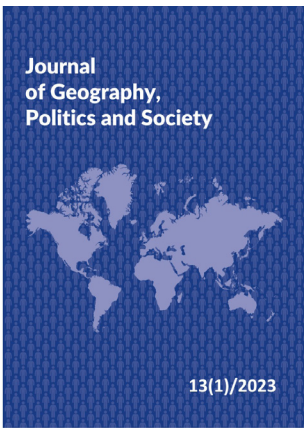

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TECHNOLOGICAL TRANSITION TO ELECTRIC AVIATION IN THE KVARKEN REGION: A REVIEW OF THE FAIR REPORTS (FINDING INNOVATIONS TO ACCELERATE THE IMPLEMENTATION OF ELECTRIC REGIONAL AVIATION)

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Abstract
Accelerating technological transitions (TT) from carbon-based aviation to Electric Regional Aviation (ERA) is contingent on increased awareness and innovative ideas. Finding innovations to Accelerate the Implementation of Electric Regional Aviation (FAIR) aims to facilitate TT to electric aviation in the Kvarken-Nordland region of Finland, Sweden, and Norway. This paper reviewed 13 reports used in the FAIR project. These reports suggest that TT will provide many socioeconomic and environmental benefits. These include increased connectivity to new areas with zero operational carbon footprints, reduced cost, and travel time. However, most of the investigations in the FAIR reports focused on economic and technical aspects. Studies suggest that TT is also contingent on human factors such as public engagement and participation. Therefore, this paper notes that it is imperative to increase the knowledge of ERA among young people in higher educational institutions in the region, particularly given that they constitute an integral part of the aviation market. In addition, although the three universities participating in the FAIR project have energy-related studies, which are essential in advancing knowledge on TT, they lack aviation-specific courses. This paper proposes that, in their next agenda, regional actors could advocate for the introduction of a multidisciplinary aviation-centred course into the university curriculum. The idea is that such inclusion not only will increase the knowledge of ERA and the chances for accelerated innovative ideas in the implementation process but could also motivate and spur increased engagement in climate actions among young people.

Key words
Electric Regional Aviation, FAIR Reports, Technological Transitions, Kvarken Region.

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1. Introduction

The FAIR Project (Finding innovations to Accelerate Implementation of Electric Regional Aviation) began in 2020-2022 to support "the early and efficient commercialisation of electric regional flying in the Kvarken-Nordland region» of Finland, Sweden, and Norway (Final..., 2022, p. 2). Many actors participated in the FAIR project, which has four main objectives: determining the best location for ERA implementation, examining the potential business and financial models for ERA implementation, and promoting the market for ERA by increasing public awareness (The Kvarken..., 2022). The major financer

of the project was the EU funding through the Interreg Baltic-Atlantic program. At the same time, the national and regional government, as well as the Nordic Council of Ministers, and municipal and private organisations, constitute the co-founders (The Kvarken..., 2022). The project is broad; hence, the scope of this paper only covers 13 reports used in this phase of the project. FAIR catalyses the kick-start of a lengthy process of implementing ERA. This paper suggests the possible areas to be considered by the regional actors, especially if they have not been considered in the broader project plan transcending the reviewed reports. In other words, the paper captures only the aspects presented in the reports. Figure 1 below shows the regions that constitute the FAIR project and the participating universities:

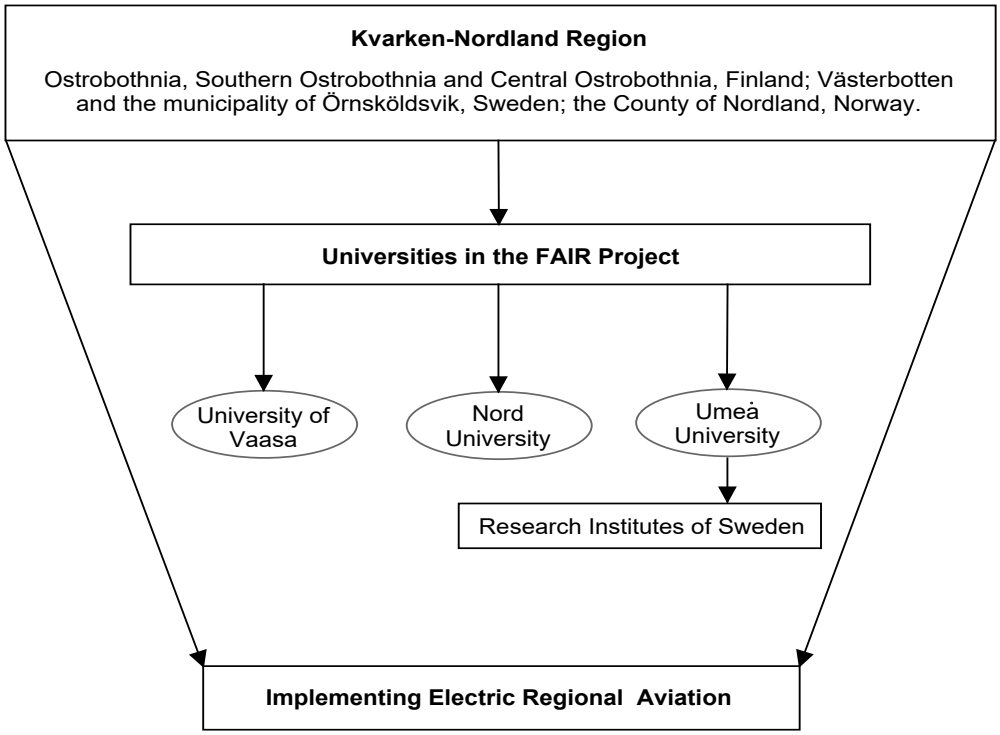

Fig. 1. . Regional actors in the FAIR Project
Source: Final..., 2022, p. 2.

