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Challenges to an Emerging Ecosystem: A Case Study of the Potential Shift Towards Electric Aviation in Sweden

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Abstract

The transition towards electric aviation is a potential key component in the broader decarbonization of transportation. However, the transition is not only a technological challenge, but also a systemic transition that affects a wide range of institutions and actors. This thesis explores how the potential shift towards electric aviation is reshaping roles and collaborations within the Swedish aviation ecosystem and the barriers that may hinder its implementation. Adopting a qualitative case study approach grounded in ecosystem theory, the study is based on 17 interviews with actors, including airports, energy providers, policymakers, and trade associations. Through thematic analysis, the study identifies shifts in actor roles, especially among municipalities, energy actors, and airports, who assume new responsibilities related to energy infrastructure and coordination. Despite initial signs of ecosystem co-evolution, the transition is slowed by four key barriers: regulatory and institutional misalignments, infrastructure and technological constraints, economic and market-related uncertainties, and collaboration and coordination complexity. The findings suggest, that without strong orchestration, clear governance structures, and shared incentives, the ecosystem risks failure. This thesis contributes to research on sustainability transitions by highlighting how emerging ecosystems develop in a publicly governed context, where actors co-evolution and alignment are crucial for successful implementation.

Keywords: Electric aviation, business ecosystems, sustainability transitions, ecosystem orchestration, institutional barriers, Sweden

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1. Introduction

1.1 Background

The aviation industry doubles in size approximately every 15 years, making it one of the fastest-growing industries globally (Avogadro & Redondi, 2024). However, the rapid expansion of the industry comes with significant environmental costs. According to the International Energy Agency (IEA), aviation in 2023 accounted for 2.5% of global energy-related CO2 emissions, reaching almost 950 million tons of CO2. Aviation emissions have grown faster than road, shipping, and rail between 2000 and 2019 (IEA, 2025). The CO2 emissions from international aviation could triple by 2050 compared to 2015, according to the International Civil Aviation Organization (ICAO). Aviation in the EU is the second largest source of CO2 emissions in the transport sector at 13.9%, after road transport, accounting for 3.8% to 4% of total EU GHG emissions (European Commission, 2023).

The European Commission addresses these challenges with ambitious goals under its Flightpath 2050 initiative. The report published in 2011 aims for future aircraft to significantly reduce aviation emissions through leveraging technological advancements (European Commission, 2011). Sweden, as part of this broader European context, has adopted even more ambitious sustainability goals. The goals Sweden set out to achieve are to have carbon-neutral domestic flights by 2030 and carbon-neutral international flights by 2045 (Svenskt Flyg, 2024). Multiple possible technologies are currently being pursued to achieve these goals, such as Sustainable Aviation Fuels (SAF), hydrogen propulsion, and battery electric aviation (Svenskt Flyg, 2024). Each possible technology has its own operational and infrastructure-related implications, and no single technology is likely to dominate (Christley et al., 2024). Among these potential technologies, electric aviation has gained attention from Swedish actors, especially regarding regional flights and routes (Christley et al., 2024). The potential of zero direct emissions aligns with Sweden's ambitious sustainability goals, especially for domestic flights, and these aircraft are expected to enter the market this decade (Svenskt Flyg, 2024). Although not a complete solution, electric aviation is increasingly seen as one way to support Sweden's sustainability ambitions, and the potential is highlighted in past studies (Salomonsson & Hammes, 2020).

1.2 Research Problem

To align with Sweden's ambitious goals for carbon-neutral aviation by 2030 and 2045, sustainable transitions are considered necessary. However, the shift towards sustainable aviation in Sweden includes multiple interrelated challenges, which encompass more than just technological innovation (Svenskt Flyg, 2024).

By drawing parallels to other industries undergoing a similar transition phase, common challenges can be identified. For example, the electrification of heavy road transport and maritime shipping highlights that such transitions are not only technical but also organizational and institutional. They impact how services are delivered, how actors collaborate, and how investments are coordinated (Guidi et al., 2017; Fenton & Kailas, 2021). Similarly, previous research indicates that the integration of battery-electric aircraft will demand development of high-capacity charging infrastructures, upgrades of the electricity grid, revised operational routines, and new regulatory standards (Schwab et al., 2021). Currently, the aviation industry is deeply interconnected and embedded in the infrastructure, regulatory frameworks, and the actors centered around traditional jet fuels. This complex system is seen as the aviation ecosystem (Schwab et al., 2021). Within this ecosystem, a shift in one area, such as aircraft propulsion, can affect other parts of the value chain, including airport services, energy supply, and governance structures (Babuder et al., 2024). The transition is further complicated by the simultaneous development of multiple sustainable technologies, including SAF, hydrogen, and battery-electric propulsion (Christley et al., 2024). The coexistence of different solutions results in strategic uncertainty, complicates investment decisions, and risks misalignment across actors and institutions (Babuder et al., 2024).

However, this study focuses on electric aviation due to the increasing attention and its potential to transform regional air travel in Sweden (Svenskt Flyg, 2024). Although the electric propulsion is still in early development, which is making it an uncertain case, it still provides a valuable perspective on how sustainability transitions are implemented in real-world settings. Thus, it is of relevance to explore how a potential emerging ecosystem around electric aviation is taking shape. By focusing on how actor roles and relationships are being redefined in response to new technological demands. These shifts highlight uncertainties regarding coordination, system alignment, and how value is created and captured across the changing aviation landscape.

1.3 Purpose and Research Questions

This study aims to explore how the potential transitions towards electric aviation might reshape the Swedish aviation ecosystem as it chases a fossil-free future. It focuses on the evolution of the stakeholders' roles and the formation or reconfiguration of relationships. It also focuses on the challenges that arise as the ecosystems respond to new technological and regulatory demands. Through examining these developments, the study seeks to better understand one of the potential emerging business ecosystems for Sweden's sustainability transition.

To guide this investigation, the thesis is structured around the following two research questions:

- RQ1: How does the potential shift toward electric aviation affect the collaborations and roles within the Swedish aviation ecosystem?

- RQ2: What are the primary barriers to implementing electric aviation in the Swedish context?

1.4 Delimitations

This study is delimited to only focus on the Swedish aviation sector. The decision to only focus on the Swedish context was made due to limited time, available resources, and the practicalities of the data collection. Although aviation operates as a globally interconnected industry, this thesis does not seek to compare international developments or policy landscapes. Instead, it focuses on the Swedish aviation sector, with a particular emphasis on the national effort towards sustainable transformation and electrification. Narrowing the research scope allowed for a deeper and more context-specific analysis of the Swedish aviation sector.

2. Theoretical Point of Departure

This chapter contains the theoretical foundation for analyzing the potential emergence of electric aviation in Sweden as a complex socio-technical transition.

2.1 Sustainability Transitions

Sustainability transitions refer to long-term and systematic transformations within socio-technical systems that aim to tackle complex societal and environmental challenges. Instead of being linear or isolated, these transitions involve interconnected changes across multiple dimensions, including technologies, infrastructures, markets, policies, cultural meanings, and user practices. (Köhler et al., 2019). These transitions are characterized by being open-ended and uncertain. Since multiple innovations and incentives may emerge simultaneously, it is difficult to predict which solution will scale up or succeed. This uncertainty is rooted in the complex non-linear processes of innovation, fluctuating public sentiment, and dynamic political conditions (Geels & Schot, 2007; Rosenbloom, 2017).

In addition, the process is further complicated by different values and disagreements. As sustainability is a normative and often disputed goal, actors differ in their visions of desirable futures. Transitions could affect the economic standing and business models of incumbent industries, which may lead to resistance from these actors who are likely to protect their vested interest and thereby complicate or slow down the transition (Köhler et al., 2019). Given that sustainability generates broad societal benefits, private actors alone are often insufficient to guide transitions. Therefore, strong public policy, such as regulations, subsidies, taxes, and standards, plays an important role in directing the transition towards socially desirable outcomes (Köhler et al., 2019).

To better understand how these complex and multidimensional transitions unfold in practice, it is useful to consider the ecosystem concept. By focusing on the relationships between actors, institutions, and resources. The ecosystem theory provides an understanding of the dynamics within socio-technical and innovation systems.

2.2 Ecosystems

The term ecosystem generally refers to the dependencies on activities within a group of interacting firms (Jacobides et al. 2018). Each member of the ecosystem, regardless of individual strength, is dependent and reliant on the survival of the entire network (Iansiti & Levien, 2004). Ecosystems are structured through a network of mutual dependencies, allowing them to function as a unit. The interconnected system ensures viable and stable relationships in its environment (Kapoor, 2018).

The concept of the ecosystem has been adopted across social sciences and business strategy to describe and explain the complex interconnectedness between various actors in an environment. These relationships facilitate the suitability and success of a focal entity, regardless of company, industry, or technology (Moore 1993, 1996). The definitions of ecosystems have changed over time. Adner (2017) defines an ecosystem as “the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize” (p. 40). In addition, Hannah and Eisenhardt (2018) define ecosystems as “groups of firms that produce products or services that together comprise a coherent solution” (p. 3164), showcasing alignment in definition between authors. Adner (2017) further states that ecosystems are characterized by their relationships and interdependencies, where the networks rely on each other for knowledge, opportunities, and resources. Ecosystems are considered more fluid and adaptive compared to traditional hierarchically structured firms or supply chains, facilitating continuous change to accommodate market dynamics (Jacobides et al., 2018). The overall function and stability of the ecosystem are ensured by the diverse set of actors, often including firms, individuals, government, and institutions (Teece, 2007).

Several factors influence the ecosystem structure, such as the interconnectedness of the network participants and the mechanisms for governance that oversee and regulate interactions. Another crucial factor is the level of collaboration and competition between actors (Iansiti & Levien, 2004). An ecosystem's participants tend to display a high level of heterogeneity due to their origins in various industries (Thomas & Autio, 2020; Jacobides et al., 2018). Interactions between participants are often guided by standards, shared norms, and mutual benefits rather than contractual obligations (Jacobides et al., 2018).

A key element to understand ecosystem structure is the role of links between the different actors. The links between actors specify the different transfers that occur within the system (Adner, 2017). The different types of transfers are divided into material, information, influence, and funds. These links are not limited to the focal actor and occur between different actors within the ecosystem. The four different link types form the operational foundation through which interdependencies and alignment are established within the ecosystem (Adner, 2017).

Moore (1993) introduces a defining feature of co-evolution to the concept of ecosystem. Co-evolution refers to the mutual and dynamic adaptation between the interconnected organizations, making them evolve together (Merry, 1999). The interdependence between organizations drives them to adapt to each other's behaviors, and adapting between organizations fosters a process of co-evolution (Merry, 1999). Moore (1993) explains that firms in an ecosystem co-evolve their capabilities around a new innovation, focusing on supporting new products and satisfying customer needs. The process of co-evolution fosters resilience in an ecosystem, a defining feature of a healthy ecosystem. Coordinating the interdependencies within the ecosystem ensures a sustainable output, while inadequate coordination among the participants risks ecosystem failure (Thomas & Autio, 2020; Adner & Kapoor, 2010).

Ecosystems face several challenges related to coordination, governance, and interdependencies. For example, the smaller actors in ecosystems often receive limited opportunities due to governance and power asymmetry (Moore, 1993). The success of one actor in the ecosystem depends on the efforts of the other actors. The interdependence of an ecosystem makes it vulnerable, a key component's failure risks the entire ecosystem (Adner, 2017).

Jacobides et al. (2018) identified three broad ecosystem groups: “innovation ecosystem,” “platform ecosystem,” and “business ecosystem”.

Innovation ecosystems focus on the development and commercialization of specific innovations through coordinated efforts of independent upstream and downstream actors (Adner, 2006; Adner & Kapoor, 2010). Platform ecosystem centers around a platform sponsor and complementors that enhance the platform value through integrated offerings, often by utilizing structures such as a “hub and spoke” model and shared technologies (Ceccagnoli et al., 2012; Jacobides et al., 2018; Cennamo & Santaló, 2013).

Business ecosystems have a broader economic perspective that emphasizes adaptation and value co-creation between different organizations (Moore, 1993; Iansiti & Levien, 2004; Adner, 2017; Thomas & Autio, 2020). Given that the focus of this study is on innovation implementation rather than development, the business ecosystem perspective provides the most suitable approach.

2.3 Business Ecosystems

The term “business ecosystem” is rooted in business strategy theory and refers to inter-organizational networks that foster both collaboration and competition, which are critical for firm success (Moore, 1993). A business ecosystem revolves around the idea of a value network, highlighted when the participants of the network create value by combining their skills and assets (Scaringella & Radziwon, 2018). A common focal user value proposition is central to the structure of the business ecosystem (Kapoor, 2018). Kapoor (2018) further states that the value proposition can only be realized through various ecosystem participants' combined contributions.

A business ecosystem can create value for individual firms not capable of commercializing a product or service on their own (Scaringella & Radziwon, 2018). Business ecosystems, unlike traditional industry structures, rely on cooperative efforts to facilitate collective value creation

(Gómez-Uranga et al., 2014). The key differentiation between the business ecosystem and traditional value chains is the incorporation of innovation and new business activities. The linear structure of traditional value chains hinders the integration of new elements, which is central to business ecosystems (Gómez-Uranga et al., 2014). This lack of flexibility in traditional value chains makes the ecosystem approach, with its adaptability and flexibility, a rigorous framework for understanding modern economic interactions (Gómez-Uranga et al., 2014).

The introduction of an innovation requires business ecosystems to function as dynamic networks to manage shifts in roles, structure, and interactions within the network (Moore, 1993). Effectively managing these shifts is crucial for the success of the ecosystem, misalignment could hinder the implementation process (Adner, 2017). This shift management may involve changing participants' roles, redefining relationships, and developing new capabilities (Adner, 2017). Business ecosystems may also provide firms with knowledge resources and strategic guidance to manage and navigate these shifts and competitive environments (Scaringella & Radziwon, 2018). Inter-organizational networks are created due to the close interactions of various organizational members that comprise a business ecosystem (Moore, 1993). Another core objective is enabling the firms to achieve competitive advantage through collaboration, which often leads to economies of scale (Clarysse et al., 2014; Iansiti & Levien, 2004).

