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Research article

Analysing transitions in-the-making: A case study of aviation in Sweden

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ABSTRACT

The aim of this paper is to analyse contemporary transitions in the aviation industry in Sweden. We take a durational perspective to consider narratives as coordinating mechanism in sustainability transitions. We find that industry actors are constructing narratives for alternative aircraft fuels and technologies as they seek to maintain aviation's societal function whilst mitigating its climate impact. By reconciling memories of the past with their expectations for the future, narratives act to coordinate actors' transition activities in the present. In this way, narrative are more than an initiator of transitions, but constitute paths in-the-making, highlighting the agency of actors in enacting change in the present and shaping sustainability transitions of the future.

1. Introduction

Sustainability transitions are considered necessary, if not inevitable, in most sectors to overcome the structural challenges facing society today. With increasing global temperatures, rising sea levels, and the loss of biodiversity, the existential threat of the climate crisis is said to be avoidable only through "a fundamental transformation towards more sustainable modes of production and consumption" (Markard et al., 2012, p. 955). The co-evolutionary complexities involved in this process are a central interest in the research field of sustainability transitions which seeks to understand how radical changes can occur in such a way that societal functions continue to be fulfilled (Geels, 2004). Early work in the field focused on historical case studies, reconstructing transitions dynamics over several decades (Zolfagharian et al., 2019; Köhler et al., 2019) to develop theoretical frameworks such as the multi-level perspective (Geels, 2002) and technological innovation system (Bergek et al., 2008). However, as the climate crisis deepens, there is an increasing need for a contemporary understanding of sustainability transitions unfolding in real-time so as to "steer into the future with much greater care" (Slaughter, 1996, p. 799).

Commercial aviation, a sector involving the flying and operation of aircraft for remuneration or hire, is in the early stages of transitions. Reliant on fossil-based jet fuel, the sector today contributes up to three percent of global carbon dioxide (CO_2) emissions (Grewe et al., 2021; Lee et al., 2021). Despite technical and operational improvements reducing fuel burn (Zheng and Rutherford, 2020), much of this work has been offset by growth in the industry. Since the 1960s, revenue passenger-kilometres have grown at an annual rate of five percent and, despite the impact of the COVID-19 pandemic, the aviation industry assumes growth will continue, with an expected annual growth rate of over four percent across the next two decades (ICAO, 2023). As such, the aviation industry believes that technological alternatives to fossil-based jet fuel[1] will be necessary to maintain aviation as a "rapid worldwide

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[1] We use 'jet fuel' to refer to Jet A, Jet A-1, and Jet B fuels for commercial aviation, each of which are mixture of a variety of hydrocarbons.

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transportation network" (ICAO, 2022a) whilst limiting global temperature rise (United Nations, 2015).

The aim of this paper is to analyse contemporary transitions in the aviation industry. We draw on a case study of Sweden in which the development and implementation of advanced biofuels, electric aircraft, and hydrogen-based fuels is ongoing as the industry works to achieve fossil-free aviation by 2045. We build on the idea that narratives act as coordinating mechanisms for transitions (Garud and Gehman, 2012), enabling the translation of meaning between actors, simplifying discourse, and making complex issues tangible (Bartel and Garud, 2009; Simoens et al., 2022). Transitions are known to be a multi-actor process, enacted by a range of actors and social groups, each with their own agendas, resources, and strategies (Köhler et al., 2019). Actors within industries have a critical agency as they work to create, maintain, and/or disrupt change (Berggren et al., 2015; Farla et al., 2012; Löhr et al., 2022). Much of this work is discursive (Rosenbloom et al., 2016; Simoens et al., 2022) involving the construction of narratives to frame problems (Hermwille, 2016; Kriechbaum et al., 2021), shape collective expectations (Konrad et al., 2012), create new business models (Doganova and Eyquem-Renault, 2009), and legitimate activities (Geels and Verhees, 2011; Roberts, 2017).

Drawing on primary data from interviews and workshops and secondary data from documents and newspaper articles, we employ argumentative discourse analysis (Hajer, 2006, 1995) to understand the construction of narratives by industry actors working for change within the socio-technical system of Swedish aviation. We find that constructed narratives draw on actors' recollections of the past simultaneously with their expectations for the future to coordinate activities in the present. In this way, narratives are more than an initiator of transitions, but constitute paths in-the-making, highlighting the agency of actors in enacting change in the present and shaping sustainability transitions of the future.

The remainder of this article is structured as follows. Section 2 reviews the role of actors and narratives in sustainability transitions. Section 3 describes our methodology. Section 4 presents our results, outlining the dominant sustainability discourse in Swedish aviation and narratives for alternative aircraft fuels and technologies from a durational perspective. Section 5 discusses our findings and their implications for transition in-the-making in Swedish aviation and Section 6 concludes..