The FAIR project reinforces the claim that energy transition "by region" is driven by institutional actors that collaborate towards co-creating knowledge and finding possible solutions for accelerated decarbonisation (Coenen et al., 2021). The increasing demand for sustainable and low-carbon transportation indicates the evolving societal preference for shifting business strategies to less emitting technological solutions (Mäenpää et al., 2021). In that case, the aviation sector is increasingly gaining attention because considerable decarbonisation gains are expected if the right strategies and policies that enable the transition to electric regional aviation are established (Final..., 2022). Electric Regional Aviation (ERA) is "a new fast and clean mode of transportation, with zero emission alternative optimal for small volumes, and serves as a tool for regional accessibility" (Mäntynen et al., 2021, p. 4). The adoption of new sustainability measures will contribute to technological transitions (TT), which consist of a "change from one sociotechnical configuration to another, involving the substitution of technology, as well as changes in other elements" (Geels, 2002, p. 1258).

The Kvarken-Nordland region has favourable conditions that support the transition to Electric Regional Aviation (ERA) and potential benefits from such transitions. For instance, the region is already a hub to different energy companies interested in sustainable energy solutions; hence, they are expected to boost the actualisation of ERA (Mäntynen et al., 2021). The region also has solid cross-border collaboration within the Kvarken region (Löfmarck et al., 2022). An electric-powered ferry was recently launched as an offshoot of the collaboration. The Aurora Botnia ferry is regarded as an environmentally friendly travel vessel and operates between Vaasa and Umeå (Wasaline, 2020). By leveraging the outlined favourable conditions, many positive impacts could accrue from the shift to electric regional aviation (ERA). These include reduced travel time due to long waiting and transfer

periods for big airport passenger planes, reduced emissions, and improved East-West connectivity challenges between Finland and Sweden (Mäntynen et al., 2021, p. 14). Similar studies reinforce the claim that ERA can substantially reduce or halve travel time due to the direct take-off and landing and high flexibility regarding the location of its operational facilities (Westin, 2021a). In addition, ERA is very suitable in regions separated by water or areas lacking rail connections (Smedberg et al., 2022, p. 29). The strait in Kvarken is an excellent example of a potential beneficiary with the implementation of ERA as it will facilitate competitive travel time across the waters separating some cities such as "Örnsköldsvik, Umeå and Skellefteå on the Western side of the strait with Jakobstad and Vaasa on the Eastern side" (Westin, 2021b, p. 21). In other words, electric regional aviation (ERA) will ensure the cross-border interconnection of areas within relative proximity in the Kvarken region.

Despite the outlined potential benefits, the aviation industry in the Kvarken-Nordland region is still characterised by a demand and supply gap, a high price level, significant passenger focus, lack of competition, and long travel time (ibid, p. 4). Currently, "the time in the air in conventional aircraft is approximately 160 minutes, adding transfer time to include two aircraft changes at airports, the total travel time could reach 380 minutes, at an average door-to-door speed of 200 km/h" (Westin, 2021a, p. 3). Effective governance driven by different international institutions can accelerate the implementation of ERA (Smedberg et al., 2021). Notwithstanding the array of institutions in the aviation industry, some governance challenges still linger in the TT process (ibid, p. 20). For example, there is still an absence of a standardised regulation for electric aviation infrastructure in determining the battery utilisation lifespan (Smedberg et al., 2022, p. 30). Also, there are long bureaucratic procedures concerning regulatory issues and the testing process of emerging technologies (Westin, 2021b). Electric regional aviation is an emerging area. Regional actors working in the FAIR project are better situated to provide governance that could influence how the knowledge of electric regional aviation (ERA) is communicated or spread in the region, especially at the citadel of learning. This paper is a review of reports from the FAIR Project. Figure 2 below highlights the three Nordic countries, Norway, Sweden, and Finland, constituting the Kvarken-Nordland region. The yellow area indicates the routes for the planned implementation of electric regional aviation. The narrow space between Finland and Sweden is the Kvarken strait, and ERA will ensure connectivity across the waters that separate both areas.

