi/a/74-20015070

Tomiola, D. (2018, October 30). Doctors on Bornholm—Find the nearest doctor. *Destination Bornholm*. https://bornholm.info/en/doctors-on-bornholm/

Tomiola, D. (2020, December 10). Visit the Visual Artists on Bornholm. *Destination Bornholm*. https://bornholm.info/en/visualarts/

Tomiola, D. (2023). *Take the ferry to Bornholm*. https://bornholm.info/en/ferry/

Trafikstyrelsen. (2023). *Passagerer Overblik-Bornholm*. http://stat.trafikstyrelsen.dk

Trafikverket. (2022). *Norrbotniabanan*. https://www.trafikverket.se/vara-projekt/projekt-som-stracker-sig-over-flera-lan/norrbotniabanan/

University College Copenhagen. (2023). *Besøg Campus Bornholm*. Københavns Professionshøjskole. https://www.kp.dk/uddannelsessteder/campus-bornholm/

University of Oulu. (2023). *New research to drive innovation in aviation and address the risks of space-weather and new electric and hydrogen-powered aircraft*. https://www.oulu.fi/en/news

University of Oulu. (n.d.). *Energy and environmental engineering*. https://www.oulu.fi/en/research-groups/energy-and-environmental-engineering

Valmot, O. R. (2021). *Widerøe skal la passasjerer fly elektrisk om fem år*. https://www.tu.no/artikler/wideroe-skal-la-passasjerer-fly-elektrisk-om-fem-ar/512577

Vestvågøy Kommune. (2022). *KOMMUNEDELPLAN KLIMA, MILJØ OG ENERGI 2022- 2031*. https://www.vestvagoy.kommune.no

Visit Akureyri. (n.d.). *How to Get There: Domestic*. https://www.visitakureyri.is/en/plan-your-visit/transport/how-to-get-there-domestic

VOPD Project Consortium. (2021). *New distance spanning services implemented in the Nordics—Healthcare and Care at a Distance.* New Distance Spanning Services Implemented in the Nordics - HEALTHCARE AND CARE AT DISTANCE. https://www.healthcareatdistance.com/new-distance-spanning-services-implemented-in-the-nordics/

Wendt-Lucas, N. (2023). *Implementing Electric Aviation: Critical Factors and Relevant Policy Instruments*. Nordregio. https://doi.org/10.6027/WP2023:3.1403-2511

Wiik, R. (2022). Elfly med 400 kilometers rekkevidde kan bli vanlig: – Håper å kunne fly allerede i 2026. *VEFSN NO*. https://www.bodonu.no/elfly-med-400-kilometers-rekkevidde-kan-bli-vanlig-i-nord-norge-haaper-aa-kunne-fly-allerede-i-2026/11.05-17:05

World Bank. (n.d.). *Population density (people per sq. Km of land area) – Iceland* [dataset]. https://data.worldbank.org/indicator/EN.POP.DNST?locations=IS

Ydersbond, I. M., Kristensen, N. B., & Thune-Larsen, H. (2020). *Nordic sustainable aviation*. Nordic Council of Ministers. https://nordicelectrofuel.no/wp-content/uploads/2021/05/Nordic-Council-of-Ministers-Nordic-Sustainable-Aviation-DEC-2020.pdf

Appendixes

1. Driving Forces of the Danish Case (Copenhagen-Bornholm)

Political Factors		
Bright Green Island Vision	Probability of Occurrence	5/5
	Level of Significance	3/5
Goal to achieve fossil-free transport	Probability of Occurrence	5/5
	Level of Significance	3/5
Aim to set example for other Green Energy Islands	Probability of Occurrence	3/5
	Level of Significance	2/5
Overall strong political will and commitment	Probability of Occurrence	4/5
	Level of Significance	3/5
Economic Factors		
Need to attract younger people to Bornholm	Probability of Occurrence	5/5
	Level of Significance	2/5
Growing sustainable tourism sector	Probability of Occurrence	5/5
	Level of Significance	3/5
Need to attract qualified workforce	Probability of Occurrence	5/5
	Level of Significance	4/5
Social Factors		
Aging Population	Probability of Occurrence	4/5
	Level of Significance	2/5
Outmigration	Probability of Occurrence	4/5
	Level of Significance	3/5