2. Theoretical background

2.1. Actors in transitions

Transitions are a multi-actor process involving the interaction of a range of actors and social groups across and between socio-technical systems, from the individual to civil society, the firm to the sector, the policymaker to public authorities (Köhler et al., 2019). Each actor, with their own beliefs and interests, resources and capabilities, agendas and strategies, has agency to enact change (Farla et al., 2012). Scholars have shown that industry actors, embedded within a specific sector, play a key role in shaping transitions. Whilst many of these incumbents may be resistant to change (Geels, 2014), other may actively participate in innovation, working to develop new products and services, create new markets, and form new industries (Berggren et al., 2015; Engwall et al., 2021; Farla et al., 2012; Penna and Geels, 2015).

Building on the concept of 'institutional work' (see Lawrence and Suddaby, 2006), Löhr et al. (2022) categorise the 'transition work' of actors as 'creating', 'maintaining', and/or 'disrupting'. Much of this work, at its roots, is discursive. For example, 'creating' involves work to lobby and advocate for political and regulatory support (Binz et al., 2016; Geels and Verhees, 2011), and to construct shared identities and visions for the future (Janssen et al., 2022; Konrad et al., 2012). 'Maintaining' involves the valorisation, demonization, mythologizing of socio-technical systems (Rosenbloom et al., 2016; Smith and Raven, 2012), the preservation and routinization of existent technologies, practices, and institutions (Lowes et al., 2020), and the deepening of networks and coalitions (Elzen et al., 2012). 'Disrupting' involves undermining or defending existent beliefs, practices, and innovations (Kivimaa et al., 2021; Roberts, 2017), dissolving or usurping coalitions (Kivimaa and Kern, 2016), and removing or adapting political and regulatory support (Trencher et al., 2021).

Narratives[2] play a role in this work, decomposing discourses into condensed stories and making complex issues tangible, allowing actors from various knowledge and institutional backgrounds to draw on a common understanding and engage in transition work (Hermwille, 2016; Moezzi et al., 2017; Simoens et al., 2022). Scholars have shown how industry actors use narratives as 'strategic tools' in their work for transitions, promoting actions, strategies and interventions that enable outcomes perceived to be desirable (Geels et al., 2016; Rosenbloom et al., 2016). Bauer (2018, p. 98) understands narratives to be "not in themselves an outcome of a transition process but rather a beginning, and entities which can be analysed to understand the politics of knowledge and technology that are being challenged in a transition". In this way, narratives provide a means with which to understand contemporary transitions (Köhler et al., 2019).

2.2. Narratives in transitions: a durational perspective

Sustainability is an intertemporal concept that reconciles with the problems of the past and the present "without compromising the

[2] We understand 'narratives' to be a subset of overarching discourses (Hermwille, 2016; Simoens et al., 2022) defining discourse as "an ensemble of ideas, concepts and categories through which meaning is given to social and physical phenomena, and which is produced and reproduced through an identifiable set of practices" (Hajer and Versteeg, 2005, p. 1). Although some consider 'storylines' to refer to the plot or arc within narratives (Moezzi et al., 2017), we follow Hajer (1995, 2006), who uses the terms 'narratives' and 'storylines' somewhat synonymously as devices that "allow actors to draw upon various discursive categories to give meaning to specific physical or social phenomena" (Hajer, 1995, p. 11).

ability of future generations to meet their needs" (WCED, 1987). As such, journeys to sustainability extend both across space and time, with continuous contestations and renegotiations of problem-definitions and solutions. To analyse these 'sustainability journeys', Garud and Gehman (2012) propose that narratives act as a mechanism for change. Inspired by the work of Bergson (1934/2007), they propose a durational perspective building on a phenomenological notion of time evoked by narratives in which the "the past is conserved in the present moment, even as the present moment is dilated or extended into the future" (Garud and Gehman, 2012, p. 986). From a durational perspective, narratives highlight the agency of actors who are always informed by memories of the past and shaped by anticipation of the future (Emirbayer and Mische, 1998). As described by Garud and Gehman (2012, p. 986), "agency is manifest in our abilities [as actors] to narrate and re-narrate, preserving both continuity and change, even as the journey is unfolding". This process of (re)narration is continuous, capturing unfolding events in real-time and is performative, constituting transitions in-the-making as social and material elements become entrained along an unfolding path (Bartel and Garud, 2009; Garud and Gehman, 2012; Van Lente and Rip, 2012).

From a durational perspective, the past is a rich ground for change, with memories acting as "the very fabric and basis of our actions" (Garud and Gehman, 2012, p. 986). In contrast to the views of evolutionary economists (e.g., Arthur, 1989; Dosi, 1982; Nelson and Winter, 1982), the past is not a place of 'unlightenment' which we must escape from for the sake of progress, but rather contains a wealth of resources, such as paths-not-taken, abandoned practices, and lessons learnt, that shape understandings in the present (Bartel and Garud, 2009; Brown and Michael, 2003). Take for example the uptake of electric vehicles in Norway. Their rapid adoption in the 2010s was ultimately supported by policies from 1990s which sought to promote a domestic electric vehicle industry and failed (Skjølsvold and Ryghaug, 2020). As Haugland (2023) reflects, the past does not necessarily determine the future, but may be a resource for path creation (Garud et al., 2010).