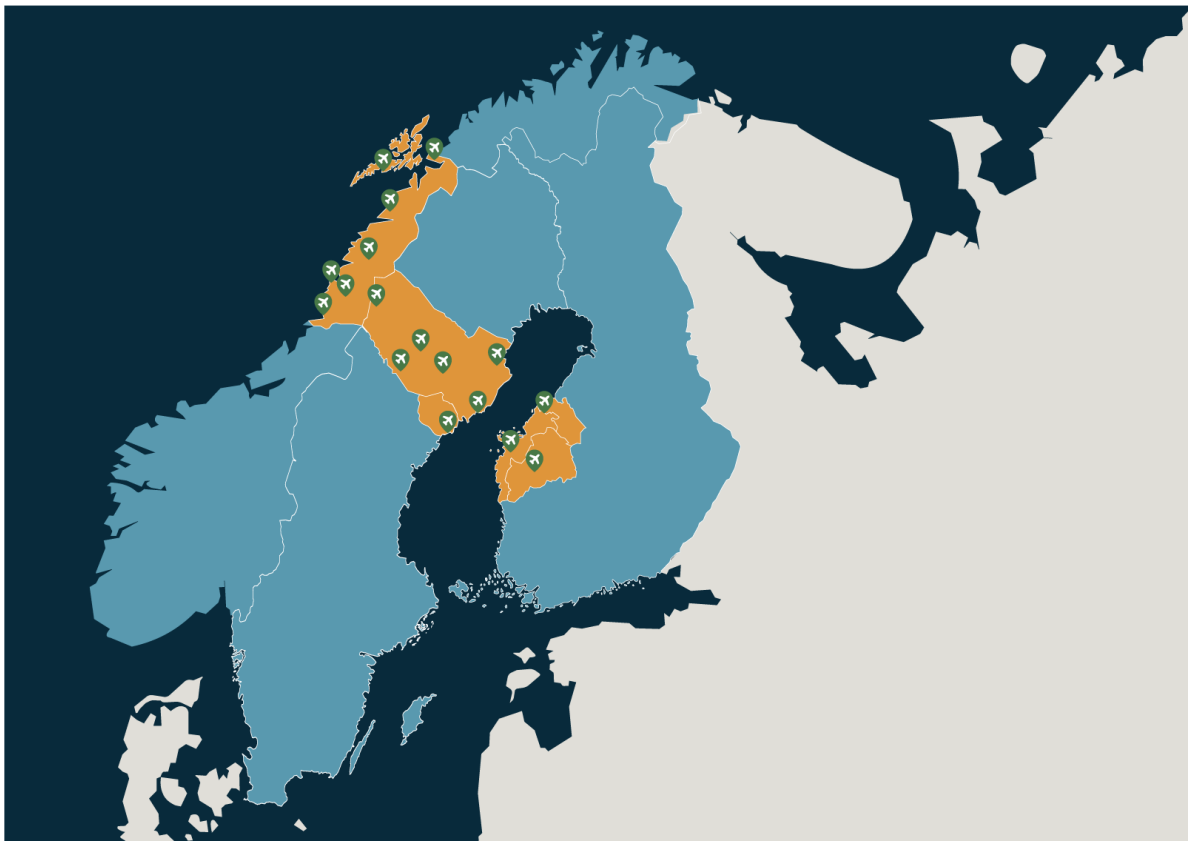

Fig. 2. The area for ERA in the Kvarken-Nordlad region
Source: The Region..., 2022.

This paper aims to find aspects considered vital towards implementing ERA that has received little or no attention in the FAIR reports, as the underexplored aspects could also contribute to the aviation industry's technological transitions and decarbonisation process. In addition, it seeks to understand how regional actors, i.e., the universities participating in the project, can strengthen the implementation of ERA. Hence, the following questions guide the study: Why is an introductory multidisciplinary course on ERA important in the technological transition process in the region? How can this introductory course accelerate the implementation of FAIR in the region? Theoretically, this study will advance the application of technological transitions theory for an increased understanding of factors that can accelerate innovative ideas towards the implementation of ERA. Empirically, the study reveals an existing gap that should be the focus of regional actors in their next agenda towards the implementation of electrical aviation. The paper comprises the following sections: introduction and background to ERA, theoretical underpinning, materials, and methods, followed by a review of the FAIR reports, discussion, and conclusion.

2. Theoretical Framework for Technological Transitions (TT)

Regional energy transitions are complex and involve changes in the technological landscape (Coenen et al., 2021, p. 221). Technological innovation is also considered a vital energy transition pathway (Hess, Sovacool, 2020; Coenen et al., 2021). Technological transition (TT) is a major "long-term technological transformation in the society; it involves not only technological changes but also changes in elements such as user practices, regulation, industrial networks, infrastructure, and symbolic meaning" (Geels, 2002, p. 1257). Other scholars alluded to the claim that different factors or heterogeneous sets of elements must align or combine to ensure TT (Huges, 1987; Rip, Kemp, 1998). For instance, human factors accelerate energy transition through policies that change technology trajectory, public engagement, and participation (Sovacool et al., 2020). Research suggests that people take more climate action and will likely participate in the TT process when they are better informed (Dickson, 2005). Regional actors act as agents of change that construct and influence the energy transition process (Coenen et al., 2021). The academic institution is essential to collective action in the transition process (Creutzig, Kapmeier, 2020, p. 1). Therefore, having a well-informed public is imperative to overcome the many factors that create a communication gap and affect the knowledge of transition initiatives within society. These factors include misconceptions, misinformation, lack of interest, and limited access to information (Creutzig, Kapmeier, 2020, p. 1). In other words, education on climate change and transitions can accelerate effective response (Heiss et al., 2013).

The FAIR reports is one way in which regional actors disseminate scientific knowledge towards the implementation of ERA. Without their input in conjunction with other stakeholders, the goal of TT in the aviation sector will likely not be achieved because the technology requires human agency or actions to become meaningful and valuable. In other words, "technology has no power, does nothing, only in association with human agency, social structures and organisations do technology fulfil functions" (Geels, 2002, p. 1257). While the dissemination of scientific research contributes to bridging the knowledge gap on the energy transition trajectory, it has been criticised for being inadequate in encouraging effective climate action on various levels, such as among individuals, due to its linear information-theoretic model (ibid). This model assumes that the recipient learns information provided by the sender and that communication fails if the information is not correctly decoded by the recipient (ibid, p. 1). The studies further suggested that participatory communication is a more effective way to increase understanding of climate change and TT. Participatory communication often occurs in classrooms at educational institutions where students can actively learn about society's socioeconomic and technological trends. Thus, having a varied source of information can enhance knowledge construction and possible climate action (Nerlich et al., 2010). Empirical inquiry suggests that some context has embraced the introduction of climate and transition-related education into the school curriculum (Chang, Pascua, 2017).