Accessibility of healthcare	Probability of Occurrence	5/5
	Level of Significance	3/5
Accessibility of education	Probability of Occurrence	4/5
	Level of Significance	1/5
Technological Factors		
Evolving green energy hub	Probability of Occurrence	5/5
	Level of Significance	2/5
Upgrade of airport infrastructure	Probability of Occurrence	2/5
	Level of Significance	2/5
Environmental Factors		
Protection of local flora and fauna	Probability of Occurrence	3/5
	Level of Significance	3/5
Legal Factors		
Lack of rules and regulations of electric aviation	Probability of Occurrence	1/5
	Level of Significance	4/5

2. Driving Forces of the Norwegian Case (Leknes-Bodø)

Political Factors		
Strong political commitment towards the implementation of electric aviation	Probability of Occurrence	5/5
	Level of Significance	4/5
Goal to achieve fossil-free transport	Probability of Occurrence	5/5
	Level of Significance	5/5
Need to establish more sustainable transport connections especially to Lofoten Islands	Probability of Occurrence	5/5
	Level of Significance	5/5
Economic Factors		
Need to attract younger people, students and qualified workforce to the region	Probability of Occurrence	4/5
	Level of Significance	4/5
Keeping the label of sustainable tourism destinations	Probability of Occurrence	5/5
	Level of Significance	4/5
Expected economic revenues from not paying environmental taxes	Probability of Occurrence	4/5
	Level of Significance	3/5
Poor economic incentives and risk of Economic Loss Until Enough Volume Is Reached	Probability of Occurrence	4/5
	Level of Significance	5/5
Social Factors		
Aging population	Probability of Occurrence	5/5
	Level of Significance	3/5
Outmigration	Probability of Occurrence	4/5
	Level of Significance	4/5
Accessibility of healthcare/education (university) from Lofoten	Probability of Occurrence	4/5
	Level of Significance	4/5

Technological Factors		
Increased energy consumption and need for higher energy production	Probability of Occurrence	5/5
	Level of Significance	5/5
Upgrade of airport infrastructure	Probability of Occurrence	5/5
	Level of Significance	5/5
Hybrid (green hydrogen) vs fully electric	Probability of Occurrence	4/5
	Level of Significance	3/5
Grid access/ capacity for charging	Probability of Occurrence	5/5
	Level of Significance	5/5
Environmental Factors		
Protection of biodiversity, especially in Lofoten	Probability of Occurrence	5/5
	Level of Significance	5/5
Reduction of emissions	Probability of Occurrence	5/5
	Level of Significance	5/5
Sustainable energy sources	Probability of Occurrence	5/5
	Level of Significance	5/5
Legal Factors		
Mandatory requirements for emission reduction (EU/national/regional)	Probability of Occurrence	5/5
	Level of Significance	5/5

3. Driving Forces of the Icelandic Case (Akureyri – Reykjavík)

Political Factors		
Electrification of domestic flights seen as an opportunity	Probability of Occurrence	5/5
	Level of Significance	5/5
Political will/commitment - Working group that developed a strategy and plan for action concerning the energy transition in aviation in Iceland	Probability of Occurrence	3/5
	Level of Significance	5/5
Achieving carbon neutrality before 2040 and replacing fossil fuels with renewable energy sources by 2050	Probability of Occurrence	3/5
	Level of Significance	5/5
Change in location of Reykjavik airport (excellent current location but plans for moving it in the near future could impact demand)	Probability of Occurrence	1/5
	Level of Significance	5.5
Economic Factors		
High price of flying domestically in Iceland	Probability of Occurrence	5/5
	Level of Significance	5/5
The electrification of the car fleet in Iceland (lower transport cost for driving)	Probability of Occurrence	5/5
	Level of Significance	3/5
Emphasis on a greener economy and ecotourism	Probability of Occurrence	3/5
	Level of Significance	3/5
Social Factors		
Accessibility of public services, ageing population will require more frequent trips to specialized doctors in the capital	Probability of Occurrence	5/5
	Level of Significance	5/5
Acceptability of new technologies, fear of flying in electric airplanes (this could be resolved with hybrid options)	Probability of Occurrence	5/5
	Level of Significance	5/5
Technological Factors		
Availability of necessary infrastructure for charging with stationary or swappable batteries	Probability of Occurrence	5/5
	Level of Significance	5/5

Environmental Factors		
Specific weather conditions (e.g. very low temperatures, windy weather, icing)	Probability of Occurrence	5/5
	Level of Significance	5/5