The future, too, is an influential resource in the present (Oomen et al., 2021). Expectations for the future act as 'prospective structures' that create a sense of obligation for actors to bring about the future they describe (Van Lente, 2012; Van Lente and Rip, 1998). Studies have shown the key role of expectations in innovation as "real-time representations of future technological situations and capabilities" (Borup et al., 2006, p. 286) which shape actors' orientation for action, act as a resource for decision making, and reduce uncertainty (Alkemade and Suurs, 2012; Budde et al., 2012; Budde and Konrad, 2019; Konrad et al., 2012). Bjerkan and Ryghaug (2021) show, for example, how expectations shape transition work in the Norwegian ports of Oslo and Kristiansand towards electrification, in part related to government policies and public funding schemes, however with no guarantee of success. Actors have to rely on "expectations rather than robust knowledge for taking strategic decisions and coordinating their efforts" (Konrad et al., 2012, p. 1084), especially in the early stages of technology development.

Narratives serve as a bridge to bring together memories of the past and anticipations of the future in the present moment (Asayama and Ishii, 2017; Bartel and Garud, 2009). They provide a common basis for interaction and allow for actors with diverse strategies, capabilities and resources to have shared understandings of social reality (Hajer, 2006, 1995). Bartel and Garud (2009, p. 113) refer to narratives as translation devices in time and space which "serve as a repertoire from which people [actors] can generate approaches that enable real-time problem solving". However, solutions for sustainability are contested since discourse (around what sustainability is) and narratives (of what the solutions are) are intertemporal (Susur and Karakaya, 2021). There will always be new memories of the past, new presents and new futures out there, engendering revisions in sustainability discourse and solution narratives. For instance, the narratives on nuclear power have been intertemporal, re-narrated continuously, such as portraying nuclear power as a solution for energy sovereignty and low-carbon electricity generation as well as an environmental or health problem or a risk to global security in various snapshots of the time (Garud et al., 2010).

3. Methodology

We draw on a case study of commercial aviation in Sweden (Merriam, 2009; Yin, 2009) collecting multiple sources of qualitative data using a mix of methods as summarised in Table 1.

3.1. Data collection

We focused primary data collection on actors within the aviation industry who position themselves to be at the forefront of contemporary transitions (see Appendix A for an overview). Interviews were held with 19 actors[3] working in the Swedish aviation industry between February and June in 2021. Interviewees were first identified from their expertise and contribution to the goal for fossil-free aviation 2045 from the Swedish Air Transport Society (2018) and later through snowballing. Interviews were semi-structured and lasted between 20 and 80 min. Interviews were conducted online via video-conferencing (due to the ongoing COVID-19 pandemic) and focussed on anticipations for the future of the aviation industry, low-carbon innovations and their challenges and opportunities. In September 2021, we held an online workshop to which actors in the Swedish aviation industry were invited to participate. A total of 16 actors participated, half of which had been involved in our earlier interviews. Participants were divided into three groups and sent to parallel breakout sessions. They were first asked to reflect on their visions for aviation in the next 25 years and discuss within their groups. Each group was assigned a moderator, who introduced the task and ensured all were given the opportunity to speak, and a note-taker, who then summarised the discussion at the plenary. Following this, participants once again returned to their

[3] A total of 16 interviews were conducted with 19 actors. Four interviewees were present at interview with 'Aviation R&D Project Leaders' (see Appendix A).

Table 1
Details of data sources.

Data source	Content
Interviews	16 semi-structured interviews with 19 interviewees (including one group interview) focussed on informants' anticipations for the future of aviation, low-carbon innovations and their challenges and opportunities.
Workshop	Online, full-day workshop with 16 participants asked to reflect on their visions for aviation in the next 25 years and steps necessary to achieve them through group discussions.
Newspaper articles	63 newspaper articles from six Swedish newspapers published between 1st January 2005 and 1st March 2023.
Legislative and regulative materials	Governing documents including national and regional legislations, official inquiries, strategies, funding prerogatives with respect to aviation from Ministries of the Swedish Government and the European Commission.
Industrial material	Reports, press releases, mission statements, investor and financial reports from firms and organisations in Swedish aviation industry (e.g. airports, airlines, fuel suppliers).
Academic material	Literature published in academic journals concerning Swedish aviation.

breakout groups and were asked to discuss what would be needed to achieve the visions previously discussed, before returning to the plenary for summation. A copy of the interview questions and workshop tasks can be found in Appendix B. All interviews and workshop discussions were held in English, recorded and transcribed verbatim.

We collected material from public media sources, focussing on articles from Swedish newspapers with the highest levels of circulation[4] (TU, 2017). Articles were retrieved from the media archive database Retriever using the search string ("aviation" AND "Sweden" AND ("technology" OR "energy"))[5]. The search was time-limited from the 1st January 2005 to 1st March 2023. A total of 849 searches were returned, which was narrowed down to a further 95 articles based on article titles, and further streamlined to 63 articles on reading full content. A full list of included articles can be found in Appendix C.