The focus of this paper is to look at the need for introducing an aviation-centric course in the curriculum of the three partner universities in the FAIR project because this will not only complement the scientific reports on the transition to ERA but will also contribute to participatory communication, increased awareness, and innovative ideas vis-à-vis technological transition within the university community, particularly among international students and staff who may be unaware of the TT trends and development in the region's aviation

sector. Theories contribute to advancing contextual understanding of new realities within a geographical context (Gong, Hassink, 2020, p. 475). This paper extends the application of TT theory to the context of the Kvarken region, where electric regional aviation is an emerging new reality; hence, it becomes imperative to facilitate the understanding and analysis of this phenomenon through a theoretical lens.

3. Materials and Methods

This paper is a case study of the FAIR reports using the narrative literature review approach. A case study ensures an in-depth analysis of a phenomenon of interest (Crowe et al., 2011). By focusing on a single case (the FAIR reports), it was possible to analyse and interpret the information in the reports to generate new knowledge that can contribute to accelerated innovation for implementing ERA. A narrative literature review is a "comprehensive narrative synthesis of previously published information; this type of review is typical in social science research" (Green et al., 2006, p. 103; Juntunen, Lehenkari, 2021, p. 2). There is no standardised structure or procedure for a narrative literature review; however, the review should be conducted to align with the journal structure (Baumeister, Leary, 1997; Ferrari, 2015). The key steps prescribed for narrative review were followed here (Ferrari, 2015). They include stating the scope and rationale of the review. The FAIR reports were selected because they are among the most comprehensive context-specific studies on the technological transition in the Kvarken region's electric regional aviation (ERA).

To determine the scope, the webpage Kvarken.org was navigated to become acquainted with the FAIR Project. Then, the final report (summary) was read, which contained an embedded hyperlink to other individual reports utilised in the project. As part of the inclusion criteria, only the reports published between 2020 and 2022 were selected. Thus, 298 pages from 13 reports and information sheets publicly available in English on Kvarken.org used in the FAIR report were reviewed. All the reviewed reports were cited and referenced to ensure the information was credible, verifiable, and valid. The summary of each document used in the FAIR reports was presented; afterwards, the trends in the content of the reports were identified. After that, the findings were separated and categorised based on their relationships. From the review, five categories were identified, and a code was developed for them: Technical – T, Historical – H, Strategic – S, Contextual – C and Practical & innovative – PI. By so doing, it was possible to highlight the aspect covered by the reports and identify essential areas that the regional actors in the implementation process of ERA can consider. Accelerating innovation for ERA via participatory communication in the university setting is one aspect that regional actors could consider. Studies suggest that this communication or information dissemination approach is more engaging among young people (Creutzig, Kapmeier, 2020).

To understand how regional actors, i.e., the universities (Nord University, Umeå University, and the University of Vaasa) participating in the project can contribute to accelerate innovative ideas for ERA, the English-based study programmes and courses available on the university's websites of the three universities that participated in the FAIR Project were scrutinised to ascertain if there are aviation-related courses based on their learning outcomes. Energy, transportation, climate change, innovation, and sustainability-related programmes were included because they are relevant to the study, i.e., they can support TT to ERA. Also, the aviation industry is within the transport sector; hence, the search criteria for courses offered at the three universities in the FAIR project were based on courses that revolve around the elements in the sociotechnical configuration in transportation (cf. Geels, 2002, p. 1258). For easy access, the findings were added as a hyperlink in Table 1. The investigation enabled supporting the proposal for an introductory course on ERA in the curriculum. Lastly, the technological transitions theory was used as an analytical approach to facilitate the understanding of technological transition in the aviation industry in the region and to make sense of the findings. It also facilitates the understanding of how the university, as one of the actors in the FAIR project, can contribute to participatory communication, which could strengthen the implementation of ERA in the Kvarken region.

4. A review of the FAIR reports

This section provides a narrative literature review, i.e., a summary of the FAIR reports to ascertain areas that could be added to the next agenda of the regional actors in the implementation process of electric regional aviation (ERA). The reports were reviewed under the following categories based on their key arguments; the historical and technical background of the aviation sector, the practical and

innovative aspects which cover the prerequisites for ERA and ways to optimise the services, and lastly, the strategic aspects, which focus on leveraging the existing regional energy transition strategies to maximise the potential benefits of ERA. In addition, part of this section scrutinised the courses currently offered at the three universities participating in the FAIR project. The findings reveal how these actors can strengthen the search for innovative ideas towards accelerated ERA implementation.