The business ecosystem possesses two main characteristics: an orchestrator or a keystone firm and a loose network of interconnected participants that collaborate and compete to create value (Clarysse et al., 2014; Iansiti & Levien, 2004). A key component of the business ecosystem structure is the orchestrator or keystone firm that enhances the participants' performances. The orchestrator or keystone firm's role is central to maintaining and developing the business ecosystem by leveraging the ecosystem relationships (Iansiti & Levien, 2004; Moore, 1996). A healthy and sustainable business ecosystem requires a strong keystone firm that manages and supports the network. Additionally, innovative start-ups play a crucial role in fostering consistent growth and evolution within the ecosystem (Iansiti & Levien, 2004). The business ecosystem consists of various interactions between established firms and new ventures. Both cooperation and competition play crucial roles in measuring the ecosystem's success (Adner & Kapoor, 2010; Moore, 1993). Cooperation and competition can occur independently between different participants or simultaneously within the same partnerships, leading to a coopetition relationship (Scaringella & Radziwon, 2018). Coopetition serves as a fundamental element in business ecosystems and occurs when firms collaborate while simultaneously competing in other areas (Scaringella & Radziwon, 2018). The functionality of the ecosystem is ensured by the roles different stakeholders take at various stages during the ecosystem development.

Scaringella and Radziwon (2018) identify two primary types of cooperation within business ecosystems. The first is the ecosystem roles strategy, which defines the interactions between keystone firms and complementors, focusing on fostering and nurturing an effective and sustainable ecosystem (Scaringella & Radziwon, 2018; Iansiti & Levien, 2004). The second is the collective, process-based strategy, which focuses on adoption, adjustment, and convergence for the business ecosystem participants by allowing firms to adapt, align, and integrate their operations effectively (Scaringella & Radziwon, 2018).

2.4 Insights from Electric Heavy Trucks

The following section illustrates how business ecosystem dynamics unfold in practice by drawing insights from the electrification of heavy trucks. This literature provides valuable parallels to the aviation sector regarding the transition of the existing ecosystem. This transition extends beyond vehicle technology and has required shifts across infrastructure, regulatory frameworks, business models, and actor relationships (Dehkordi et al., 2024; Sjödin et al., 2024).

An important aspect of this transition is the growing importance of ecosystem thinking. The deployment of electric trucks involves collaboration between multiple stakeholders, such as vehicle manufacturers, fleet operators, utility providers, regulators, and digital infrastructure companies. Early engagement with electric utilities, development of scalable charging solutions, and adaptation of operational routines and maintenance practices have been required for the successful transitions (Fenton & Kailas, 2021; Bernard et al., 2022).

The concept of complementarity is another important aspect that enables businesses to create strategic partnerships that can leverage shared capabilities and mutual benefits. For example, innovations such as second-life battery applications, smart charging, and charging-as-a-service models illustrate how coordinated innovation across sectors can generate new forms of value while addressing bottlenecks like grid capacity and infrastructure cost (Reinhardt et al., 2020; Dehkordi et al., 2024). These interdependencies require governance mechanisms to manage partnerships and ensure system-wide alignment (Dehkordi et al., 2024).

Projects like Volvo LIGHTS demonstrate how reconfiguration of ecosystems is not led by a single actor but emerges through ongoing coordination that aligns the interests of OEMs, fleet operators, utilities, and policymakers. Furthermore, the need for workforce development and cross-sector knowledge sharing has been highlighted as a notable aspect for enabling effective adoption of new technologies (Fenton & Kailas, 2021).

These transitions do not occur in isolation since policy plays a central role in shaping the conditions for ecosystem change. Strategic regulatory adjustments, financial incentives, and cross-sectoral policy alignments have been shown to accelerate adoption by mitigating the high upfront costs of the charging infrastructure (Bernard et al., 2022; Dehkordi et al., 2024). However, misalignment in policy and uncertainty across energy, transport, and digital sectors can complicate and delay an ecosystem transition, which underscores the demand for long-term and coherent governance frameworks (Sjödin et al., 2024).

2.5 Insights from Electric Ferries

Another example of how sustainability efforts reshape transport ecosystems is provided by the literature regarding the transition towards electric ferries.

As in electric aviation, the transition extends beyond technology to incorporate the development of high-capacity charging infrastructure, cross-sector partnerships, and energy grid coordination (Sæther & Moe, 2021; Andersen et al., 2023). One of the key insights is the demand for strategic complementarity between ecosystem actors. Ferry operators, technology firms, energy storage providers, and grid companies have collaborated and, by joint efforts, reduced infrastructure costs and enabled a renewable integration (Guidi et al., 2017; Seidenberg et al., 2023). One example of joint efforts by the actors is local energy storage on shore to stabilize peak loads and help ensure fast turnaround charging for ferries (Guidi et al., 2017; Seidenberg et al., 2023).

One project that highlights the role of policy alignment, collaboration, and trust is Norway's success with ferry electrification. The government helped reduce first-mover risks, created a stable investment environment, and supported pilot programs, which are essential for ecosystem change (Sæther & Moe, 2021). Standardization and modularity are other insights to help enable an electric transition. Modular design and standards of charging systems allowed for adaptation to differences in routes, regional constraints, and infrastructure capacity (Seidenberg et al., 2023). Ensuring that charging systems remain scalable, efficient, and adaptable to future advancements is essential. Therefore, the continued development of cross-sector partnerships, regulatory frameworks, and digital infrastructure is necessary to support the ongoing growth of the electric ferry ecosystem (Sæther & Moe, 2021; Seidenberg et al., 2023).

3. Methodology

The methodology for this study is structured around the research onion model developed by Saunders et al. (2019). This model was selected because it offers a systematic and layered approach to research design, which helps to guide the researcher through the philosophical, methodological, and practical decisions involved in conducting a robust study. The research onion supports transparency and reflexivity, which makes it easier to communicate and justify the methodological choices in a coherent and logical manner.

The thesis utilizes an abductive, qualitative case study methodology with semi-structured interviews for in-depth data collection. The goal is to facilitate an analysis that addresses the thesis's research aim. The chapter will continue to describe each step in the process and the choices made in the methodology.

This study is a part of a collaborative project conducted together with VTI (The Swedish National Road and Transport Research Institute), which conducted a parallel study that focused especially on the charging infrastructure for electric aviation. Although their research had a narrower scope, the thematic overlap justified conducting joint interviews with selected stakeholders.

3.1 Research Approach

This study utilized an abductive research approach. Abduction is particularly suited for case studies that aim for theory development, as it allows for an iterative process that combines theory and empirical data rather than a rigid deductive or purely inductive process (Dubois & Gadde, 2002). Given the complexity and evolving nature of the ecosystems, this approach ensures flexibility, which allows for theoretical refinements based on emerging insights (Saunders et al., 2019). An advantage of the approach is its ability to enable continuous refinements of the results by redefining the research process as new findings emerge. Instead of strictly defining the research goals from the beginning, abduction allows for a more flexible formulation, enabling the research goals to be gradually refined and thoroughly developed over time. This adaptability ensures that the study remains responsive to significant findings, while at the same time discarding less relevant aspects, which in the end leads to a greater understanding of the phenomenon (Dubois & Gadde, 2002; Saunders et al., 2019). The time horizon of this thesis is cross-sectional, which means that the research collects data at a specific point in time rather than over an extended period. Since this study was conducted within a limited time frame, a longitudinal approach would not be feasible, due to the requirement of prolonged data collection and repeated observation (Saunders et al., 2019).

3.2 Research choice

A qualitative research design was selected for this study to explore the emerging ecosystem for electric aviation since it is a complex and evolving field shaped by diverse stakeholder perspectives, technological uncertainties, and regulatory developments. According to Bell (2010), qualitative research is suitable for studies where the aim is to understand individuals' perceptions of a certain subject. This is especially relevant for studying emerging technologies, where subjective interpretations and social dynamics play a critical role. Additionally, Saunders et al. (2019) highlight that a qualitative research design supports the use of flexible, in-depth methods, which in this case can be utilized to uncover how different actors, such as innovators, policymakers, and infrastructure providers, perceive and shape the development of the emerging electric aviation ecosystem.

3.3 Research Strategy

This thesis utilizes a case study research strategy, allowing for an in-depth examination of the key stakeholders in the aviation ecosystem. Case studies are especially effective for examining real-life contexts where complex processes exist and where boundaries between phenomenon and context are not clearly defined (Bell, 2010). Qualitative case studies are flexible and showcased by how they can be expanded to incorporate a wider set of variables and actors when they serve the research purpose (Bell, 2010). The case study approach enables a more detailed, context-specific insight into the strategies and different perspectives of the stakeholders in the emerging ecosystem. The in-depth nature of a case study aligns well with the study´s abductive research approach (Bell, 2010). The strength of a case study lies in the ability to reveal deep insights that are relatable to similar contexts. Therefore, this methodological choice is particularly suitable for this study.

The initial selection of five participants was conducted by VTI as part of their parallel study on charging infrastructure for electric aviation before the authors joined the broader collaborative project. These participants were later included in this thesis due to thematic relevance and overlap.

Following the initiation of this study, the authors independently selected additional participants through a purposive sampling technique. This method was chosen to ensure that the selection of participants is most likely to provide rich and relevant in-depth information that is aligned with the research objective. The participants were deliberately selected to present relevant knowledge and experience, which increases the likelihood of collecting in-depth data until no new insights emerge (Campbell et al., 2020). In qualitative research, the purposive sampling approach supports a deeper understanding of the subject matter by focusing on the quality and relevance of participant insights rather than the quantity of responses (Campbell et al., 2020).

This sampling process was conducted independently from the VTI´s study to maintain analytical separation and to mitigate potential bias. By selecting participants independently, the authors aimed to ensure a broader and more balanced representation of perspectives within the Swedish electric aviation ecosystem.

In addition to purposive sampling, snowball sampling was also employed to reach further relevant participants. Snowball sampling is a form of convenience sampling that is particularly useful when it is difficult to get in contact with certain individuals. In this method, the current participant helps recruit future participants from their social or professional network. This process also contributes to achieving data saturation and ensuring that a comprehensive range of perspectives is included in the study (Naderifar et al., 2017).

The general guidelines in selecting participants were:

- Have experience and/or insights into the aviation industry
- Existing in the aviation ecosystem currently or deemed to possibly be in the future.

3.4 Selected Participants

The following table describes the selected participants:

Participating Actor	*Role in the Swedish Aviation Industry*
Electric Aircraft OEM 1	An electric aircraft manufacturer based in Sweden, focusing on regional flights.
Electric Aircraft OEM 2	An electric aircraft manufacturer based in Sweden, focusing on regional flights.
Airport Operator 1	An airport operating both regional and international flights based in Sweden.
Airport Operator 2	An airport operating both regional and international flights based in Sweden.
Infrastructure Provider 1	An autonomous vehicle, battery, and charging infrastructure manufacturer based in Sweden.
Governing Actor 1	This actor is a governing body in Sweden.
Trade Association 1	This actor is a trade association in Sweden.
Regional Airport Operator 1	A regional airport operating in Sweden. At the forefront of implementing electric solutions to accommodate electric aviation.

Electric Aircraft OEM 3	An electric aircraft manufacturer based in Sweden, focusing on regional flights.
Network Actor	A network company that provides infrastructure for customers in the south of Sweden.
Trade Association 2	A trade association in Sweden that focuses on aviation
Trade Association 3	A trade association in Sweden that focuses on aviation
Governing Actor 2	This actor is a governing body in Sweden.
Governing Actor 3	This actor is a governing body in Sweden
Governing Actor 4	This actor is a governing body in Sweden
Regional Airport 2	A regional airport similar to Regional Airport 1, but operates in the north of Sweden.
Infrastructure Provider 2	A battery and charging infrastructure manufacturer based in Sweden.

Table 1 describes the participating actors and their roles in the Swedish Aviation Industry

3.5 Data Collection Technique

The primary data collection method for this thesis was semi-structured interviews, which are a widely used technique within qualitative research. This approach offers a balance between structure and flexibility, by enabling the researchers to maintain consistency across the interviews while at the same time allowing the participants freedom to express their perspectives in depth. As noted by DeJonckheere and Vaughn (2019), semi-structured interviews are well-suited for collecting rich, detailed data and for exploring complex experiences and viewpoints.

The interview guide was created to gather relevant insights related to the current operation within the current business ecosystem. With a particular focus on identifying barriers to the implementation of electric aircraft in Sweden. In addition to these core areas, follow-up questions were asked depending on the selected interviewees to foster discussions and capture additional information relevant to addressing the research questions. See Appendix A for the full interview guide.

Ethical considerations have been taken into account to ensure the integrity of the research process and respectful treatment towards the participants throughout this study. Following the ethical research principles outlined by Saunders et al. (2019), appropriate measures were taken at various steps of the data collection to ensure transparency and uphold the participants' trust. All of the interviewees were informed in advance about the purpose of this research and how the data would be handled. Informed consent was obtained from all participants before conducting the interviews. To encourage the participants to speak freely and protect their confidentiality, all data was handled securely, and both personal and company identifiers were anonymized in the published report.