Industry reports were collected from leading industry actors, such as aircraft manufacturers, airlines, fuel producers, as well as industry representatives. We also drew on the main governing documents concerning the past and future development of aviation in Sweden which included national legislation (Ministry of Environment and Energy, 2017; Ministry of Infrastructure, 2021, 2020), official inquiries (SOU, 2019), national strategies (Ministry of Trade and Industry, 2017) and funding prerogatives of government agencies (Swedish Energy Agency, 2022a; Vinnova, 2022). As Sweden is a member of the European Union we also included plans and proposals from the European Commission for the future of aviation to explore the alignment of expectations between industrial actors in Sweden, Swedish policymakers and the European Commission (European Commission, 2021a; NRL, 2022).

3.2. Data analysis

We employed argumentative discourse analysis as a method for data analysis, an approach developed by Maarten Hajer (2006, 1995) to understand the social construction of environmental problems which has proved particularly useful when exploring the early stages of technology development in transitions (Binz et al., 2016; Ohlendorf et al., 2023; Rosenbloom et al., 2016). Argumentative discourse analysis pays particular attention to the role of storylines as "narratives through which elements from many different domains are combined that provide actors with a set of symbolic references that suggest a common understanding" (Hajer, 1995, p. 62). They allow for actors with diverse experiences, priorities and positions to gain a shared understanding of social reality by simplifying the discursive complexity of "what is being said to whom, and in what context" (Hajer, 2006, p. 72).

The first step of our analysis was a general survey of secondary data to provide a 'first reading of events' (Hajer, 2006; Hajer and Versteeg, 2005). This gave us an understanding of the broader discourse surrounding the sustainability of aviation and its problem-definition by industry actors. Although actors may have different approaches – with their own beliefs, resources, and strategies – they all appear to understand one another to reproduce the problem-definition and solution, i.e., that technological innovation can mitigate the climate impact of aviation by developing alternatives to fossil-based jet fuel.

The second step of our analysis was to explore primary data to interpret narratives within the discourse which actors construct to coordinate transition activities in the present. We found three narratives which each present a technological alternative to the problem of fossil-based jet fuels: advanced biofuels, electric aircraft, and hydrogen-based fuels. As we present below, although there are tensions within and between narratives, they deliver us to a future that is both desirable and attainable. By sharing in the construction and use of these narratives, we understand actors to be in a discourse-coalition,[6] reproducing and re-narrating narratives continuously by reconciling new memories of the past, new presents and new futures, assuming that technological innovation can mitigate the climate impact of aviation.

[4] Aftonbladet, Expressen, Dagens Nyheter, Svenska Dagbladet, Dagens Industri, and Göteborgs Posten

[5] Original search in Swedish: (”flyg” AND ”Sverige” AND (”teknik” OR ”energi”))

[6] We acknowledge that by focussing on narratives constructed by industry actors, we overlook those of alternative discourse-coalitions emerging from civil society (e.g., social movements such as #IStayOnTheGround (Ullström et al. 2021)) or opposition political groups (e.g., the Green Party (Kulanovic and Nordensvärd, 2021)). A comparison of narratives between discourse-coalitions is an avenue for further research discussed in Section 5.

4. Results

4.1. Sustainability discourse in Swedish aviation: a durational perspective

We began our analysis by analysing the dominant sustainability discourse surrounding aviation in Sweden from a durational perspective. Aviation is purported to have substantial social and economic benefits at national, transnational and global scales. Beyond the transport of goods and people, the industry claims that aviation is an enabler of trade and tourism, a supporter of economic growth, a driver of development and innovation, and a mechanism for cultural exchange, social inclusion, and sustainable development (ICAO, 2022b). This framing of aviation, as more than just a mode of transport, is present in Swedish public discourse, for example,

> "Flight and free movement are a prerequisite for an open and free society. Flying allows us to experience the world and exchange experiences." – Article No. 6, Svenska Dagbladet, 25/11/2010

Aviation is positioned as crucial for connectivity. As Europe's fourth largest country by land area, air travel connects Sweden's 40 airports (Fig. 1) to enable the movement of 40 million people every year[7] in, out, and across the country (Traffic Analysis, 2021).

The need for aviation is a long-held, institutionalised belief at all levels of governance from the Swedish government, to the European Commission, to the United Nations and its special agency of the International Civil Aviation Organisation (ICAO). The ICAO has a vision to support the "sustainable growth" of the industry globally (ICAO, 2022a). The European Commission seeks to maintain "the benefits that aviation brings to the global community" (NRL, 2022, p. 4) whilst meeting the target for net-zero CO_2 emission from the industry by 2050. These ambitions indicate that policy seeks to support the continuation, rather than the decline, of this industry, leaning into a neoliberal ideology that has dominated the political framing of air travel locally and globally as a deregulated system (Kulanovic and Nordensvärd, 2021; Ullström et al., 2021).

Aviation is not included in the national climate agenda of Sweden (Ministry of Environment and Energy, 2017), but is subject to a government strategy (N2017/00590/MRT) which aims to achieve an efficient and sustainable national air transport system (Ministry of Trade and Industry, 2017). Additionally, the Swedish aviation industry falls under the 'Fossil Free Sweden' initiative, launched in 2015 by the Swedish government to support the achievement of the national climate agenda. The country has an ambition to be the "world's first fossil-free welfare state" (Fossil Free Sweden, 2022) and achieve net-zero GHG emission by 2045 (Ministry of Environment and Energy, 2017). This will necessitate low-carbon transitions in all societal sectors, including aviation, which accounts for approximately five percent of national greenhouse gas (GHG) emissions annually (Al-Ghussein Norrman and Talalasova, 2021).