Table. 1. Summary of findings from the review of the FAIR reports

Reports	Areas covered	Category
Smedberg et al. (2020a)	Evolution of electric aircraft. Advantages & challenges (storage issues)	T
Smedberg et al. (2020b)	Overview of energy carriers Governance challenges, ethical and sustainability issues	T
Smedberg et al. (2021)	Prerequisite for ERA (charging infrastructure &effective governance)	T
Westin, Beijar (2022)	Historical accounts of aviation in the Kvarken region	H
Mäntynen et al. (2021)	Driving factor for ERA (Pandemic, global electrification in the aviation sector)	C
Westin (2021a)	The reason for the absence of ERA (Prioritisation of profit for international routes)	C
Westin (2021b)	Pros of ERA (reduced emissions, low energy consumption & less disruption on the landscape by infrastructure development	C
Smedberg et al. (2022)	Prerequisites for ERA (charging infrastructure, & funding)	PI
Solvoll & Hanssen (2022)	The obligation of the public service (mapping out the energy requirements, learning from others, collaboration)	PI
Peeters et al. (2021)	Prototype for the management of air travel	PI
Mäenpää, Kalliomäki (2022)	S3 economic strategy a boost for ERA implementation	S
Mäenpää et al. (2021)	The Potential impact of ERA (Cross-border cooperation, potential new routes); Next steps	S

Technical – T Historical – H
Strategic – S Contextual – C
Practical & innovative – PI
Source: Own study.

4.1. Technical and historical aspects

One of the FAIR preliminary studies examined essential technological components of an electric aircraft (Smedberg et al., 2020a). Three types of electric aircraft based on their energy storage systems were identified. These include battery electric aircraft, fuel cell aircraft (hydrogen), and hybrid electric aircraft; the latter are of two types: a parallel hybrid and a serial hybrid (ibid, p. 1). A parallel hybrid is a "plane with an electrical and an internal combustion engine. In a serial hybrid, the propellers are powered by one or several electrical motors. The electricity comes from batteries or fuel cells and a generator powered by a turbine engine" (ibid, p. 3). Electric-powered engines are more cost-effective because they require less operational infrastructures, such as shorter runways, primarily because of their ability to take off and land vertically. These innovative technologies are also efficient and have faster acceleration, reduced noise, and emissions compared to carbon-based aircraft (ibid, p. 1). The challenge remains that it can only travel within a short range due to its energy storage capacity. The study also highlighted the leading industries and contexts where these aircraft are manufactured. Pipistrel (Slovenia), MagniX (Seattle, US), ZeroAvia (U.K. and U.S.), H2FLY (Germany), and Ampaire (U.S.).

The subsequent investigation provided an overview of the energy carriers used in the development of electric aviation and the challenges in the development of battery technologies which are a crucial component in electric aircraft (Smedberg et al., 2020b). According to the report, batteries and hydrogen are the two leading energy carriers and can be combined with other energy sources. Despite the importance of batteries, their current storage capacity and the production cost are the two main hurdles in the development process. The absence of international regulation on the length of usage or the lifespan of batteries in the industry constitutes an additional challenge (ibid, p. 1). Beside the regulatory issues, there are other ethical and sustainability concerns regarding where and how

the raw materials required for battery technologies are exploited. The study suggested that recycling will contribute to the battery industry's sustainability and reduce the raw materials needed to produce new batteries and other essential technologies.

Follow-up scrutiny also provided a technical overview of the Infrastructural requirements for ERA (Smedberg et al., 2021). Charging infrastructure, charging standards, electrical grid, and fuel cell infrastructure are some of the vital infrastructures that can support the implementation of ERA (ibid, p. 17). Moving on to other inquiries, the historical accounts of aviation within this context have been investigated to appreciate better the planned technological transitions to electric aviation in the Kvarken region (Westin, Beijar, 2022). Three key dates are significant in the historical evolution of aviation. These are 1918, when the first flight passed the strait of Kvarken, 1951 when the first commercial flight began in the region, and 1960 when regular aviation was initiated by one of the biggest commercial operators, and Finnair/Aero O.Y. began operating in the region (ibid, p. 3).

4.2. Contextual aspect

Studies by J. Mäntynen et al. (2021) include the COVID-19 pandemic as one of the factors that accelerated a demand for a new form of sustainable aviation and a transition to ERA in the region and globally. The pandemic led to less demand for air travel due to travel restrictions, especially on leisure trips, and the substitution of many business trips with virtual meetings. Consequently, this led to the government's collapse and bailout of most airlines; that being the case, sustainable measures are expected to salvage the industry. Another driving factor is the electrification agenda, a current trend in the global aviation industry. Electrification suits smaller aircraft, which fit into cross-regional travel within proximities. Also, the pandemic-orchestrated crisis has opened new opportunities to test sustainable fuels and new technology vis-à-vis electric aviation.

Furthermore, the report posits that ERA in the region is a sustainable and cost-effective tool for meeting the mobility demand and supply; for example, it will contribute to solving the connectivity challenges in the region via a new business model focusing on a smaller number of passengers. Additionally, ERA will also serve as a link to the global and international markets. Most notably, it will provide new supplies that were once limited, such as new routes. Lastly, ERA will support economic activities, such as the export and tourism industries and improve the competitiveness of industries domiciled in the region. These changes will not be drastic but slow-paced due to many interdependent factors in the industry (Mäntynen et al., 2021, p. 6).

Despite all the expected benefits of ERA that can be leveraged, L. Westin (2021a) examined the reason for the absence of ERA. The prioritisation of profitable international routes is one of the challenges. The reason is that electric aircraft are small and do not provide the same profit margin compared to conventional carbon-based aircraft with larger passenger capacity. The unavailability of ERA thus exacerbates the transportation challenges around the Kvarken strait, which not only lacks road and rail connection to the cities around the strait but is also confronted by irregular commercial aviation routes despite the vast potentials and opportunities regular aviation could have provided compared to other modes of transport that are still non-existent (ibid, p. 1). The study also reinforces the claim that reduced travel time will be one potential benefit of implementing TT in the industry. It argues that achieving a sustainable ERA will be contingent on adopting the right strategies to create the needed market, such as increasing the region's population.