The study employed both face-to-face and internet-mediated video calls, following the approach outlined by Saunders et al. (2019). While face-to-face interviews were the preferred method due to their potential to support richer communication, such as interpretation of body language, and facilitate more fluid and uninterrupted conversation. Practical considerations played an important role in selecting the interview format. Factors including time, cost, and geographical distance influenced the decision to select online interviews as the primary mode of data collection. While this format differs from face-to-face settings, it still enabled the participants and the researchers to engage in meaningful dialogue, even at a distance (Saunders et al., 2019). All of the interviews were recorded and electronically transcribed with the informed consent from the participants to ensure accurate and reliable documentation (Saunders et al., 2019). They were also conducted in Swedish and later translated into English by the research team to align with requirements from the collaborative partners and to ensure consistency in analysis and presentation. After each interview, peer debriefing sessions were conducted to compare the interpretations and to promote a consistent understanding among the researchers. According to Nowell et al. (2017), peer debriefing acts as an external check on the research process and helps to ensure that the findings were not influenced by individual biases and that the analysis maintained a high standard.

As previously mentioned, this study was conducted as part of a broader collaboration with VTI. During the data collection phase, five interviews were conducted with these partners due to overlapping thematic interests. The researcher participated in these joint interviews and was given the opportunity to ask follow-up questions that aligned with this study's research objective. This arrangement enabled a broader exploration of the electric aviation transition while maintaining the focus of this thesis.

Table 2 below presents the full list of the 17 interviews conducted for this thesis. The joint interviews are marked with an asterisk in the “Duration” column.

Participant	Role	Duration (min)	Location	Date (Y-M-D)
Electric Aircraft OEM 1	Battery & Charging Engineer	54*	Online Video Call	2024-12-03
Electric Aircraft OEM 2	Corporate Development Analyst	51*	Online Video Call	2024-12-18
Airport Operator 1	Innovation Manager	56*	Online Video Call	2025-01-09
Infrastructure Provider 1	Director of Autonomous Electric Transport	56*	Online Video Call	2025-02-18
Airport Operator 2	Head of Key Account Management	71*	Online Video Call	2025-03-10
Governing Actor 1	Project Manager	37	Online Video Call	2025-03-27
Trade Association 1	Head of E-mobility	49	Online Video Call	2025-04-01
Regional Airport Operator 1	Business Developer	46	Online Video Call	2025-04-03
Electric Aircraft OEM 3	Head of Research and Development	49	Online Video Call	2025-04-04
Network Actor	Network Manager	46	Online Video Call	2025-04-07
Trade Association 2	Aviation Professional	54	Online Video Call	2025-04-08
Trade Association 3	Project Manager	61	Online Video Call	2025-04-10
Governing Actor 2	Senior Manager Program Management	57	Online Video Call	2025-04-14
Governing Actor 3	Inspector	65	Online Video Call	2025-04-16

Governing Actor 4	Program Manager	70	Online Video Call	2025-04-16
Regional Airport Operator 2	Sustainable Aviation Consultant	66	Online Video Call	2025-04-16
Infrastructure Provider 2	Head of BESS product offer	60	Face-to-Face	2025-04-23

Table 2 describes the data collection from the participating actors

3.6 Secondary Data

Apart from the semi-structured interviews, secondary data sources were also incorporated into the thesis to complement the empirical findings and strengthen the data analysis (Saunders et al., 2019). These sources included government reports, industry publications, and annual reports. This data provided better context, refined the interview questions, and supported the analysis by offering a better understanding of current trends, policy frameworks, and technical developments within the field. By combining these sources with primary data, the study aims to ensure a more comprehensive and robust interpretation of the transition toward electric aviation. This utilization of multiple data sources not only enriches the analysis but also contributes to data triangulation, thereby strengthening the credibility, which aligns with Nowell et al.´s (2017) recommendation to use diverse forms of evidence in qualitative research.

3.7 Data Analysis

The analytical method for this thesis is a thematic analysis approach, which allows for exploration of connections in the empirical data (Williams & Moser, 2019). The analytical method involves a structured process for coding, including open, axial, and selective coding to identify patterns and refine themes. This analytical method is an iterative and reflective process that enables the research group to construct meaning from patterns in the raw data. The thematic analysis enables researchers to develop an in-depth understanding of the studied phenomenon by focusing on the experiences of the participants and identifying recurrent patterns and meanings within the raw data (Williams & Moser, 2019). The analytical method of thematic analysis allows researchers not to be constrained by a pre-existing theoretical framework and enables a close connection to the data to capture the nuanced perspectives of the participants (Williams & Moser, 2019). The process is transparent and rigorous but offers flexibility in handling complex data. Additionally, abductive reasoning is supported by thematic analysis, which enables the researcher to remain open to new emerging insights throughout the analysis (Williams & Moser, 2019). The categories developed by thematic analysis can be linked into a coherent theoretical framework or narrative, which enhances the richness and credibility of the research findings.

First, the research group familiarized themself with the raw data by reading the generated transcripts that VTI provided and listening to the recorded interviews. This initial step helped the research group understand the general context and become immersed in the raw data to start the coding. The process of the thematic analysis approach is described below.

3.7.1 Open coding

Open coding is the first step in the thematic analysis process, and it involves identifying initial concepts, ideas, and patterns from the raw data. The research group engages the data in depth during this step, often line by line, to capture and take out relevant phrases, words, or segments that appear significant (Williams & Moser, 2019). This stage was supported by the use of the online tool Taguette, which is a qualitative analysis tool to manage data. Broad and inclusive initial codes were generated, utilizing an abductive approach where some open codes emerged from insights from the data, and some open codes were derived from existing theoretical concepts. A wide range of perspectives embedded in the participants' experiences was identified through this process. The open coding process facilitates openness and enables the research group to remain responsive if unexpected insights emerge in the raw data (Williams & Moser, 2019). To structure the coding, seven initial categories were developed by the research group, and they were based on key ecosystem concepts from the theoretical point of departure. These predefined categories still allowed for new inductively driven open codes to emerge from the raw data, highlighting the abductive logic of the thesis. The outcome of the first phase was a diverse and rich dataset organized into seven categories to help the research group identify and manage patterns in the data. Table 3 below highlights the seven categories and the number of open codes divided into each.

Categories for raw data	**Number of initial codes**
Actors and Relationships	80
External Influence and Policy	40
Innovation and Adaptation Processes	85
Lessons from Related Ecosystems	25
Resources and Competency Shift	50
Risks, Challenges, and Barriers	130
Important Aspects	55

Table 3 describes the open coding divided into categories

3.7.2 Axial coding

Axial coding is the second step of the thematic analysis process, and it focuses on connecting and organizing the generated open codes into analytically useful and abstract categories (Williams & Moser, 2019). In this phase, the research group began to move beyond the initial categories by examining the relationship between the generated open codes to enable grouping them according to patterns, similarities, or other links (Williams & Moser, 2019). This phase was conducted with the help of Excel spreadsheets, which allowed the research group to systematically cluster, sort, and visually represent links between the open codes. The open codes were color-coded, sorted, and grouped based on merging patterns, relationships, and conceptual similarities. This approach led the research group to identify new thematic groupings based on the patterns and similarities in the open codes. The process was highly iterative and required the research group to extensively discuss and compare the data and groupings. By extending beyond the original categories and taking a broader analytical view, the research group began to identify initial themes grounded in the participants' experiences and the broader systemic context of the dataset. This helped the research group to clarify how different parts of the dataset were connected and build the foundation for the final theme development in the last step.

3.7.3 Selective coding

Selective coding is the final step of the thematic analysis process, and it focuses on refining the core concepts identified during the axial coding and integrating them into a coherent framework that captures the central dynamics of the study (Williams & Moser, 2019). In this step, the research group discussed and identified the most representative and significant core themes derived from the axial coding phase, which effectively convey the essence of the data from the interviews. The selected core themes were revised and discussed multiple times in the research group to ensure a fair and clear representation of the data. Initially, six core themes were identified and constructed based on patterns in the dataset. However, because of thematic overlap and inconsistency, the research group further refined and reconfigured the themes into a final set of four:

- Regulatory and Institutional Barriers
- Economic, Financial, Market-related Barriers
- Ecosystem Coordination and Collaboration Complexity
- Infrastructure and Technological Constraints

These four finalized themes help build the foundation of the findings chapter and reflect the recurring patterns that emerged from the interviews. They were developed through a combination of empirical insights with theoretical reflections. However, these themes primarily help to analyze RQ2, which explores the barriers to implementing electric aviation in Sweden. The open coding phase helps more directly address RQ1, which focuses on evolving roles and collaborations. In the open coding phase, the use of theory-based categories helped the research team identify shifts in actor relationships, inter-organization dynamics, and emerging responsibilities within the aviation ecosystem. This process highlights the abductive nature of the thesis, where both inductive and theory-based insights guided and supported the analytical process to address the two research questions.

4. Empirical Context

The chapter outlines and describes the context in which this study is set and provides the necessary background for understanding the findings section. This empirical context chapter provides overviews of the Swedish aviation sector, the relevant policy developments, and the evolving technological landscape. The contextual elements mentioned in this chapter also help frame the ecosystem-level challenges explored in the findings section, where data from interviewed participants are presented and analyzed.

4.1 Overview of the Aviation Sector

The aviation sector in Sweden plays an important role in maintaining regional connectivity across its country with large geographical distances and low population density in many inland areas. While the state-owned airports, such as Stockholm Arlanda, handle the majority of long-haul travel, the regional airports serve as a meaningful transport for domestic mobility and stability (Wigler et al., 2024). Due to its environmental impact, the aviation sector faces increasing attention (Lee et al., 2023).

As previously mentioned, the Swedish government has set up goals to address the environmental impacts of aviation. Such as fossil-free domestic aviation by 2030 and net-zero emissions from international aviation by 2045 (Energimyndigheten, 2023). These goals are supported by strategic programs such as the government's draft action plan under the AFIR regulation, which outlines infrastructure development to enable sustainable transport, including aviation (Landsbygds- och infrastrukturdepartementet, 2025). Under the initiative *Fossilfritt Sverige,* other steps have been outlined to transform air transport through both SAF and emerging electric aircraft technologies (Al-Ghussein Norrman & Talalasova, 2021). Although SAF plays a role in decarbonizing medium and long-haul flights, electric aviation has been increasingly seen as a viable solution for short-haul regional routes especially in the Nordic context, where flight distances are moderate and the access to the grid is fairly robust (International Air Transport Association, 2023; Babuder et al., 2024). The development of electrical aircraft is currently led by companies such as Heart Aerospace, which aims to deliver battery-electric regional aircraft for commercial use in 2030. The Swedish Energy Agency has highlighted this opportunity as part of a broader transformation in how energy systems and air transport will intersect in the coming decades (Energimyndigheten, 2023).

Despite this momentum, there are several institutional and infrastructural challenges that need to be addressed. Many of the regional airports face declining passenger volumes and operate under tight municipal budgets, which raises concerns about their ability to invest in the needed infrastructure for electrification (Wigler et al., 2024). Furthermore, since the transformation is not only technological but also systematic, new forms of collaboration between the actors in aviation, energy regulation, and municipal governance are required. As airports start to function as integrated energy hubs, not only supporting aircraft, but for balancing the local grid and vehicle charging. This indicated that boundaries of the aviation ecosystem are beginning to expand (Daniels & Eek, 2024).

4.2 Technological Landscape

The implementation of electric aviation creates a new layer of infrastructural needs. Unlike conventional aviation, where the fuel is stored on site, electric aircraft require a high-capacity electricity supply, likely up to several megawatts per plane turnaround. According to Daniels and Eek (2024), Swedish regional airports will need charging systems to handle the future demand. These systems will not only require grid upgrades but also load balancing, cooling technology, and potential energy to manage peak loads. Which could be especially important during wintertime when the electricity supply might be more constrained. In addition, the need for a system-wide coordination between the aviation and energy sectors complicates the transition further. Many of the regional airports are not currently integrated into the local energy planning process or have contractual and technical frameworks in place with the grid operators (Daniels & Eek, 2024). Some municipalities are investigating the use of on-site renewable generation, for example, solar energy combined with battery storage, to meet these needs. However, financial and regulatory uncertainties remain high (Energimyndigheten, 2023).

4.3 Regional or Organizational Specifics

The transformation toward electric aviation is not uniform across Sweden. While national policy sets overarching goals, the actual progress and experimentation are mainly driven by regional initiatives, municipal ownership structures, and individual airport strategies. These local initiatives offer valuable insight into both the opportunities as well as the constraints in the ecosystem transition.

Some smaller regional airports have emerged as key testbeds for electric aviation. For example, Skellefteå Airport has been involved in early pilot projects focused on electric aircraft operations and pilot training using electric aircrafts (Energimyndigheten, 2023). These types of airports are often focused on short to medium-haul flights, which aligns with the expected range and turnaround requirements of early electric aircraft. Their size also allows for more flexible experimentation with the grid integration and charging logistics, compared to the larger and more regulated airports.

5. Findings & Analysis

The findings and analysis chapter presents the empirical findings from the conducted interviews on the topic of transition to electric aviation in Sweden. The chapter is structured to present relevant findings to the study's two research questions. The first part of the chapter addresses RQ1: How the potential shift towards electric aviation affects collaborations and roles within the aviation ecosystem. The research question is addressed by first mapping the existing ecosystem with key actors, their roles, and current inter-organizational relationships. This is followed by an exploration of how these actors, roles, and relationships are expected to shift in an electrified aviation ecosystem. The second part focuses on RQ2: What are the key barriers to the implementation of electric aviation. The research question is addressed through four thematically derived themes, each highlighting distinct areas of challenges, misalignment, or constraint.

5.1 Current Swedish Aviation Ecosystem

The current Swedish aviation ecosystem consists of a diverse but interconnected set of key actors. Each key actor plays a vital role in sustaining the functionality and operation of the Swedish aviation system. The following ecosystem mapping draws on secondary data, including reports from Swedavia, Trafikverket, Svenskt Flyg, and other relevant sources that help map and describe the structure and coordination logic of the current Swedish aviation ecosystem. The secondary data is validated by interviewed participants from the sector, to highlight roles, relationships, and interdependencies that confirm the function of the ecosystem.