Working towards this goal, industry actors recall the past as a place of innovation that has enabled the mobility system we have in the present. Efforts from the past by the aviation industry have reduced fuel burn over the decades through technical and operational measures. For example, engine and aircraft manufacturers have improved engine bypass ratio, airframe efficiency and aerodynamics and airlines have worked to reduce payloads, optimise flightpaths, and upgrade fleet (Cansino and Román, 2017; Müller et al., 2018). These measures have led to a decline in fuel burn by one percent per year since 1960s (Zheng and Rutherford, 2020) and whilst motivated to reduce costs rather than emissions, it supports the framing that aviation is an innovative industry that has worked for sustainability for many years, for example,

> "Few industries have done as much as aviation to adapt and contribute to reduced emissions. In the last 40 years, aeroplanes have become 70 percent more fuel efficient. It is with new technology and new alternative fuels that we can reduce emissions and make aviation more sustainable."– Article No. 37, Göteborgs Posten, 15/08/2019

Coupling the perceived necessity of air travel in the present with the innovative history of the industry globally, there is a collective expectation that the future of aviation can, and will, be sustainable. In Sweden, this conviction has led industry actors to set a target, as part of the Fossil Free initiative, to achieve fossil-free domestic flights by 2030 and all flights departing from Swedish airports to be fossil-free by 2045. The industry, led by the Swedish Air Transport Society[8] (2018), announced this target in their published roadmap, proposing the ways in which aviation can maintain its societal function whilst contributing to a sustainable society. This was followed up in 2021, when the government-funded 'innovation cluster', Fossil-Free Aviation 2045, published a report "Fossil-Free Aviation 2045: Action, obstacles, and needs" (Al-Ghussein Norrman and Talalasova, 2021). This report depicts the imagined future for aviation in Sweden as follows,

> "The year 2045 marked the final destination in Sweden's journey towards fossil-fuel freedom. Sweden became the world's first fossil-free social welfare country, and the transformation of the aviation industry was an essential piece of the puzzle on the journey to the goal." (Al-Ghussein Norrman and Talalasova, 2021, p. 16)

From a durational perspective, ideas from the past dominate sustainability discourse as the industry, as well as policy, seeks to maintain aviation as a global mobility system. By evoking the past as evidence of the industry's innovation capabilities, the future is expected to be 'sustainable' through the development of alternative aircraft fuels and technologies.

[7] Although the COVID-19 pandemic reduced travel demands across 2020 and 2021, by December 2022, air travel was back to pre-pandemic levels.

[8] The Swedish Air Transport Society is a membership organisation representing actors in the Swedish aviation industry with a mission to promote better regulation, policy, innovation and sustainable growth for the benefit of Swedish society. Members include airports, airlines, aircraft and component manufacturers, and air navigation service providers.