Subsequent research reinforced most of the points from preceding investigations on the driving factors, opportunities, and challenges of electric aviation (Westin, 2021b). These include how the change within the sociotechnical landscape in the health sector (COVID-19) facilitated the societal demand for TT towards greener and sustainable mobility. For example, the reduced travel and air traffic orchestrated by the pandemic resulted in a significant reduction of emissions, thus indicating what could be achieved with the transition to electric aviation. The claim that ERA will ensure reduced travel time within the region is reinforced, even though the storage capacity of batteries persists and limits long travel destinations. It concurs with previous studies, which claim that the region's population size, inhabitants' income levels, the region's attractiveness for tourism and other investment purposes, the general travel preference among the residents and the cost involved are some of the determinants for the demand of ERA in the region. Currently, the population size, to a large extent, does not support the needed market for regular and profitable ERA. Hence, measures to attract more people to the region are imperative. One option is increased industrialisation, which leads to job creation and added value to regional assets (ibid, p. 10). The supply side for ERA is contingent on the cost of the airline, offered fares, and airport fees. The

region could also benefit from shifting from being only a consumer of aviation services to a producer of electrical aviation products by leveraging the emerging battery production in the Nordic cluster (ibid, p. 12). As a point of departure from previous inquiries, the studies claim that the justification for TT in the industry is due to the environmental impacts and other existing challenges of carbon-based aviation, such as operational greenhouse emissions and the weak east-west connectivity in the region, which has been unabated by the traditional aviation system (Westin, 2021b).

4.3. Practical and innovative aspects

Subsequent examination analysed the regional prerequisites for ERA (Smedberg et al., 2022). Charging infrastructure (stationary, mobile or a battery backup solution) is identified as one of the main requirements; their electrical demand and charging time vary (ibid, p. 14). The report argues that an airside connection point is currently the most suitable due to the absence of a global charging standard because this provides charging flexibility at airports. Also, they posit that more gain from this infrastructure will accrue to airports that own and operate the charging infrastructure (ibid, p. 30). Further investigation into the national aviation goals and the ownership structure of airports in the Kvarken region reveals a variation in ownership. For example, in comparison, Norway has more state-owned airports, followed by Finland and Sweden being the last. These variations impact regional airports' ERA infrastructural, financial support and investment trajectory, and policymakers face the concomitant challenges (ibid, p. 28). Lastly, the report notes that international efforts and agreements establishing international standardised rules for charging infrastructures are vital to curbing emissions in the industry. Furthermore, financial assistance to regions will contribute towards developing these infrastructures. One option is via support from the Connecting Europe Facility (CEF) fund of the European Union (ibid, p. 17).

The subsequent studies by G. Solvoll, T.E.S. Hanssen (2022) suggest that the public service must fulfil an obligation towards implementing ERA. The key argument is that the government can facilitate ERA in the region by ascertaining the power and energy requirements. Some ways to achieve this involve establishing strong communication, cross-sector and institutional stakeholder cooperation and collaboration; this could be between suppliers and subcontractors (ibid, p. 7). In addition, learning from others is considered a binding obligation that can contribute to the development of ERA. That being the case, intra-sectoral success stories or experiences in the TT within the transport industry in the region can provide valuable lessons across sectors.

While the advantages of ERA have been highlighted earlier, further enquiries suggest an innovative, albeit imaginary, idea that can be used to manage air travel to increase travel flexibility (Peeters et al., 2021). The study introduces FAIR Volta, a booking website for an imaginary airline Volta, specialising in electric air travel in the region (ibid, p. 1). VOLTA is "an imaginary 10-seater electric airline that offers Volta on-demand travel with flexible departure times and prices for the Kvarken region" (ibid, p. 1). Volta provides services that are different from what exists in traditional airlines, such as «door to door, or address to address, instead of airport to airport» booking to ensure the use of the closest airports for trips (ibid, p. 1). Secondly, the services will provide flexible times and prices, meaning «planes can leave at any time, and the schedule will be based directly on the demand of passengers» (ibid, p. 1). Stakeholders are evaluating Volta to determine its pros and cons in regional aviation.

4.4. Strategic aspects

A. Mäenpää, H. Kalliomäki (2022) provided a different dimension to the FAIR project. They examined the potential role of Smart specialisation in implementing electric aviation in the region. Smart specialisation (S3) is a place-based economic strategy developed by the European Commission so that regions can align their development trajectory to suit their existing strengths, potentials, capabilities, expertise, and knowledge (McCann, Ortega-Argilés, 2015). One of the main goals of the region is to transition from carbon-based to green mobility; hence "electric aviation would fit alongside forthcoming battery production activities, as well as the Aurora Botnia ferry project for the transport of human and material resources" (ibid, p. 3). They argue that new areas for S3 are emerging in the region, such as the push for electric aviation and the establishment of the FAIR project to facilitate the implementation process. Other areas include the emergence of battery clusters and regional networks, such as the Nordic battery belt, to accelerate cross-border cooperation. ERA could benefit by leveraging these energy transition trends, and the S3 strategy can thus contribute to identifying the potential path for the shift to electric aviation in the region.