Airports are the first key actors in the current ecosystem mapping, and they contribute the fundamental infrastructural resources within the aviation ecosystem. This enables value co-creation between airlines, passengers, and service providers. The airports operating in Sweden consist of state-owned airports, operated by Swedavia AB, and various regional, municipal, and privately owned airports. As Governing Actor 3 confirms, *“We have Swedavia operating its own airports, many municipalities that own their own airports, and a few that are privately owned."* One of the state-owned airport's roles is to connect Sweden both internationally and domestically. They offer services that facilitate cargo traffic and over 30 million passengers annually (Swedavia, 2024). The state-owned airports are complemented by the regional airports in their role of connecting and enhancing accessibility across Sweden. They provide an infrastructure network that connects Sweden and facilitates both passengers and cargo (Swedavia, 2024). Airports actively coordinate relationships with, for example, airlines to handle services and gate access, which facilitates crucial material and information links between the two actors to support operational interdependencies.

The next key actor is airlines, which in the current ecosystem mapping contribute by offering transport solutions within Sweden. The airlines range from the country's primary national carrier to regional carriers (AirlinePros, 2023; Braathens, 2024). The national carrier's role focuses on facilitating national and international travel, enabling the country's global connectivity. The role of the regional airlines is to maintain and facilitate domestic connections, enabling connectivity within Sweden. These carriers serve routes that larger airlines may deem economically unfeasible, making air travel accessible to a broader public (AirlinePros, 2023; Braathens, 2024). As Trade Association 3 observed, "*If we start with the airlines, they've really become a rare breed. There aren't that many airlines operating in Sweden today, and very few of them are actually Swedish. The biggest one is actually more Danish than Swedish. Then there are a few smaller regional carriers."* Mentioning the current fragility of carriers that reflects their reliance on regulatory support and infrastructure access. In turn, airlines rely, for example, on stable policy frameworks and legitimacy provided by governance actors. This forms an influence link where the regulatory bodies oversee aviation in Sweden and enforce policies.

Regulatory bodies and trade associations are the next key actors in the current ecosystem mapping, occupying a governance role within the aviation ecosystem and shaping actor interactions through policy. The ecosystem includes regulatory bodies such as the Swedish Transport Administration and the Swedish Transport Agency. The Swedish Transport Administration is responsible for the planning of the transport system for all types of traffic. The Swedish Transport Agency has overall responsibility for drawing up regulations to achieve good accessibility, high quality, secure, and environmentally aware rail, air, sea, and road transport (Trafikverket, 2021). As Governing Actor 3 underscored, "*The Swedish Transport Agency handles the operational regulations. What's really central in Europe is EASA. They, along with the EU Commission, adopt various aviation regulations."* The ecosystem also includes trade associations such as Svenskt Flyg and Svenska Regionala Flygplatser. Svenskt Flyg fosters policy influence, regulatory alignment, and innovation among the Swedish aviation actors (Svenskt Flyg, 2024). Svenska Regionala Flygplatser represents 33 non-state-owned airports and contributes to ecosystem connectivity by facilitating regional integration and accessibility (Svenska Regionala Flygplatser, 2024). These regulatory and institutional actors especially influence infrastructure development and the management of environmental targets. They influence the practices of, for example, fuel and ground services providers, which form information and influence links that ensure compliance with standards and synchronize operations.

Fuel and ground handling providers are the next key actors in the current ecosystem mapping, providing day-to-day operational continuity and ensuring quality service. Fuel suppliers are involved in the ecosystem and provide resources such as Jet A-1 and SAF, with the latter seen as a resource needed to meet long-term environmental targets (IATA, 2023). These actors create, for example, material links within the ecosystem, which enable the continuous operations and long-term decarbonization efforts. As Trade Association 3 noted, *"On regional airports, there are global fuel suppliers, however, some smaller airports sometimes manage the fuel by themselves,"* showcasing the differences in capacity and processes regarding fuel at Swedish airports. Ground handling providers, whether operated by airports or outsourced, contribute additional material links by facilitating catering, passenger processing, and baggage handling. This highlights the importance of coordination between multiple actors to sustain services and smooth flows throughout the ecosystem.

Manufacturers are the next key actors in the current ecosystem mapping, including globally established aerospace and engine component producers. The backbone of airline operations is formed by these actors delivering components, systems, maintenance services, and aircraft (ICAS, 2022). The manufacturers establish, for example, information and material links with airlines and other operational actors, which form the foundation of aviation value creation. The manufacturers as a central actor in the decarbonization of the aviation industry by developing next-generation low-emission aircraft. As Trade Association 2 mentions, *"The global aircraft fleet is currently around 25,000 to 30,000 aircrafts. The order book is about 11,000, which will be delivered over the next ten years using existing technology. Then those aircrafts will keep flying for another 20 to 25 years."* The participant underscores the long technological life cycle, which dictates the pace of transition, and underlines the strong influence of incumbents. These manufacturers control the critical technologies and existing material interdependencies within the ecosystem. They have the ability to maintain or shift the ecosystem alignment as they see fit because of their position.

Air navigation service providers are the next key actors in the current ecosystem mapping, managing airspace, and air traffic efficiently to ensure smooth and safe operations. LFV (Luftfartsverket) is responsible for air traffic control in Sweden, as well as for the safety and development of Swedish airspace (Trafikverket, 2021). As Governing Actor 3 explained, *"LFV manages air traffic control services."* Their role is a governance function central to the aviation ecosystem, which, for example, shapes critical information links affecting actors such as airlines and airports in how they operate and interact.

Finally, customers are the last key actor in the current ecosystem mapping. The demand of the Swedish aviation ecosystem is represented by both passengers and cargo clients, and they strongly influence both the structure and direction of the ecosystem. Customer expectations and needs shape decision-making regarding operations, service design, route planning, and infrastructure development (Swedavia, 2024). As Airport Operator 1 explained, *"Customer satisfaction for us is mainly the airline, but it's also the passenger in a sense, including a smooth boarding and off-boarding process. Then there are the customers who walk through the terminal and spend money. So there are shops and businesses that are willing to pay rent because they will make money from customers."* In the ecosystem, customers actively affect the value co-creation process with their experiences and behaviors. For example, they generate influence and material links through service expectations, travel choices, and spending patterns, which affect how other actors, such as airports and airlines, configure their operations. This reflects the dynamic and co-evolving nature of interdependencies within the ecosystem.

5.2 Emerging Swedish Aviation Ecosystem

The shift towards electric aviation is not only a technological shift but a thorough reconfiguration of the Swedish aviation ecosystem. The shifts bring new energy and infrastructure needs, create emerging actor interdependencies, and generate regulatory uncertainties, which affect the collaborative nature and alignment structure within the aviation ecosystem. Actors such as airports, energy providers, and municipalities are navigating the coevolving roles and engaging in new inter-organizational coordination. Based on data gathered from the interviews, central shifts are identified and illustrated in the following section. The section describes how actor roles evolve and how new inter-organizational collaborations are created through links, while reflecting on the broader systematic impact of electrification.

5.2.1 Airports as energy providers

The transition towards electric aviation introduces new radical demands on airport infrastructure and challenges the established role of airports in the ecosystem. The role of the airports extends beyond traditional operation, and several participants expect them to manage charging systems, coordinate energy storage, and potentially become part of local energy production and grid operation. The transition creates uncertainties regarding the airport's ecosystem role, and they may turn into what several participants describe as *“local energy hubs”*.

The concept of airports as local energy hubs is an ongoing discussion in the sector, and several participants brought it up. As Trade Association 1 noted, *“It's a difficult challenge, but what's interesting about the airport is that it can be seen as a local energy hub. You'll need to charge cars, airport equipment, and aircraft, so it becomes a localized energy center where different components can be optimized on site.”* The shift towards electrification brings new demand and potentially creates a new role for the airport as an energy provider. A shift from traditional material links (e.g., runways and terminals) towards new material and information links focusing on managing local energy flows, balancing charging needs for aircraft, ground vehicles, and other airport systems. Emphasizing the potential of the new role where airports take responsibility for energy optimization. As Trade Association 3 mentioned, *"On airports, you have a lot of equipment running on diesel and HVO, and then when it’s time to replace them, you often look at electric instead. So there’s quite a large demand, and that’s why we look at the airport’s capacity, it needs to be able to charge its own vehicles. Also, passengers are arriving with their electric vehicles, which need to be charged too. And if we’re going to have electric aviation, the electricity demand at the airport increases significantly."* This highlights an emerging interdependence and co-evolution regarding infrastructure and operations, where airports directly influence both upstream (e.g., energy providers) and downstream (e.g., airlines and passengers) ecosystem actors.

Trade Association 1 continued, *"If you, for example, have an airport that has charging, batteries, and solar cells, you may have times during the year when you have a lot of excess power. Then these volumes of electricity could go back out on the network."* This illustrates how airports can potentially establish new information and material links with the energy grid. It would enable electricity transfer back to the grid as well as the coordination of how and when to transfer. Regional Airport Operator 1 explains the changes already being discussed at their airport, *"We need to produce electricity on the airfield, because we think it is preferable. There will be fewer costs if we produce our own, and it is important to create resilience. The power demands will be high, so it will be difficult to just take energy from the network, and that's where the storage comes in. What can you do with batteries? Balancing the network frequency-wise, if there are any glitches."* This highlights how airports may evolve to become active energy providers within the ecosystem, facilitating both energy system resilience and aviation operations. This enables airports to co-create value for both traditional aviation actors and the energy and infrastructure actors.

However, this evolution is not without friction. Trade Association 3 pointed out, *"And I don't think there's any airport today that claims they will be an energy producer or energy provider. So, it's not exactly obvious that the airport should take on that role, and they might not even be formally allowed to do so at this point.* This reflects on the misalignment between emerging expectations and institutional readiness, which may hinder the creation of new influence and material links between airports and energy actors. The uneven pace of role adaptation across the ecosystem introduces fragmentation and suggests the need for clear governance and shared ecosystem strategy. At the same time, this shift may weaken existing influence and material links between airports and traditional fuel suppliers, as some parts of the operations shift towards electric charging infrastructure.

5.2.2 Energy Providers Expanding Role

The transition towards electric aviation creates new and complex demands on the Swedish energy system and potentially reconfigures the role of energy providers in the aviation ecosystem. Traditionally viewed external actors, energy providers are increasingly expected to deliver more than just electricity. Their evolving role and new responsibilities could include strategic infrastructure planning, system flexibility, and collaborating with airports and other actors in new business models.

Not all energy providers are aware or prepared for the scale of the potential transition. As Governing Actor 2 noted, *"The energy companies haven't realized how big the transition already is for them. They're sort of keeping up, some companies might have done some analysis, but especially the smaller local ones have not to the extent that might be necessary to understand this transition."* This underscores a misalignment in ecosystem readiness and the necessity for new forms of influence and information links between energy providers and actors such as regulators and airports. The increasing demand for energy at airports creates a complementary relationship, where increased value creation depends on synchronized investment and planning across the emerging ecosystem. New customers with different consumption patterns are expected to emerge, highlighted by several participants.

As Trade Association 1 explained, *"The network companies, but also electric actors in general, will get a new type of customer. This will require a new type of relationship where both parties must understand each other better. For the network companies, they will have a very important role in enabling e-flight."* This quote reflects on the need for clear information links and alignment in planning and demand between the actors. The ecosystem's ability to establish infrastructure for electric aviation depends on effective coordination mechanisms.

However, this transition is not without friction. The question of control and ownership regarding charging infrastructure introduces tensions in funds and influence links. As Electric Aircraft OEM 3 puts it, *"The energy companies want to have a big cake of this. They are ready, and they are saying that they have a whole energy solution for us. They put energy storage there, or they can bring new cables to us, and so on. But they want to own that solution."* Meanwhile, Local Energy Provider 1 contended, *"It is the airports that have to take it [ownership], because they offer the service that you can come with an airplane and charge. So it's probably the most probable that it's the airport that has to take it."* These conflicting comments highlight an emerging ecosystem where responsibilities and roles are being negotiated. This also points out an evolving need for role redefinition and governance adaptation.

Despite such uncertainties, there is at least one clear regulation to follow: energy providers are legally obligated to connect a customer when demand is presented. As Trade Association 1 explains, *"It is not the network company or the energy industry that decides that now it's the time to do this. When a customer comes and says, Now we want to have this many megawatts because we are just going to run electric flights on this airport. Then you have a law requirement on you as a network company to fulfill this request."* This quote illustrates that while ownership and commercial arrangements may be debated, regulatory obligations can force energy providers into an emerging aviation ecosystem, which demands co-evolution of planning and infrastructure and long-term alignment between actors.

5.2.3 Municipalities and Regional Actors Taking on New Responsibilities

The electrification of the aviation ecosystem introduces new responsibilities for regional actors and municipalities, especially in the municipalities where regional airports are located or supported. These public actors are shifting from supporting actors in the current aviation ecosystem to a central role for enabling infrastructure transformation, regional accessibility, and energy integration. The broader shift in roles is underscored by the participants, where municipalities are evolving into an active central actor of the emerging aviation ecosystem structure.

Several participants emphasized that municipalities are often the primary funders or owners of regional airports. The ownership creates both material and influence links that facilitate decision-making in shaping infrastructure development. As Trade Association 3 explained, *"We have regional airports that are largely funded by a municipality. Is it then that specific municipality that happens to have an airport that should bear the cost and build new infrastructure? I don't really think so, and that's why we need to look at it from a system* *perspective."* This reflection captures the emerging misalignment between local financial capacities and national ambitions for the transition. Highlighting a fragmentation of fund links across governance levels that hinders effective coordination across the ecosystem. Participants also pointed out that political priorities in municipalities could hinder investments in electric aviation infrastructure, underscoring the need for ecosystem alignment. As Governing Actor 3 noted, *"There's an inherent issue in local politics. Who dares to prioritize electric aviation over elderly care, more teachers in schools, or more hours in preschool? It's politically sensitive."* The tension between political incentives and long-term ecosystem commitments is illustrated by this quote. It also underscores the difficulty of municipalities in allocating resources for uncertain future technologies. These constraints influence links from trade associations and national authorities that seek to promote electrification at the regional level.