4. Driving Forces of the Finnish Case (Oulu-Kajaani-Kuusamo)

Political Factors		
Uncertainty about state aid	Probability of Occurrence	4/5
	Level of Significance	4/5
National and EU climate targets	Probability of Occurrence	4/5
	Level of Significance	5/5
Regional development objectives and connections to Helsinki	Probability of Occurrence	4/5
	Level of Significance	4/5
Socioeconomic Factors		
Need to attract workforce to the region	Probability of Occurrence	3/5
	Level of Significance	4/5
New industrial projects	Probability of Occurrence	3/5
	Level of Significance	4/5
Connections to Sweden, Skellefteå	Probability of Occurrence	4/5
	Level of Significance	4/5
Growth in Oulu as a hub	Probability of Occurrence	4/5
	Level of Significance	5/5
Technological Factors		
Wind energy and surplus electricity generation	Probability of Occurrence	2/5
	Level of Significance	3/5
Geographical Factors		
Limited public transport between Oulu, Kajaani and Kuusamo	Probability of Occurrence	5/5
	Level of Significance	4/5
Long distances, effectiveness of travel chains	Probability of Occurrence	3/5
	Level of Significance	4/5

5. Driving Forces of the Swedish Case (Skellefteå – Oulu)

Political Factors		
A strong political commitment to the introduction of electric flight	Probability of Occurrence	4/5
	Level of Significance	4/5
Relevant regional policies/strategies, e.g. targets for fossil-free transport.	Probability of Occurrence	5/5
	Level of Significance	5/5
Cooperation across national borders	Probability of Occurrence	5/5
	Level of Significance	5/5
Economic Factors		
Supply of competence: the need for skilled workers in the green industries	Probability of Occurrence	5/5
	Level of Significance	4/5
Demand for workers in ancillary services such as health and education	Probability of Occurrence	3/5
	Level of Significance	3/5
Need for increased accessibility for companies in the region and research/business networks	Probability of Occurrence	5/5
	Level of Significance	5/5
Establish sustainable transport connections to Finland	Probability of Occurrence	3/5
	Level of Significance	2/5
Uncertain market: weak economic incentives for electric aviation and risk of economic losses until sufficient capacity is reached.	Probability of Occurrence	5/5
	Level of Significance	4/5
Social Factors		
Accessibility to public services, e.g. health services	Probability of Occurrence	3/5
	Level of Significance	2/5
Acceptance of new technologies (such as electric aircraft)	Probability of Occurrence	4/5
	Level of Significance	4/5
High demand for population growth & migration	Probability of Occurrence	3/5
	Level of Significance	3/5

Technological Factors		
Investment in electric/hybrid aircraft, upgrading Skellefteå Airport infrastructure and access/capacity for charging	Probability of Occurrence	5/5
	Level of Significance	5/5
Network of actors: collaborations and projects, green flight school, etc.	Probability of Occurrence	4/5
	Level of Significance	5/5
Certification processes (of new technologies)	Probability of Occurrence	5/5
	Level of Significance	5/5
Specific weather conditions (e.g. very low temperatures)	Probability of Occurrence	4/4
	Level of Significance	4/4
Environmental Factors		
Climate impact & emission reduction	Probability of Occurrence	5/5
	Level of Significance	5/5
Sustainable energy sources	Probability of Occurrence	5/5
	Level of Significance	5/5

About this publication

Ten-year Regional Outlook: Future Perspectives for Electric Aviation in the Nordic Region

Rebecca Cavicchia, Jonas Kačkus Tybjerg, Hilma Salonen, Maja Brynteson, Nicola Wendt-Lucas, Sæunn Gísladóttir and Hjalti Jóhannesson

Nordregio report 2024:8
ISBN: 978-91-8001-095-5
ISSN: 1403-2503
DOI: http://doi.org/10.6027/R2024:81403-2503

Maps: Karina Berbert Bruno
Layout: Mette Agger Tang
Cover Photo: iStock

Nordregio

Nordregio is a leading Nordic and European research centre for regional development and planning, established by the Nordic Council of Ministers in 1997. We conduct solution-oriented and applied research, addressing current issues from both a research perspective and the viewpoint of policymakers and practitioners. Operating at the international, national, regional and local levels, Nordregio's research covers a wide geographic scope, emphasising the Nordic and Baltic Sea Regions, Europe and the Arctic.

Nordregio
Holmamiralens Väg 10
Skeppsholmen
Stockholm, Sweden
www.nordregio.org