Lastly, stakeholders' view on the potential impact of ERA and its effects on cross-border cooperation, business models, potential new routes and the

possible next steps have been examined via a survey-based investigation (Mäenpää et al., 2021). Many respondents believe that ERA could have a positive impact because it will increase accessibility to the region, especially to smaller cities and rural areas. Also, it will ensure several flexible and smaller cost-effective planes that support commuting to work from multiple locations across the region, support business operations and cooperation, e.g., increasing collaboration via face-to-face meetings crucial for building trust. All these can be accomplished with little or no environmental footprint. Furthermore, different business model could be adopted for ERA, such as «hybrid models with scheduled flights and charter options» (ibid, p. 16). Finally, regarding new ERA routes, some of the most preferred suggestions are a line between Skellefteå and Kokkola, followed by a line between Vaasa and Umeå (ibid, p. 16). The report reveals that the possible next steps to support the early implementation of ERA can be concrete (fast-paced) measures, such as infrastructural development, or research-based (slower-paced) measures that involve organising "competitions (hackathons) at universities for developing business models" (ibid, p. 17). The report concluded that the potential impacts are expected to vary and cannot be all determined now, probably due to its early stages and evolving nature.

As shown in Table 1, there are similar areas of alignment between the reports. Most of them provided background-related information on ERA in the Kvarken region. In contrast, others focused similarly on the technological evolution within the aviation sector, the challenges, and the possible benefits of technological transitions in the industry. The identified benefits of ERA reoccurring in the reports include improved regional connectivity and cooperation, low operational costs, reduced emissions, and travel time. Demographic-related issues and the need to create more attractive opportunities towards increasing the potential market for ERA also constitute a recurring theme in the reports. Other similar focus areas in the reports are the emphasis on the existing institutional gap in terms of the absence of standardised international regulations on charging infrastructure and battery lifespan or usage, which constitutes some of the challenges that could hinder the implementation of ERA. While these reports covered a broad scope, particularly the technical aspects of ERA, an important point to note is that only the online survey in the inquiries by A. Mäenpää et al. (2021) directly involved the opinion of staff working within the university context concerning ERA and the possible educational needs and measures in the implementation phase of ERA. The suggested measure or next steps include organising competitions at the universities.

4.5. Programmes and courses at the three universities in the FAIR project

This paper proposes that the regional actors in the FAIR project should work towards ensuring the introduction of a basic introductory multidisciplinary course on electric aviation, herein referred to as ERA_101 into the university curriculum of the three partner universities in the FAIR project. Table 2 below indicates that many of the courses and research at these universities already deal with energy transitions, sustainability, and transport-related areas; however, none are explicitly targeted at conferring the basic knowledge of ERA in the region. ERA_101 will further increase the knowledge of ERA and the chances for more innovative ideas for accelerated TT in the aviation industry.

5. Discussion

Changes in the technological landscape contribute to energy transitions within the regional context (Coenen et al., 2021, p.221). In addition, different factors or heterogeneous sets of elements combine to ensure TT (Huges, 1987; Rip, Kemp, 1998). The FAIR reports, on the one hand, provide an insight into various technical, historical, and economic factors essential in ERA's implementation. Studies suggest that Human factors accelerate energy transition e.g., through policies that change the technology trajectory, public engagement, and participation (Sovacool et al., 2020). Hence, the collaboration by regional actors in the FAIR project enables the exchange of ideas and knowledge essential for accelerating innovation for the technological transition from carbon to electric-based aviation. The participation of regional actors in the project also reinforces the claim that "technology has no power, does nothing. Only in association with human agency, social structures and organisations do technology fulfil functions" (Geels, 2002, p. 1257).

On the other hand, the FAIR reports provided little coverage on accelerating the knowledge of the current trends in ERA via a participatory approach at the universities. Only the studies by A. Mäenpää et al. (2021) covered issues relating to the role of education and research in the implementation phase of ERA in the region. It notes that one option for enhancing the knowledge of ERA can be via organising "competitions (hackathons) at universities for developing business models" (ibid, p. 17).

Table 2. Energy, climate, transport, and sustainability courses.

Universities	Courses and Programmes in English	Scope
University of Vaasa	Sustainable and Autonomous Systems Smart energy, Industrial Management Industrial Systems Analytics Strategic Project Management	ICT, digitalisation, business studies, supply chain management, technology management, & innovations, data analysis, project implementation in energy, logistics, transportation, operations management, smart & flexible energy system.
Nord University	Business Models for Circular Economy Energy Management Business & Governance in the Arctic Geopolitics and Energy Innovation and Change Processes Sustainability in Practice Considering sustainability	Sustainable resource management, energy governance and business, energy policies, sustainable development, green transition, geopolitics, innovation.
Umeå University	Environmental Science Transportation design Advanced Materials Analyses of Environmental Changes Environmental Governance Sustainability, Destinations & Regional Development GIS for Transportation Solar Cells.	Sustainable & regional development, renewable energy, policy making & implementation, transport networks & flows, design of innovative technology
* + Biannual teacher training to integrate the sustainability perspective into their courses and programmes at Umeå University.		

Source: Own study.

Even though the paper supports the claim that education and research will play an integral role towards generating knowledge that can be translated into practicalities in ERA, such as battery-related research and training, it did not provide a deeper insight into when and how to integrate education and research into the university curriculum in the implementation process of ERA. The study only concluded that "more knowledge is needed, but it is also important to connect experts of varying fields to gather global knowledge and implement it in the Kvarken region" (ibid, p. 18).