Extending beyond financial perspectives, several participants add that municipalities also shape the demand and legitimacy of the emerging ecosystem. As Electric Aircraft OEM 3 pointed out, *"But who benefits from the ability to fly or to travel? It's often the regions, municipalities, cities, and, of course, the travelers themselves. But regions and municipalities are particularly important need-owners, because they want people to live in their municipalities, and those people need to be able to travel elsewhere."* Municipalities play a dual role as demand driver and enabler for regional adoption. They contribute to emerging influence and information links that can guide route planning and public support.

However, inconsistencies in regional readiness and coordination across the ecosystem were mentioned by several participants. For instance, as Trade Association 3 illustrates, *"In the region, the Social Democrats support it together with the Moderates. In the municipality, they are in opposition with the Greens and Left Party and voted against it. So now it's happening anyway, but that kind of political mismatch shows the challenges we face."* This example of mismatch highlights the lack of alignment across political levels, which hinders joint investments and shared transition strategies for evolving the ecosystem.

Despite the challenges, participants also emphasized the opportunities in the potential increase of regional connectivity. As Governing Actor 2 noted, "*There is very little regional air travel compared to what there used to be. So if it can be made cheaper, more sustainable, and so on, then there is quite a large gap to fill there."* Similarly, Regional Airport Operator 2 highlighted, "*It will make it possible to start up routes that would never have been launched under current conditions. So, it provides new and improved local accessibility. But it's not like it's going to be super cheap. This is more about creating new accessibility, expanding labor market regions, and making it more attractive to live in these areas."* These comments underscore how regional actors and municipalities can contribute to complimentary to foster value creation in a regional setting, especially for new routes and justifying infrastructure investment for enabling the electric aviation ecosystem.

5.2.4 Electric Aircraft Manufacturers: A Potential Keystone Firm

Infrastructure development and energy readiness are key components in the transition towards electric aviation. However, several participants emphasize that the shift depends heavily on the emergence of commercialized electric aircraft. Electric aircraft manufacturers are seen as technological catalysts and a potential keystone firm to shape the ecosystem. Keystone firms play a pivotal role in orchestrating collaboration, enabling complementarity among other actors, and maintaining alignments across the ecosystem. Participants discussed that electric aircraft manufacturers not only provide the enabling technology but also influence the direction, pace, and coordination of ecosystem change.

A recurring insight from the interviews is the disruptive nature of electric aircraft technologies and how they challenge existing value chains and actor interdependencies. As Electric Aircraft OEM 3 explained, *"We get in a new technology, that's why it's often called disruptive technology. It's often these current business models and so on that dictate. So, a new technology will come in that makes it possible to do something to change that."* This reflects how the introduction of new aircraft technology challenges existing complementarities and reconfigures the structure of collaboration to co-create value, underscoring the need for established structures to evolve. This also showcases the manufacturers´ ability to reconfigure the ecosystem structure, a core function of a keystone firm. By introducing new timelines, standards, and technologies, they reinforce their potential role as a keystone firm.

However, uncertainties regarding the future demand for operations and infrastructure are brought up by several participants, as the aircraft technology itself is still under development. As Regional Airport 2 noted, *"One day someone will stand there and say, now we have a certified electric or hybrid aircraft. Then you know the technical specifications, the cost, and the safety requirements. But what are its charging needs? What certifications does it have for proximity to other infrastructure?"* These questions underscore the need for information and influence links that connect policy, timelines, and infrastructure development to the progress and transparency of manufacturers. The lack of clear regulatory and technical specifications limits complementarity among actors and their ability to plan, invest, or adapt, which hinders ecosystem alignment.

At the same time, several participants described how electric aircraft manufacturers are expanding their ecosystem role by engaging in inter-organizational collaboration across the aviation ecosystem. As Electric Aircraft OEM 3 mentioned, *"We have a project called Nordic Network for Electric Aviation, where we have the Nordic airlines and airports. We look at* *what new policies are needed, what new routes need to be flown, and what kind of infrastructure is needed."* This illustrates the influence and information links created by manufacturers as they coevolve the direction of the emerging ecosystem, which contribute to coordination and governance efforts across the ecosystem.

However, the interdependencies created by manufacturers also generate risk, especially when planning relies on uncertain timelines. As Governing Actor 1 pointed out, *"It's also difficult, what if they say to the network operator, 'We need this much electricity at this time,' because these aircraft are coming, but then maybe the aircraft doesn't come."* Underscoring again the level of uncertainties regarding the rollout of electric aircraft and the transparency needed for risk-sharing and planning across the aviation ecosystem. This quote also highlights the challenges actors face in coordination under uncertainties. Investments by actors rely on the timelines of manufacturers if they shift the asset risk to become stranded. The misalignment reflects a lack of material, information, and influence links that demand transparency, trust, and shared responsibility.

Trade association 3 extends further on this topic by illustrating that regional actors are waiting for clarity from manufacturers before initiating long-term planning and investments, *"We've come to the point where we have to rethink. Electric aircraft don't exist yet. We don't know exactly how charging will work, the regulatory framework isn't ready. There are a lot of question marks."* This illustrates the central role of manufacturers in evolving the ecosystem structure. Their actions and communications can either delay or enable alignment throughout the ecosystem, reinforcing their role as a potential keystone firm to enable electric aviation. Simultaneously, the information and influence links held by incumbent manufacturers may weaken if they remain outside the transition towards electric aviation, highlighting a potential shift in ecosystem centrality.

5.2.5 Visualizing the Current and Emerging Swedish Aviation Ecosystems

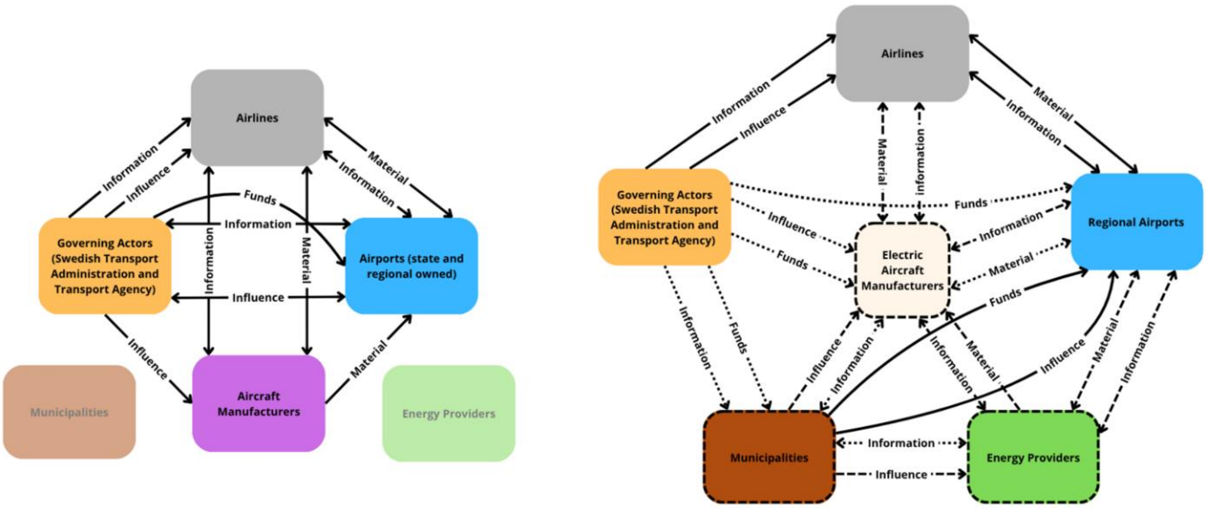

Figure 1 – Conceptual simplification of the current and emerging Swedish aviation ecosystems

These two figures illustrate the structural transition of the Swedish aviation ecosystem as it responds to the potential transition toward electric aviation. The figure on the left maps the current Swedish aviation ecosystem, which is centered around established actors such as Airlines, Airports (state and regionally owned), Aircraft Manufacturers, and Governing Actors (Swedish Transport Agency, the Swedish Transport Administration, and relevant ministries). The figure shows how these actors are connected through a series of material, fund, influence, and information links which help them sustain conventional aviation operations. For example, airports maintain influence and material links with airlines, while governing actors influence regulations, infrastructure, and environmental standards. Energy providers and municipalities are not viewed as central actors in the current aviation ecosystem. Instead, they are primarily viewed as supporting actors that operate in the background rather than as strategic participants. Their roles remain peripheral in the existing configuration, and that's why they appear transparent in the left-hand figure.

The figure on the right presents the emerging Swedish aviation ecosystem that is potentially taking shape in response to electrification. The figure illustrates several structural changes. First, Electric Aircraft Manufacturers enters as a potential keystone firm and is positioned centrally, which establishes new influence, funds, information, and material links throughout the ecosystem. Second, Energy Providers and Municipalities enter and become increasingly central as they take on active roles in infrastructure development, planning, and funding. Third, Regional Airports expand their responsibilities in managing energy systems and coordinating charging needs, reflecting a shift to becoming “local energy hubs.”

The arrows in the figures represent the primary ecosystem links between actors. These links are based on Adner's (2017) categorization of material, information, influence, and funding links, and their directionality reflects the primary flow of influence, information, and resources from one actor to another. However, some arrows are bidirectional, showcasing mutual dependency interaction, while others flow one-way, reflecting asymmetrical influence or responsibility.

- Solid lines represent well-established links in the ecosystem.
- Dashed lines indicate emerging links based on shifting responsibilities.
- Dotted lines highlight weak or underdeveloped links, where coordination, capacity, or legitimacy is still lacking.

To ensure interpretability and clarity, the figures focus on the most frequently discussed and affected actor groups identified during the interviews. The broader aviation ecosystem includes many additional actors, but these were either mentioned less frequently or fell outside the scope of the most impactful when the structural changes were identified. Similarly, many more inter-organizational links exist in practice, the figure specifically highlights those links that were most prominent in the findings and most relevant to the emerging ecosystem. As such, the figures should be viewed as a conceptual simplification aimed at showcasing the core shifts in roles and ecosystem structure rather than as a complete system map.

5.2.6 Summary Analysis of Findings

The shift towards electric aviation can be a potential significant transformation of the Swedish aviation ecosystem, including the evolution of actor roles, coordination structure, and interdependencies. The analysis reveals key shifts that reshape the aviation ecosystem and its alignment structures.

Reconfigured Actor Roles:

Airports are evolving from traditional providers of aviation infrastructure into an energy management role. The concept of airports as an energy hub introduces new needs for complementarities within the ecosystem. Airports can co-create value not only for traditional actors such as airlines but also for energy and infrastructure actors. Producing electricity on-site is considered by airports, which would shift their role towards an energy actor in the emerging aviation ecosystem. This role would include, for example, managing power storage and supporting aircraft and vehicle charging.

Energy providers currently support the aviation ecosystem, but are seen as central actors in the potential emerging ecosystem to enable electric aviation. These actors are expected to support infrastructure planning, regulatory compliance, and foster stability. This positions energy providers in an active central role in the potential emerging electric aviation ecosystem, with new expectations and responsibilities around facilitating collaboration and coevolution.

Municipalities and regional actors are emerging as enablers of policy legitimacy, infrastructure investment, and route planning in the potential emerging aviation ecosystem. Their influence and decision-making in shaping the emerging ecosystem transition are based on their dual role as promoters and enablers of regional accessibility and connectivity.

Electric aircraft manufacturers are increasingly viewed as potential keystone firms in the emerging aviation ecosystem. These actors not only provide the enabling technology but also shape investment logic, timelines, and standards throughout the ecosystem. Manufacturers reinforce their potential role as keystone firms in cross-sector collaboration, focusing on developing strategies, routes, and policies that are essential for the potential implementation of electric aviation.

Evolving Ecosystem Links:

The emerging ecosystem forces the reconfiguration of links between actors.

- Material links are changing and evolving as the transition towards electric aviation demands new infrastructure like megawatt charging, grid upgrades, and storage integration. Energy providers and airports are establishing new physical interdependencies on-site to enable electric aviation.

- Information links are becoming a central aspect as timelines, needs, demands, and standards are highly uncertain regarding the potential transition. Airports need, for example, to inform grid actors about projected demands, and electric aircraft manufacturers need to be transparent about aircraft specifications and timelines to guide investments.

- Influence links are also shifting as municipalities and regional actors are central in projects and funding decisions, while trade associations increasingly try to coordinate and guide alignment between public and private actors.

- Fund links are becoming fragmented and unclear as local governments and regional airports are often expected to fund the critical infrastructure required for this transition themself. National policies and guidelines may incentivize change, but funding responsibilities are expected to fall to under-resourced municipalities, leading to tensions and misalignments.

Co-evolution and new interdependencies

The ecosystem is transforming through co-evolution, where energy providers, manufacturers, and airports need to align their strategic planning. For example, if an airport waits too long to prepare necessary infrastructure, aircraft deployment may be delayed. Conversely, if infrastructure is built too early and the timelines for aircraft deployments are unclear, the investment may be stranded. These mutual dependencies raise concerns of misalignments and highlight the need for transparency and trust in effective ecosystem coordination.

Ambiguities in Emerging Roles and Responsibilities
Participants described the potential transition as filled with competing interpretations and uncertainties regarding emerging roles. Several expressed confusion over evolving responsibilities of the emerging ecosystem, specifically regarding funding and infrastructure ownership. This leads to hesitation among actors about when and how to act in order to successfully transition. Rather than coordinated action, the participants reveal a lack of a clear leader to guide investments and structure, and fragmented views on planning. This ambiguity complicates necessary efforts to achieve ecosystem alignments, which delays the co-creation of shared plans for this transition.