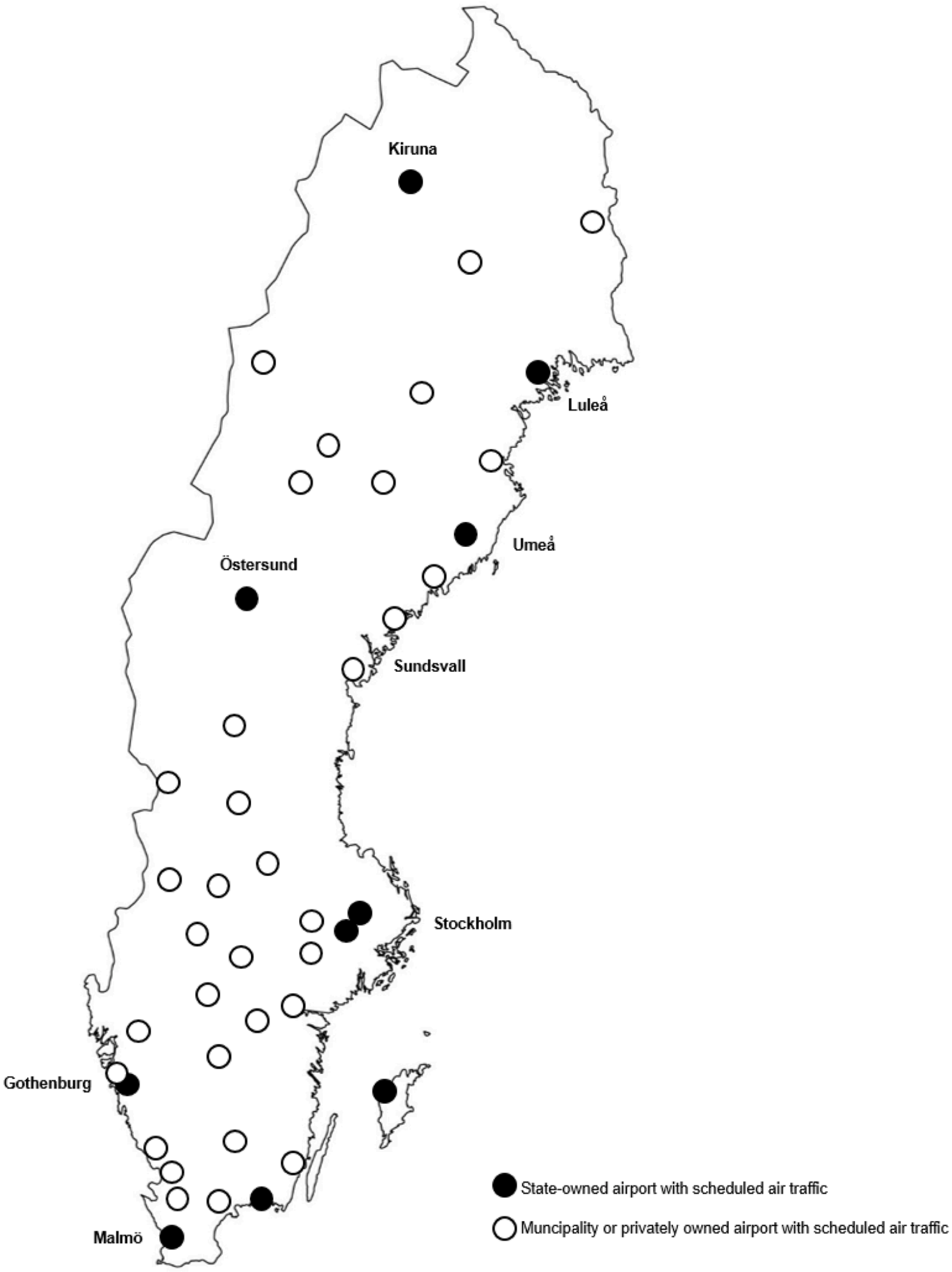

Fig. 1. Location of airports in Sweden.

4.2. Narratives for alternative aircraft fuels and technologies

The imagined future for fossil-free aviation in Sweden is based on the expected development of advanced biofuels, electric aircraft, and hydrogen-based fuels. As we shall show, this expectation draws on resources from the past, including experimentation from other sectors as well as abandoned practices. We present the narrative for each alternative separately, taking a durational perspective in our analysis. However, they are far from independent but interrelated, a point we return to in more depth in the discussion.

4.2.1. Advanced biofuels

The first narrative is for advanced biofuels.[9] Biofuels have long been used as a transport fuel, with the blending of ethanol and gasoline for use in passenger cars an established, although declining, practice in Sweden (Sprei, 2017). The lessons learnt from this practice are believed to be transferable to the aviation sector as a way to reduce the climate impact of air travel (Dahal et al., 2021). Advanced biofuels can be blended in up to a volume ratio of 50 percent (ASTM, 2018, 2017) depending on production pathway (see Table 2 for an overview).

Industry actors began to explore the possibility of introducing advanced biofuels into the Swedish aviation fuel supply system around a decade ago. In 2015, Karlstad Airport, SkyNRG, and Nordic Initiative for Sustainable Aviation set up the Fly Green Fund as a non-profit economic organisation to encourage the use of biofuels as an alternative to carbon offsetting (Fly Green Fund, 2021). Recollecting the early days of the initiative, one actor reflected,

> "When the Fly Green Fund was being built, it was, how can I put it…? It was mostly the sustainability nerds that were interested, both from business and private travellers. But I could already see that it was quite an easy idea to sell because I think most of us want to contribute to and live in a sustainable world" – Aviation Sustainability Consultant (in interview, April 2021)

Actors remember that Sweden has always had high ambitions for sustainability. Although the world-wide production of advanced biofuels is less than one percent of global jet fuel demand (IEA, 2021), industry actors recollect that they have long been engaged in promoting the alternative, positioning themselves as 'ahead of the game' with advanced biofuels accounting for approximately two percent of jet fuel demand in Sweden today. As one actor commented,

> "We have been able to buy biofuels at the major airports in Sweden and Norway for a number of years. And now they are talking about the fact that it is possible to do it in Munich and Frankfurt. So in Sweden we are well ahead of the thinking at least, and in making it possible." – Sustainability Executive in Major Airline (in interview, May 2021)

Nevertheless, there remains a gap between the future described by industry actors and present realities. The 2018 roadmap expected Sweden to have large-scale production plants by 2025 but there are no current production facilities in the country. Here we see a tension in the narrative for advanced biofuels. Although there is an expectation that Swedish forestry can be used in the production of advanced biofuels, it is unclear where these biofuels could or should be produced. Some actors argue for leveraging the country's long-established competences for bioenergy, particularly in the transport and heat sectors for the domestic production of biofuels. Others argue that the country should focus its efforts on the sustainable management of forestry and export to production facilities abroad. This tension is illustrated below,