The introduction of a multidisciplinary course on electric aviation, herein referred to as ERA_101, into the curriculum of the three universities, as shown, is essential in the technological transitions (TT) in the Kvarken region. Against this backdrop, regional actors such as universities can act as agents of change, which can influence the energy transition process (Coenen et al., 2021). Hence, the rationale for this proposal firstly stems from the prevailing contextual conditions which shape transitions trajectory (Coenen et al., 2021). For example, the planned increase in the population and demographic size in the region is geared towards providing a market for a sustainable ERA (Westin, 2021a). That being the case, young people in higher educational institutions will probably constitute a sizable portion of the projected future new arrivals in the region. With the Ministry of Education and Culture's (2016) strategy of increased internationalisation of studies in Finland, many young people will probably be migrating from outside the region, thus forming a large part of future residence. Most of them will not be well informed about ERA due to several causative factors. For instance, misconceptions about the complex systems in the region on climate change strategies and policies. Also, the different socioeconomic system they will be immigrating from, which differs from the prevailing realities in their new region of residence, is another militating factor. Earlier studies show how the stated factors influence knowledge and behaviours regarding climate and environmental issues (Creutzig, Kapmeier, 2020, p. 1). The highlighted factors could impact young people's decisions and choices towards a greener transportation alternative when they have inadequate knowledge. As F.W. Geels (2002, p. 1257) observes, "TT involves not only technological changes, but also changes in elements such as user practices, regulation, industrial networks, infrastructure, and symbolic meaning". Hence, an introductory multidisciplinary course on electric aviation could increase the knowledge and interest in ERA among students who will constitute an integral part of the aviation market.

An introductory multidisciplinary course on electric regional aviation will increase the chances for accelerated innovative ideas in implementing ERA. For instance, from the online survey conducted in the preceding study by A. Mäenpää et al. (2021, p. 6), respondents were drawn from different organisations such as public organisations (airports, cities, regions, municipalities), companies (50+ personnel), SME (less than 50 personnel), regional development organisation (Vasek, INTO Seinäjoki.), NGOs (chambers of commerce) and higher education institutes or research organisations. However, only five respondents were from higher educational institutions. These respondents represent experts in their various fields. Understandably, students are nonexperts; hence this explains why their views are not represented in the report. That being the case, engaging students via participatory communication in the classroom will provide an opportunity to ascertain students' opinions regarding ERA and can serve as a practical approach for increasing knowledge and collective action. One way to achieve participatory communication is by introducing the basics of ERA into the curriculum at the universities, which will ensure that more students are abreast with the trends of TT in the aviation sector. By so doing, this will likely translate to accelerated knowledge, interest and understanding of decarbonisation within the industry.

An introductory multidisciplinary course on electric aviation could be a source of motivation and spur increased engagement in climate actions among young people in the educational context. The success of decarbonisation hinges on the collective action of different groups in society (Creutzig, Kapmeier, 2020, p. 1). Studies suggest that people take more climate action when they are better informed (Dickson, 2005). That being the case, education relating to climate change will "promote learning about its causes, effects and possible responses, thus providing a cross-curricular and multidisciplinary perspective" (Heiss et al., 2013, p. 4). Technology and innovation are one of the energy transition pathways (Hess, Sovacool, 2020; Coenen et al., 2021). The planned transition to electric aviation in the region is a mitigative response to the impact of climate change. Although there are many programmes and courses on climate change, energy, and sustainability at the universities, as shown in Table 2, courses on ERA are still lacking. The proposed new course on ERA could cover the various areas highlighted in the FAIR project and other socio-technological developments in the region, such as the emerging Nordic battery belt. Finally, the introductory course will complement and broaden the scope of aviation knowledge beyond the traditional aviation schools domiciled outside the Kvarken region, e.g., the Finnish Aviation Academy domiciled in Pori, among others. Lastly, it is imperative to note that the introductory course on electric aviation being advocated for in this study is only a starting point. The idea is that this practice can be extended to other universities in the region that are not participating in the FAIR project.

6. Conclusions

The role of regional actors in the implementation process of electric regional aviation (ERA) must go beyond the current focus on the historical, economic, and technical aspects, as obtainable in the FAIR reports. The next step in the implementation agenda should also focus on increasing the knowledge of ERA within educational contexts because there are potential benefits to leverage towards achieving an accelerated technological transition (TT) to electric aviation. One option is to work towards introducing a multidisciplinary aviation course, herein referred to as ERA_101, into the curriculum of universities participating in the FAIR project. The rationale is that young people in higher educational institutions will continuously form an integral part of the aviation market. Hence, as they become increasingly aware of the TT trends in the region's aviation sector, they can contribute more innovative ideas to the implementation process of ERA. In addition, increased awareness could influence collective action, such as making sustainable transport choices in favour of greener alternatives. As a narrative review, this paper contributes to an increased understanding of the role of regional actors in the decarbonisation process. Theoretically, the paper advances the application of the technological transition perspective for understating energy transitions within the Kvarken regional context. Regional actors may consider and include the proposal from this paper as one option that will complement its planned engagement strategies, such as hosting events, conferences, and seminars. This paper does not provide an insight into how the regional actors may perceive the suggested next step in their subsequent agenda-setting, nor other areas in the project that are not in the reports. Future research could engage the regional actors via a semi-structured interview to gain deeper insight into any recent development vis-à-vis accelerating innovative ideas that may have emerged at the end of the publishing the project reports and the possible strategies for actualising them.

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