5.3 Barriers to Implementation

While the shift towards electric aviation introduces new possibilities for innovation, sustainability, and collaboration, participants repeatedly highlighted various hindrances to this transition. These include a range of structural and systematic barriers that extend beyond the technological aspects and reflect on deeper challenges such as regulation, infrastructure, economics, and the coordination among the actors within the aviation ecosystem.

From the thematic analysis, the researchers could identify four categories of barriers:

1. Regulatory and Institutional Barriers

2. Infrastructure and Technological Constraints

3. Economic, Financial, and Market-related Barriers

4. Ecosystem Coordination and Collaboration Complexity

These categories reflect on how the existing frameworks, resources, and relationships might fail to adapt to the demand of electric aviation.

5.3.1 Regulatory and Institutional Barriers
A successful implementation of electric aviation in Sweden is highly dependent on overcoming regulatory and institutional barriers. The findings highlight a fragmented landscape of mandates, governance structures, and unclear responsibilities that hinder coordinated action. These barriers reflect a broader misalignment between the structure of the evolving ecosystem and the governance structures that shape the actors' behaviors.

One prominent issue is the need for stronger governmental involvement and financial support. Several participants emphasized that the current level of involvement from the government is insufficient for enabling a system-wide transformation. As Regional Airport 2 stated, *"We think that the state needs to take on a greater responsibility for the aircraft infrastructure in order for it to exist. Then, for example, the electric supply to all airports may also be taken over in the future. For a lot of different reasons."* This underscores both a lack of orchestration and uncertainty about which actor should take on long-term responsibilities for the infrastructure. When no clear orchestrator emerges within an ecosystem, the coordination efforts become fragmented, making it difficult to achieve alignment among interdependent actors. Some governing actors also highlighted the need for central involvement. Governing Actors 2 stated, *"If you don't go in strongly with tax money or central stimulus, it is very difficult to get these research initiatives to actually reach success on the market."* This points to the lack of sufficient fund links, and the absence of institutional mechanisms to distribute risk and build trust.

Regional Airport 2 also raised concerns regarding over-reliance on local initiatives: *"It can't just be based on doing local initiatives. For example, not just one municipal council that happens to be a bit tough and dares to invest money can do it, because it has to be done everywhere."* This quote reflects on the misalignment in role expectations and underscores that a lack of shared accountability undermines the co-evolution of responsibilities.

The budget priorities of the municipalities were also identified as an obstacle that affects the ability of the regional airports to invest proactively. As Regional Airport 2 noted, *"It's not easy to justify investing 10 million in the airport for something that will be needed in maybe four or five years. You are then competing with money that is linked to school, healthcare, or the municipal business."* This reflects on the difficulty of balancing future-oriented ecosystem goals with immediate local demands, underscoring the need for better coordination and strategic alignment.

The findings also revealed that regulatory and policy uncertainties undermine stakeholder commitment and discourage investments. Governing Actor 4 stated, *"No one dares to invest in something that may not really be what it appeared to be. It's a bit of a chicken and egg problem here."* The participant further stated, *"The government can't just step in and demand focus on a technology when it's still unclear whether it will become the accepted standard."* These reflections point out an absence of stable influence and information links, and how technological uncertainty undermines role clarity. Without regulatory alignment, actors hesitate to move forward.

This is further complicated by the lack of a clear vision. As Governing Actor 4 explained, *"Right now we have one manufacturer here, but should we build up a whole infrastructure around just one actor in Sweden? It might actually be something from China that becomes the standard. You just don't know."* This quote illustrates the ecosystem's reliance on actors without the legitimacy as orchestrators. This uncertainty regarding standardized designs hinders the development of complementarity between actors such as infrastructure providers, energy suppliers, and OEMs. Similarly, participants also highlighted the competition between different decarbonization solutions. As Trade Association 2 stated, *"It is SAF that will be the big thing in the aviation sector, because you can use SAF in existing aircraft. If we are talking about Airbus and Boeing, their order book is at 11,000 aircrafts. So they will be delivered during a 10-year period. Then you will fly with them for 20–25 years more. So if we want to fix the climate, we have to concentrate on changing fuel for these planes."* This illustrates how electric aviation may be deprioritized in favor of other alternatives like SAF, which is seen as more scalable and compatible with current aircraft. Such strategic divergence, where actors follow parallel decarbonization pathways rather than aligning around a shared vision, complicates ecosystem orchestration by making it harder to coordinate investments, policies, and infrastructure development.

Governing Actor 4 emphasized the need for a *"symbiosis of development,"* which highlights that achieving institutional alignment between public and private stakeholders is essential to overcoming fragmented efforts. In this context, effective ecosystem orchestration requires not only coordination mechanisms but also shared incentives, clear mandates, and strong relational trust.

The long timelines that are required for safety certifications were identified as another barrier to implementation, as they add complexity and delay the technological adoption. As Regional Airport 2 underscored, "*It's not just put one there and fly from day one. You will also have to prove that all of this actually works and that it is safe. That takes time, and only after proving its reliability will you have a solution that can actually be used. So that's a challenge".* This was also strengthened by Trade Association 2, who stated: *"But it would be much, much harder today than it was 40 years ago. And there will be new regulations."* These delays hinder the ecosystem's co-evolution by misaligning technological development with operational readiness.

Some regulatory limitations on government incentives were also seen as challenging. Governing Actor 2 mentioned restrictive EU regulations, *"It's the regulations, there's something called Geber. The state is not allowed to support industry in Europe. But there are exceptions, and one of them concerns research. It's called the block exception for research, and under those rules, support has to be directed towards basic research."* Similarly, Governing Actor 4 highlighted that, *"The decision-making in Europe is so long that it takes five years to make the smallest change possible. It doesn't seem to be to our advantage."* These reflections highlight how slow-moving regulations and jurisdictional complexity introduce structural barriers and restrict the ecosystem's ability to respond and adapt.

In addition, political instability was brought up as a structural limitation. Trade Association 2 stated, *"The problem with politicians is that they are generalists and when it comes to transport authorities, they change people quite often, even during the mandate period."* The participant further noted, *"That's probably the problem. It's hard to build something long-term when governments are changing all the time."* This results in an unstable institutional environment, where the lack of continuity in influence links undermines the formation of durable complementarities.

Finally, inconsistencies between municipal travel policies and expected demand illustrate internal contradictions. Governing Actor 2 explained, *"Regional airports are often municipally owned. While many local officials express a desire to maintain the airport, they don't use air travel themselves, as their policies strictly prohibit flying."* Governing Actor 4 added, *"Yes, but they have travel restrictions in place and are not permitted to fly. At the same time, they express frustration over the lack of airline service to their municipal airport. Yet they haven't contributed to the demand themselves, so naturally, no one flies there. It becomes something of a paradox."*

This paradox highlights a disruption in the institutional logic of the ecosystem. Municipal travel policies limit demand, but expectations for continued flights remain. This misalignment challenges both value creation and system viability. As Trade Association 2 noted, *"In a typical domestic route, 30% is from the public sector. If you take away 30% of customers, then it's not profitable anymore."* This emphasizes how public sector travel behavior directly affects the economic feasibility of regional routes, making alignment crucial. Thereby, it further underscores how weak orchestration and misalignment hinder progress toward electric aviation in Sweden.

5.3.2 Infrastructure and Technological Constraints

The transition towards electric aviation is intertwined with both infrastructure readiness and technological maturity. Uncertainties around grid capacity, operational conditions, battery performance, and charging infrastructure were frequently mentioned. These constraints create misalignments in actor expectations and highlight the need for synchronized development across the ecosystem.

One prominent aspect was the uncertainty of the current state of electric aviation technology and its corresponding infrastructure. Trade Association 3 pointed out, *"We've probably reached the point where we need to start thinking again. Maybe create some sort of vision, but there are still so many question marks. Electric aviation doesn't exist yet, we don't know exactly how the charging will work. We don't know, the regulations aren't in place".* This quote reflects on the broader uncertainty surrounding the technological trajectory of electric aviation. Actors hesitate to invest due to the lack of a coherent vision and shared technical assumptions. This reveals weak information links across the ecosystem, especially from OEMs, which hinders coordination as actors are not able to align their strategies.

According to the findings, the charging infrastructure poses a big challenge. Trade Association 3 emphasized the importance of standardized infrastructure, *"But being able to charge at only one airport isn't sufficient. The aircraft isn't simply returning to its point of origin, you need charging infrastructure at both departure and arrival points."* The participant added, *"Aviation is such a small industry overall, so the charging infrastructure should ideally be the same as what's used for heavy-duty transport to extend useability"*. This points out the weak material links, especially in the absence of standardized charging systems. The suggestion of cross-sector alignment with heavy trucks illustrates a possibility to leverage complementarity. However, this also implies a risk that aviation may not be prioritized in broader infrastructure decisions due to its relatively limited influence in shaping market-wide standards.

The development of battery technology also came up as a central concern. Several participants pointed to the limitations in battery capacity and performance. Governing Actor 2 stated, *"The biggest risk is the battery".* Trade Association 2 reinforced this point, *"You thought that they would come up with stronger batteries. For batteries to work, they have to be at least three times as strong as they are now*". Similarly, Governing Actor 3 observed, *"It's a lot about how slow the battery development is compared to everything"*. These quotes reveal an ecosystem-wide perception of technological stagnation. Limited technological improvement discourages actors from aligning their strategies to facilitate electric aviation, which weakens co-evolution and interdependencies throughout the ecosystem. Airports and grid operators struggle to invest and plan until credible information links are created by OEMs or battery developers.

Climate and geographical factors further complicate infrastructure deployment, especially in the Nordic context. As Regional Airport Operator 2 explained, *"Sweden is a big country, and northern Sweden has a really cold climate and a lot of snow. A lot of this equipment is not made for this. Cables become hard, and there will be ice formation in the connections. There will be a lot of things like this. How are you supposed to handle that?"* This perspective illustrates how infrastructure may become unreliable in certain climates, underscoring a significant challenge in standardization, further complicating the potential of ecosystem coordination.

Beyond the equipment, concerns were raised about the readiness and adaptability of the Swedish electricity grid. Network Actor noted, *"Then maybe we need to build a new station with a new connection to the regional network. We've been talking about it for a long time."* These dependencies on external infrastructure actors illustrate the ecosystem's lack of orchestration. Without clear links between energy actors and aviation, even modest progress will be limited.

Trade Association 1 provided insights on the operational side of grid management, stating, *"It's smart to think about the local system. How can that be optimized so that you reduce the worst electrical loads against the power supply? I suspect that many of the charging sessions will be quite time-critical."* Regional Airport 2 added, *"If you dig into this, you will see that today's electricity system is not rigged for the future. It is also built from a much more static environment."* These reflect an increasing awareness that technological constraints also include the lack of flexibility and insufficient coordination between energy providers and airports. The absence of dynamic resource sharing and joint planning highlights the increasing need for complementarity.

Finally, Governing Actor 4 concluded, *"We need to see some actual airplanes before we can move on to the next step"*. This underscores that some actors in the ecosystem remain in a state of standstill, while waiting for more concrete technological proof of concept before committing to substantial action. This mutual waiting game reflects fragile interdependencies and highlights a lack of orchestration that hinders ecosystem evolution.

5.3.3 Economic, Financial, and Market-related Barriers

The transition towards electric aviation involves uncertain returns, high upfront costs, and unclear funding responsibilities. Several participants described and discussed financial barriers as a major challenge, especially for regional airports facing tight margins and budget limitations. Limited public funding and unclear business models contribute to hesitation, weaken commitment, and hinder the orchestration needed to push the transition forward.

Several participants expressed recurring concerns regarding the assumption that the aviation sector should finance its own transition. As Trade Association 3 discussed, *"Well, the costs are quite significant, and when it comes to aviation, the industry is expected to cover everything itself. But if you look at other types of infrastructure, like road transport, the operators don't pay for the charging infrastructure themselves. That's handled by someone else."* These differences in financial expectations reveal a lack of alignment across the ecosystem and highlight fragmented institutional support, which hinders the ecosystem to mobilize resources and co-invest. The misalignment becomes more apparent in the financial positions of different airport types. As Trade Association 3 added, *"Only the state-owned airports are profitable, and they say, 'We won't invest unless there's a return.' But regional airports don't operate at a profit, they exist for entirely different reasons."* These comments highlight ecosystem misalignment in terms of resource capabilities and role expectations. Regional airports lack both funds and the economic justification to lead the investments crucial for enabling electric aviation. Clear orchestration and complementary financial support are deemed necessary for the ecosystem.

Looking beyond just the airport, other concerns that involve the complexity and cost of expanding the power grid to accommodate electric aircraft charging were mentioned by several participants. As Trade Association 1 explained, *"It's not really a big technical challenge, it's more about big investments. It takes a long time, it costs a lot of money to get it in place. That's what's challenging, rather than a new technology."* The participant also stressed the importance of smart investment strategies. "*A lot of it is about the fact that the charging is optimized and executed as smartly as possible, so that you reduce the need for power supply expansion. Because it takes an incredible amount of time to build a power supply."* These quotes highlight the interdependence between actors, where smart planning by infrastructure providers or airports can support grid operators. Collaboration and complementarity help prevent overbuilding or duplication, which could escalate costs and slow down implementation.

On the operational side, one observation from the interviews was that electricity is seen as a lower-cost fuel in the long run, while economic viability remains unclear. As Governing Actor 2 remarked, *"Electricity as an energy carrier already has a cost advantage over other types of fuel. We have a perception of electricity as 'low cost.'"* Yet this advantage does not automatically translate into business viability. As Governing Actor 3 warned, *"If it's more expensive than flying with conventional fuel, the ticket prices will rise. Then I find it hard to see much excitement about it. So I think the business side of it all is most important. Costs need to come down enough."* These comments underscore a tension between long-term operational savings and short-term capital intensity. The ecosystem lacks economies of scale, and the shared risk management needed to make electric aviation financially competitive.