> "Sweden is one of the countries that can produce the biofuels regardless of area. I mean, if we can't produce it, none else can. So we have to take that task. We have to be the forerunner and do it in a sustainable way." – Executive Manager in Biofuels Producer (in interview, May 2021)
>
> "In Sweden, we are focusing a lot on local production and there is a huge potential for forestry that Sweden has. But I think Sweden, or even Scandinavia, will have a role in the feedstock field, not in the production." – Executive Manager in Biofuels Producer and Distributor (in workshop, September 2021)

Nevertheless, all actors agree that Swedish forestry is a unique resource available, and as one actor put it "green gold to support alternative fuels" (Sustainability Manager in Charter Airline, in interview, April 2021). This narrative positions advanced biofuels as a near-term solution, but increasingly, it is only a temporary one. As one actor stated,

> "In the short term there will definitely be different kinds of biofuels as drop-in fuels because they work in the existing aircraft and the existing infrastructure. So they are very, very easy to introduce" – Aviation Sustainability Consultant (in interview, April 2021)

As advanced biofuels are compatible with existing aircraft, they can allow existing aircraft or those coming to the market to fulfil their service life which can be anywhere from 10 to 35 years (IPCC, 1999; Schäfer et al., 2015). However there are concerns as to the sustainability of advanced biofuels due to increased pressure on land and water resources (Dodd and Yengin, 2021; Lai et al., 2022) as well as the fact they are not CO_2 emission free which is acknowledged by actors.

> "We should not use biofuels if we can find on other energy sources, but for the most part, it's the only way to decrease emissions right now" – Aviation Sustainability Consultant (in interview, April 2021)
>
> "Biofuels are not perfect […] they aren't net-zero in terms of carbon dioxide emissions, but they're still better than fossil fuels" – Sustainability Manager at Major Airport (in interview, April 2021)

Yet the belief that advanced biofuels will have a role to play in the decarbonisation of aviation in the near-term is legitimised by policy. In July 2021, a national reduction obligation came into force mandating jet fuel suppliers to reduce GHG emissions through the blend-in of increased ratios of advanced biofuels (Ministry of Infrastructure, 2021). This legislation was the result of a yearlong enquiry from 2018 to 2019 which proposed the blend-in of one percent in 2021, up to 30 percent in 2030, to lead to a GHG reduction of 27 percent by 2030. Within the mandate, there is a step-up of blending from five to eight percent in 2025 to 2026. This is motivated by the

[9] Advanced biofuels refers to liquid fuels derived from non-edible bio-based feedstock, also known as second-generation biofuels

Table 2
Drop-in approved production pathways for advanced biofuel. Table adapted from EASA (2022a).

Production pathway	Feedstock	Certification name (blending limit)
Biomass Gasification + Fischer-Tropsch (Gas + FT)	Energy crops, lignocelluslosic biomass, solid waste	FT-SPK (up to 50 %)
Hydroprocessed Esters and Fatty Acids (HEFA)	Vegetable and animal fat	HEFA-SPK (up to 50 %)
Direct Sugars to Hydrocarbons (DsHC)	Conventional sugars, lignocelluslosic sugars	HFS-SIP (up to 10 %)
Biomass Gasifications + FT with Aromatics	Energy crops, lignocelluslosic biomass, solid waste	FT-SPK/A (up to 50 %)
Alcohols to Jet (AtJ)	Sugar, starch crops, lignocellulosic biomass	ATJ-SPK (up to 50 %)
Catalytic Hydrothermolysis Jet (CHJ)	Vegetable and animal fat	CHJ or CH-SK (up to 50 %)
HEFA from Algea	Microalgae oils	HC—HEFA-SPK (up to 10 %)
FOG co-processing	Fats, oils, and greases	FOG (up to 5 %)
FT co-processing	Fischer-Tropsch (FT) biocrude	FT (up to 5 %)

expectation that the supply of biofuels will be "greater then thanks to growing production capacity" (Ministry of Infrastructure, 2021, p. 32), aligning with those expressed in the 2018 roadmap, and legitimising the belief that,

> "Everything is pointing in the direction that we will have an increase and that the blending percentage increases […] Hopefully, the volumes available will increase in such a way that the ball starts spinning on its own so that the price will go down and the supply will increase" – Executive Manager in Biofuels Distributor (in interview, March 2021)

4.2.2. *Electric aircraft*

Our second narrative centres on the development and operation of electric aircraft. Batteries have been an established power source for transport with the rapid growth of electric vehicles for passenger mobility since early 2010s (Kester et al., 2020). Battery technology has undergone several waves of innovation, and today lithium-ion (Li-ion) technology has the capacity to support either hybrid- or all-electric[10] propulsion systems (Schäfer et al., 2019). Innovation is expected to continue, as one actor explained,

> "Electric aviation will be very dependent on battery technologies and disruptive technologies that I'm sure we haven't seen a lot of it yet but there's such a drive towards electrification in society. And that isn't driven by aviation, but by many, many industries. And when other industries electrify and need better technologies, better solutions, it will be of benefit to aviation as well" – Aviation Sustainability Consultant (in interview, April 2021)

Although the range and capacity of electric aircraft are considerably lower than existing aircraft which run on liquid fuels today, actors are already imagining the potential implementation of the technology over time. As one actor reflected,