Participants also disagreed with the optimistic forecast that electric aviation would automatically create new demand. As Governing Actor 4 reflected, *"Some people think that with electric aircraft, suddenly you'll be flying everywhere. But you have to ask, why aren't we flying there now? Maybe there isn't enough demand, or it isn't profitable."* The participant further expanded on this skepticism by stating, *"Why would you operate electric flights if you're not even operating regular flights on these routes? What advantage will electric flights offer if they are not more cost-effective?"* These insights challenge the perception that electric aviation will generate new markets easily. They reveal the need for clear value propositions and target market design. Highlighting the need for orchestration, which remains underdeveloped in the current transition phase.

Network Actor summarized this challenge: *"So it's the business model that's the hard part."* This points to a deeper strategic vacuum within the ecosystem, where technical enthusiasm has outpaced commercial logic. In the absence of a clear business model for route profitability, revenue-sharing, or infrastructure ownership, most actors hesitate to commit. The lack of established fund and influence links between public agencies, airlines, and grid actors leaves key coordination and investment unresolved.

5.3.4 Ecosystem Coordination and Collaboration Complexity

Challenges in organizational and collaborative structures were identified as additional potential barriers. Unlike traditional aviation models that rely on well-established roles and value chains, the emerging electric aviation ecosystem is dependent on complex collaborations among stakeholders across various sectors. It requires close coordination between actors that previously were more disconnected, such as airports, grid operators, and technology firms. As a result, managing this transition involves navigating across a diverse landscape with varying levels of capacity, resources, and readiness. This underscores that effective business ecosystems depend on co-evolution and role transformation across sectors.

The data reveal that ecosystem orchestration remains fragile due to unclear roles, limited mutual dependencies, and a lack of shared planning. Trade Association 3 emphasized the importance of clarity and alignment among the involved actors: *"That's where collaboration comes into play. There has to be 100% commitment from all parties involved for it to be implemented. Otherwise, the risks become too great."* This statement reflects how interdependencies in the ecosystem increase the risk of misalignment. Full transparency, engagement, trust, and coordinated action are necessary not to derail collective progress.

However, Governing Actor 2 mentioned that some stakeholders, especially in the energy sector, have not yet fully grasped the scale of changes that will be required for this transition: *"The electric companies have not understood how big the change already is for them today, especially not the smaller local companies."* This illustrates the lack of information and influence links across the ecosystem. Actors need to align in order to mobilize change in tandem and not become disconnected or reactive.

Organizational and physical heterogeneity across airports adds to this complexity. As Regional Operator Airport 2 stated, *"The thing is that all airports don´t look the same. Geographically, or architecturally, there is no airport that looks the same".* Similarly, Regional Airport Operator 1 observed, *"You can think of a big concept, but every single airport has its own problems".* These comments reveal the lack of architectural alignment and standardization, which hinders the application of cohesive solutions. These variations increase the need for coordination and limit scalability, as custom solutions may be needed.

This lack of standardization creates difficulties with scaling shared solutions, especially when new infrastructure or business models are involved. Regional Airport Operator 2 highlighted the uncertainty around ownership and management of energy systems, by stating, *"In some cases, the airport itself might manage electricity supply, buying, selling, and distributing it on-site. Alternatively, that responsibility could be handed over to the local electricity provider or managed through an intermediary acting as a broker. Each of these options represents a potential new business model for handling energy, which makes this an especially interesting area for development".* This showcases the need for ecosystem actors to reconfigure their roles and expand their collaborations, but as mentioned before, due to the lack of established models or frameworks, orchestration is lacking.

Furthermore, not all actors have the same ability to participate in such collaborative arrangements. As Governing Actor 4 stated, *"They often have a hard time allocating resources to cooperate with, there's an imbalance there, and that's a dilemma".* Particularly, regional airports and local utilities may lack the organizational knowledge or personnel to engage deeply in the ecosystem planning process. This creates power asymmetries and may result in decision-making being skewed towards larger actors, which undermines the shared value creation. Effective coordination is also dependent on proactive planning from the airports, which is an important factor within this ecosystem. Governing Actor 2 stressed the need for the airport operators to define their future demands clearly: *"The important thing is that the customers, in this case the airports, are clear about their needs, so that others can start building out and planning for this".* This kind of proactive signaling is critical to synchronize development and co-evolution. If signals are weak, delayed, or misaligned, actors will be left uncertain, leading to fragmented efforts and hesitation.

Finally, the findings highlight that the transition of electric aviation is not only about aligning technologies or investments, but rather the orchestration of collective action under uncertainty. As Governing Actor 2 concluded, *"There are numerous stakeholders that need to be aligned and work in coordination."* From an ecosystem perspective, addressing these challenges requires strategic leadership, effective communication, and clear roles. Without effort to strengthen governance and mutual commitment, coordination challenges may hinder progress.

5.3.5 Summary Analysis of Findings

The deployment of electric aviation technologies in Sweden is influenced by a variety of structural challenges that are not limited to technological maturity. Although the participants of the study broadly recognized the potential of electrification, they underscored that the lack of alignment between actors, policies, and incentives is holding back the transition. As an example, regulatory frameworks have not adapted to meet the needs of emerging electric technologies, which causes uncertainty among actors regarding their responsibilities and the rules of engagement. This regulatory misalignment complicates infrastructural planning and the financial justification for long-term investments. This kind of institutional uncertainty represents a critical challenge in early-stage ecosystems, where regulatory clarity is essential for actors to allocate resources and coordinate development strategies.

Multiple participants underscored how the emerging aviation ecosystem lacks a clearly defined keystone firm or orchestrator, which potentially could coordinate planning, resolve uncertainties, and promote aligned development. This absence complicates the distribution of responsibilities and justification of role changes. Although larger airports have the resources to act independently, smaller regional airports are often financially constrained and lack the capacity to take initiative without external support. By looking from an ecosystem perspective, this reveals a governance gap where no actor has taken on the orchestrator role, which is typically needed to drive co-evolution and strategic alignment among interdependent actors.

The findings also illustrate the challenges of evolving inter-organizational relationships within a context of shifting responsibilities and unclear expectations. For example, actors such as airports, municipalities, energy providers, and OEMs are all interdependent in ensuring the availability of electric aviation, but coordinated processes for communication and shared planning are often missing. This interdependence highlights the need for complementarity in capabilities and improved mechanisms for coordination.

Several of the participants frequently emphasized that the absence of clear direction from aircraft manufacturers or governmental authorities would affect the willingness to invest in infrastructure, despite a shared commitment to the transition. In addition, the adoption of electric aviation technologies is closely connected to economic viability, which remains uncertain. Even though electricity is perceived as cost-effective, high upfront costs, fragmented market conditions, and uncertain profitability limit commitment. This reflects on the importance of developing shared business models and reducing risk asymmetries, for enabling commitment in the ecosystem.

Such economic concerns are further enhanced by the lack of long-term incentives or supportive public procurement models. For many of the actors, adoption is dependent on reducing the financial risk as well as achieving complementarity with existing operations, which is an aspect where the current regulatory and market structures remain lacking.

In addition to these structural and institutional challenges, the findings also revealed skepticism. Some participants expressed concerns regarding the practical viability of electric aviation. This includes concerns over market demand, business models, and whether the technology is suited for Swedish conditions, such as long distances and harsh winter climates. These perspectives reflect on deeper uncertainties not limited to infrastructure or regulation, since they signal a broader hesitation to commit without clearer signals of technological readiness, economic scalability, and long-term returns. By reflecting on the ecosystem perspective, this skepticism represents an additional barrier that may slow down the progress as interdependent actors hesitate to act without clear commitments from others.

Overall, the findings indicate that barriers to electric aviation in Sweden are not simply technological but are rooted in structural coordination gaps, regulatory uncertainty, role ambiguity, and lack of aligned incentives. These reflect core challenges in business ecosystem formation, where success relies not only on innovation but on the co-evolution of institutions, infrastructures, and actor roles. Meaning that overcoming these challenges requires more than technological advancements. It calls for effective orchestration to clarify responsibilities, align governance structures, and foster coordination among the actors in the ecosystem. Without this, the ecosystem risks fragmentation, slower adoption, and limited capacity to scale emerging innovation, especially given the skepticism surrounding demand, profitability, and the long-term viability of such initiatives in the Swedish context.

6. Discussion

The findings of the study are discussed in this chapter in relation to the theoretical framework. The aim was to enrich the understanding of how the transition towards electric aviation is influencing and affecting the dynamics and structures in the Swedish aviation ecosystem. The chapter is structured around the two research questions, focusing first on the shifting of actors' roles and collaborations and then on the central barriers hindering the transition.

The discussion is guided by concepts derived from sustainability transitions, ecosystem, and business ecosystem theory, including role changes, inter-organization relationships, coordination, alignment, cooperation, complementarity, and the lack of a keystone firm. These different concepts serve as analytical tools to help interpret the findings related to how the transition towards electric aviation is unfolding. The aim of the chapter is to make sense of the patterns identified in the findings by linking them to theoretical concepts, highlighting the management of sustainability transition in an ecosystem context.

6.1 Shifting Roles and Collaboration in the Aviation Ecosystem

The transition towards electric aviation in Sweden appears to demand a reconfiguration of the current aviation ecosystem´s structure. The shift suggests that actors need to adjust their roles, responsibilities, and interdependencies. However, this shift towards electric aviation is far from coordinated or linear. The findings reveal that although the roles of OEMs, energy providers, airports, and municipalities are beginning to evolve, these shifts are often uneven, slow, and shaped by unclear expectations. These characteristics align with the complex, non-linear nature of sustainability transitions (Köhler et al., 2019; Rosenbloom, 2017).

A key insight from the findings is the shift of certain actors traditionally occupying passive roles to more active and central positions within the potential emerging aviation ecosystem. Regional airports and municipalities, for example, are evolving from strictly operational actors to increasingly being viewed as emerging enablers to coordinate infrastructure, energy, and local systems. Similarly, energy companies, which traditionally had a supporting role, are viewed as another essential enabler of the transition towards electric aviation. These shifts and the evolution of actors' roles align with Adner´s (2017) argument that successful ecosystems need alignments in the focal value propositions, which can be achieved by the dynamic reconfiguration of actor roles.

However, while these shifts highlight potential for co-evolution (Moore, 1993), they also highlight new tensions and uncertainties. The concept of interdependence implies that shifts in an actor's role affect the viability of other actors. Municipalities, for instance, face pressures to lead local transitions where balancing constrained budgets and unclear mandates with enthusiasm is necessary. Similarly, airports rely on uncertain specifications and timelines from OEMs regarding the development of infrastructure. These conditions align with the view of Thomas and Autio (2020) and Adner and Kapoor (2010) that interdependence with coordination and alignment risks ecosystem fatigue or even failure. The findings of actors' hesitations regarding when to act reflect a standstill based on the absence of shared expectations, stable governance, and mutual trust. The initial collaborative efforts observed in the findings point towards early signs of co-evolution. These initiatives bring together diverse actors in aviation to address uncertainties about safety, infrastructure, and new standards. These initiatives showcase how ecosystems need mutual dependencies and alignments for structure (Kapoor, 2018). However, it is worth noting that these efforts rely on continued funding and they remain largely experimental and fragmented, raising doubts about whether they will become firmly established over time.

A significant structural insight from the findings is the evolution of ecosystem links in the emerging aviation ecosystem. Information and influence links are increasing as actors try to shape and understand safety standards, investment logics, and regulatory frameworks. For example, grid operators and airports are co-producing knowledge through joint scenario planning, which could be seen as an attempt to create new influence and information links that extend beyond their traditional roles. However, these information and influence links remain fragile, especially between electric aircraft manufacturers and the other aviation ecosystem actors. The findings emphasized a lack of reliable technical specifications, communications, and timelines from OEMs, which hinders actors from knowing and deciding upon when and how to act. This coordination stalls across the ecosystem reflects Adner´s (2017) argument that weak links can disrupt and hinder coordination and alignment throughout the ecosystem.

At the same time, fund links are fragmented, particularly between national support mechanisms and local actors, which raises doubts about the feasibility of infrastructure development. These inconsistencies and uncertainties mirror challenges observed in other transport sectors undergoing electrification transitions, such as heavy trucks and ferries. In the case of heavy trucks, the transition has required coordination among OEMs, utilities, policymakers, and fleet operators, where clearly defined roles and early engagement help reduce risk and improve readiness (Dehkordi et al., 2024). This underlines the importance of complementarity to align capability and incentives to enable value creation. Insights that are comparable to the findings, where a lack of alignment across actors hinders the ability to coordinate timelines and investments. The shift to electric ferries highlighted how modular infrastructure, standardizations, and trust enabled a smoother transition (Sæther & Moe, 2021; Seidenberg et al., 2023). Also showcasing how coordinated governance and clearly defined responsibilities supported role clarity and mitigated first-mover risks. In contrast, the aviation actors in Sweden are still negotiating such structures, and the lack of stable government coordination remains problematic for co-evolution.

In addition, the findings also highlighted not just confusion, but fatigue among some actors. Navigating new responsibilities and roles, without additional resources or strategic clarity, has begun to strain smaller actors. Their willingness to participate and allocate resources in the transition is conditioned by whether the ecosystem can offer more than the moral arguments. As explained by Köhler et al. (2019), transitions must be supported by practical structures of legitimacy, incentives, and support to be sustainable over time.

Finally, the absence of a clear orchestrator further complicates the emerging aviation ecosystem structure. Electric aircraft manufacturers are often discussed as a potential keystone firm, but they currently lack resources, authority, and legitimacy, which are necessary to coordinate a potential emerging electric aviation ecosystem. While their role in enabling the core technology was broadly acknowledged, doubts were raised about their ability to guide ecosystem alignment. Some participants express hesitation, especially when transparency regarding timelines remains limited. This has weakened influence and information links needed for coordinated action, leaving many actors uncertain about when or how to act. These concerns align with how Iansiti and Levien (2004) emphasized that keystone firms should facilitate shared value creation and stabilize the ecosystem. Without coordinating capacity, co-evolution remains fragmented, and the ecosystem remains misaligned.

6.2 Discussion – RQ2: Barriers to the Implementation of Electric Aviation

The findings of this study indicate that the primary barriers for implementing electric aviation in Sweden are not exclusively determined by technological readiness, but also within a broader systematic misalignment across the aviation ecosystem. Although technical obstacles like infrastructure and aircraft certification were recognized. The majority of participants emphasized that regulatory uncertainty, lack of coordination, and unclear financial responsibilities were challenges that may hinder or delay progress. These observations align with the sustainability transitions literature, which conceptualizes transitions as long-term and systematic processes that involve interconnected changes across different dimensions, such as technological, infrastructural, regulatory, and economic aspects (Köhler et al., 2019).

Electric aviation not only requires new infrastructure but also a reconfiguration of stakeholder interactions and value co-creation within the ecosystem. A central concern that emerged is the lack of alignment among ecosystem actors. Since the regulatory frameworks have not adapted to the demands of electric aviation, airports, municipalities, OEMs, and energy providers have been left with uncertainties about their respective responsibilities. This exemplifies the kind of coordination challenges described by Jacobides et al. (2018), where interdependent actors lack shared governance mechanisms and thereby struggle to collaborate effectively. This misalignment in the end creates planning difficulties and raises the risk associated with long-term investments.

Furthermore, the ecosystem lacks a keystone firm or orchestrator, which is a central actor capable of guiding the transition by providing stability and ensuring role clarity (Iansiti & Levien, 2004). Although some participants viewed the electric aircraft manufacturers as potential leaders, their ability to fill this role remains uncertain due to unresolved technical and regulatory questions. Without effective orchestration, the collective ability to progress is constrained and increases hesitation among smaller regional actors, particularly those with limited resources. This reflects on a broader issue of weak orchestration capacity, which is seen as a vital factor for cross-sector innovation in business ecosystem theory (Adner, 2017).

The transition also highlights tension in evolving inter-organizational relationships. The shift requires closer cooperation between stakeholders who have traditionally operated independently. In this emerging ecosystem, airports will now require partnerships with energy providers, municipalities engaging in cooperative funding efforts, and OEMs engaging in shared infrastructure planning. Addressing these interdependencies involves not only collaboration but also the establishment of relational trust and joint planning mechanisms, which are not yet fully established. This supports the arguments made by Adner and Kapoor (2010) and Thomas and Autio (2020), who emphasize that managing interdependencies is essential for achieving sustainable outcomes within ecosystems. A lack of coordination, in this case, infrastructure planning and funding, threatens the ecosystem's coherence and resilience and underscores the need for robust collaborative governance mechanisms.

In addition, the economic feasibility of electric aviation remains uncertain. While electricity is seen as a low-cost energy source, the high capital expenditures that are required for charging systems and energy upgrades make the business case fragile. Particularly for the smaller regional airport, where the risk of investing without assurance of return or government support acts as a significant barrier. These financial burdens are further intensified by the lack of a public funding mechanism for electric aviation, in contrast to other transport sectors, which often benefit from national subsidies and coordination. From a business ecosystem perspective, this reflects a breakdown in collaborative value capture (Scaringella & Radziwon, 2018), in which the uneven distribution of costs and risks undermines stakeholder engagement.

The skepticism expressed about whether electric aviation can generate sufficient demand and profitability underscores that, even if technical readiness advances, low perceived business viability may continue to delay stakeholder commitment. These concerns align with what Adner and Kapoor (2010) describe as ecosystem risk, where the failure of complementary elements, in this case, regulatory support, demand-side adoption, or infrastructure readiness, can hinder successful implementation, even if the core technology is viable.

Moreover, the absence of a clear business case aligns with Thomas and Autio (2020), who note that unclear business models can lead to strategic hesitation among actors and may thereby lead to reduced willingness to invest or coordinate action.

The findings also indicate that the value creation is dependent on the synchronized development of multiple components across the ecosystem. However, the limited degree of integrated planning among stakeholders highlights a lack of alignment structures necessary to support this coevolution (Adner, 2017). Furthermore, the interdependent nature of ecosystems means that the underdevelopment or failure of a single component, for example, regulatory support or infrastructure readiness, may risk destabilizing the entire system (Adner, 2017). These insights point to the importance of aligning complementarities, as disruptions in one area can hinder advancement throughout the broader business ecosystem.

It is also worth noting that battery-electric aviation is not developing in isolation, since there are other parallel sustainable innovations, such as SAF and hydrogen propulsion (Svenskt Flyg, 2024; Christley et al., 2024). These alternatives differ in terms of required infrastructure, timelines, and operational implications, which contribute to creating strategic ambiguity for stakeholders. The absence of a clearly dominant technology also introduces an additional aspect of uncertainty that may further hinder coordination and investment within the ecosystem. Although electric aviation has gained momentum for regional flight in Sweden, the implementation should be considered in the context of a wider set of competing innovation pathways.

Although these systematic barriers are not unique to the aviation sector, similar challenges have been documented in the electrification of trucks and ferries, where the infrastructure, policy, and stakeholder coordination also emerged as critical obstacles (Sæther & Moe, 2021; Dehkordi et al., 2024). However, the aviation sector sets itself apart from other sectors due to its scale of energy demand, complexity of regulation, and the absence of clear orchestrating actors. All of which creates coordination challenges and underscores the need for adaptive, integrated governance structures to navigate infrastructure, financial, regulatory, and collaborative complexities.

Therefore, overcoming these challenges requires not only target investments and regulatory adaptation but also orchestrated collaboration and the establishment of long-term alignment structures across the ecosystem. This progress is also dependent on the development of demand-driven models that reduce uncertainty and encourage actor participation through credible market signals and shared expectations. Without these foundational supports, the ecosystem risks fragmentation, strategic hesitation, and ultimately, the inability to scale sustainable aviation solutions.

7. Conclusion

This thesis examined how the potential transition towards electric aviation is affecting roles and collaboration within the Swedish aviation ecosystem, as well as the key barriers to implementation. The findings of the qualitative case study reveal that the transition requires not only new technology but a fundamental reconfiguration of responsibilities, interdependencies, and coordination structures.

The roles of actors such as municipalities, airports, and energy are beginning to evolve, underscoring initial signs of ecosystem co-evolution. However, these shifts are loosely coordinated and uneven. The lack of a clear keystone firm or orchestrator and fragile communication, particularly between OEMs and other ecosystem actors, leads to uncertainties and slow transition progress.

Barriers to implementation are more about systemic misalignment than technical readiness. Limited governance structures, regulatory gaps, and unclear financial responsibilities hinder alignment and strategic commitment, especially for resource-constrained actors. Some participants see potential, but the emerging ecosystem lacks stable structures, coordinated leadership, and shared expectations that need to support long-term implementation. Greater policy support, structured coordination, and role clarity will be crucial for a sustainable ecosystem transition.

7.1 Key Findings

By looking from a business ecosystem perspective, this thesis has investigated the potential shift towards electric aviation in Sweden. The analysis focused on two research questions: (1) how the transition is reshaping roles and collaborations among actors in the aviation ecosystem, and (2) what key barriers hinder the implementation of electric aviation.

Shifting Roles and Emerging Interdependencies

The transition towards electric aviation will require reconfiguration of the traditional actors roles. Airport, municipalities, and energy providers are moving towards increasingly central roles, by taking on responsibilities related to charging infrastructure, energy coordination, and planning. These developments reflect early signs of ecosystem co-evolution but remain highly fragmented.

Fragile Ecosystem Coordination

Within this emerging ecosystem, collaboration is increasing, but lacks robust coordination mechanisms. Fragile information and influence links, especially from OEMs, restrict the ability of other actors to coordinate investments and planning. This uncertainty points to broader ecosystem misalignment, where unclear mandates and insufficient institutional support continue to slow down progress.

Absence of a Keystone Firm

Electric aircraft manufacturers are often perceived as a potential orchestrator. However, they currently lack the legitimacy, resources, and authority needed to align the ecosystem. This absence of a coordinating actor not only delays infrastructure development but also weakens collective planning efforts, thereby highlighting a deeper structural weakness in the emerging ecosystem.

Structural and Institutional Barriers

Regulatory ambiguity, lack of long-term public funding, and unclear business models contribute to hesitation among stakeholders, particularly for smaller airports and municipalities with limited resources. Despite increasing technical feasibility, the implementation is restricted by coordinated governance and credible market demand signals.

Uncertain Market Demand Limits Financial Commitment

Limited proof of future demand, especially from the public sector, creates hesitancy about investment across the ecosystem. Actors such as airlines, regional airports, and energy providers remain hesitant to allocate resources without credible market signals, shared business models, or long-term incentives. This lack of rigorous fund and influence links limits coordinated action and restricts value creation.

Technological Ambiguity Delays Adoption

Although electric aviation is perceived as a promising solution for sustainable aviation. Uncertainties regarding certification timelines, aircraft readiness, battery performance, and charging infrastructure contribute to the complexities in coordination in the ecosystem. These technological uncertainties undermine trust in the maturity of the solution, leading to strategic hesitation among interdependent actors and hindering co-evolution within the ecosystem.

7.2 Contributions

This thesis contributes to the understanding of how sustainability transitions unfold from an ecosystem perspective by examining the potential emerging Swedish electric aviation ecosystem. The study does not aim to develop a new theory, but it provides a novel application of ecosystem and sustainability transition frameworks in an underexplored empirical context. The thesis provides valuable insights into existing concepts such as actor alignment, interdependencies, orchestration, and co-evolution, highlighting how ecosystem structures may evolve when established industries face disruptive innovation. The study highlights how actor roles in the Swedish aviation ecosystem are potentially beginning to shift due to electrification and how new link structures, particularly fragile or missing influence and information links that hinder coordinated action. These findings contribute to existing theory by empirically illustrating the challenges of alignment in a fragmented, broad ecosystem during a transition.

In addition, the thesis identifies several coordination challenges, governance gaps, and role uncertainties that may interest private and public actors involved in the transition. While not offering prescriptive solutions, these findings can create further discussion and support the development of more coordinated alignment strategies in the future. It also brings forward the aspect of actor hesitancy and strategic ambiguity, highlighting how perceived risk and role confusion can stall collective action even when the technology exists.

Finally, this thesis applies the ecosystem perspective to a publicly governed context, where actors like regulated energy providers and municipalities can potentially play central roles. Unlike digital or commercial contexts, this setting highlights unique coordination and governance challenges. This includes fragmented mandates, slower institutional adaptation, and asymmetrical resources. These illustrate how ecosystem structure unfolds differently when public-sector constraints and social goals shape actor interactions.

7.3 Limitations and Future Research

This study provides valuable insights regarding the transition towards electric aviation in Sweden, however, several limitations must be acknowledged. First, the research focuses especially on the Swedish aviation ecosystem, which limits the generalizability of the findings to an international context. Political priorities, regulatory environments, and infrastructure maturity could differ significantly across countries and regions. Second, the study includes a diverse range of actors, but certain actors, such as international regulatory bodies and airline operators, were underrepresented. The perspectives and insights of these two groups could have provided a more comprehensive understanding of barriers and the effect of the transition towards electric aviation. Third, the time of the study explores a transition still in its initial stage. The data gathered reflects limited practical implementation and reflects more on assumptions and actor expectations. As electric aviation technologies reach maturity and deployment, new types of barriers or types of collaboration and interactions may emerge that were not researchable at the time of the study. Finally, the study focuses on the Swedish institutional and political setting. Broader international contexts, such as cross-border regulations or global supply chains, were not explored in depth.

Building on these limitations mentioned, several suggestions for future research are proposed. The evolution of the aviation ecosystem could be studied longitudinally on how roles, governance structures, and collaborations change over time. This would offer in-depth insights into the dynamic nature of sustainability transitions. Other areas of potential future research are business models and market design. It could focus on the operational models for electric airlines or on charging infrastructure. In correlation to the strong regulatory influence, policy-oriented research on procurement strategies, subsidies, or standards could help accelerate ecosystem alignment and adoption. The study also touches briefly on how the electric aviation ecosystem interacts with other ongoing transitions, such as hydrogen or SAF. Future studies could investigate how these parallel innovations co-exist, complement, and compete with each other within the shared infrastructure and policy context. This alignment will be crucial for understanding ecosystem fragmentation or integration. Finally, future research could explore societal acceptance and user demands. This study focuses on infrastructural and institutional perspectives, but understanding the passenger behaviors and public acceptance is necessary to ensure the viability and legitimacy of electric aviation.

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Appendices

Appendix A: Interview Guide

Introduction and Background

1. Can you describe your role?

2. Can you describe your organisation and its involvement in the aviation industry?

Current Structure and Ecosystem Roles

3. From your perspective, who are the key actors in the current aviation ecosystem?

4. Do you think these actors or roles will change with the transition toward electric aviation?

5. How does your organisation contribute to supporting electric aviation (e.g., funding, technology, regulation)?

6. How does your organisation currently interact with other stakeholders in the aviation ecosystem, and how do you think these interactions will change with electric aviation?

7. Does collaboration with other actors facilitate or hinder your contribution to the electric aviation transition? If so, how?

Transition to Electric Aviation

8. In your view, how does the infrastructure for conventional airplanes differ from the infrastructure needed for electric airplanes?

9. How do your organisation and its investors currently perceive the risks and opportunities associated with electric aviation?

10. From your perspective, what are the biggest barriers or challenges in transitioning from conventional fuel-based operations to implementing and supporting electric aircraft?

Final Reflections

11. Is there anything else you think is important to consider when implementing electric aviation?