> "We're working with two parallel questions: one being the introduction of electric aviation to replace current aircrafts, and the other being the introduction of new regional routes that don't exist or have existed in the past, but not anymore." – Aviation R&D Project Leader (in interview, April 2021)

On the one hand, the low operating range and carrying capacity means that electric aircraft will not and cannot compete with existing technology for several years, but on the other hand, there is still potential to operate electric aircraft on short-haul, point-to-point routes, creating a new domestic and regional market in Sweden and across the Nordics. Actors return to the past, remembering how aviation used to operate in Sweden before deregulation in the early 1990s. In a 2020 assessment of the potential for electric aircraft, the government agency Transport Analysis, identified an additional 44 airports and airstrips across Sweden with the potential to operate electric aviation (Transport Analysis, 2020). As one actor, reflected, this opens up the possibility for a new means of connectivity,

> "I think electric aircraft will have the possibility to be part of a new regional public transport system, and in sparsely populated areas like northern Sweden, where fewer people live in the four northernmost counties than the Stockholm municipality and the cities are small or non-existent […] then a public transport system based on electric aircraft within this region, the four northernmost counties and northern Finland and northern Norway will be very interesting" – Aviation R&D Project Leader (in interview, May 2021)

But this future is currently at odds with the present system, and does not fit with the existing operations of airlines. Unlike advanced biofuels, which can be blended in with jet fuels, electric aircraft are a new technology, requiring new infrastructure and new operations. As one actor explained,

> "Right now for SAS and Norwegian, for example, an aeroplane can do a Stockholm-Gothenburg, Gothenburg-Stockholm, Stockholm-Nice, Nice-Stockholm, Stockholm-Kiruna route, and spend the night at Kiruna. An electric aeroplane, might have the range for Gothenburg to Stockholm and not to Kiruna, so it's a whole different routine that they need to think about" – Sustainability Strategist in Major Airport (in interview, April 2021)

In Sweden, much of the anticipation for electric aviation rests on the activities of Heart Aerospace. The Swedish-based start-up, first

[10] The two-seater Velis ELCTRO from Pipistrel (Type certified EASA.A.573 TCDS) uses Li-ion batteries and has a flying time of 50 minutes and range of approximately 100 km.

established in 2018, initially worked to develop a 19 seater all-electric concept for commercial release in 2026 with a range of 400 km (Heart Aerospace, 2021). In September 2022, Heart Aerospace announced that their work would now focus on a 30 seater hybrid concept for commercial release in 2028 (Heart Aerospace, 2022). The 'ES-30' concept is expected to have a fully electric range of 200 km and further possibility to fly up to 800 km through use of its "reserve-hybrid" turbojet propulsion system,[11] designed to fulfil the reserve energy requirements of European Union Aviation Safety Agency Certificate Specification 25 (EASA, 2022b; Heart Aerospace, 2022). In upscaling the size of their aircraft, Heart Aerospace align their activities more closely with the present socio-technical system, in many ways reducing the perceived 'radical' nature of their innovation. The company has received purchase orders for 230 aircraft from major airlines including United Airlines and Air Canada and letter of intent for 96 aircraft, including Swedish airlines BRA and SAS.

The activities of Heart Aerospace is also gaining support from Swedish policy actors. The range and operation of Heart Aerospace concept is being taken as the standard in government-commissioned assessments for the potential for electric aviation in Sweden from agencies such as Transport Analysis and Swedish Energy Agency, exampling the power of expectations. In 2022, the Swedish Energy Agency began their investigation for a 'climate premium' to support electric aviation (Swedish Energy Agency, 2022b). They anticipate that the implementation of electric aircraft will begin in late 2028 in line with Heart Aerospace and will take an increasing share of the domestic market as the technology develops over time. Both government agencies believe that electric aviation is to be of benefit in reducing the climate impact of aviation and achieving national climate goals, an idea shared by industry actors, who compare the technology with existing train infrastructure, for example,

> "If you want to travel energy efficiently and be climate friendly, you should fly in an electric aircraft. It's actually the same, or better, than going by an electric high-speed train like the X2000 [operating between Stockholm, Gothenburg, and Malmö]. You don't need any infrastructure on the ground. You need only two runways and air" – Aviation R&D Project Leader (in interview, May 2021)

4.2.3. Hydrogen-based fuels

Our final narrative includes two alternative aircraft fuels – electrofuels and liquid hydrogen – both of which are derived from hydrogen, hence their collective narrative which we term 'hydrogen-based fuels'. Hydrogen has been a fuel for aircraft for several decades, being used to inflate airships in the early 20th century until the Hindenburg disaster in 1937 brought an end to use of rigid airships (Windischbauer and Richardson, 2005). Hydrogen has been explored as an alternative fuel for aircraft several times since the 1950s, for example, by Lockheed in 1950s and 70 s (Brewer, 1976) and Tupolev in the 1980s (Piesing, 2022), however, expectations for hydrogen as an energy carrier are resurfacing with advancements in fossil-free hydrogen production technologies.

Green hydrogen is being produced through the electrolysis of water[12] using renewable electricity in Sweden as part of the country's successful pilot project for the production of fossil-free steel through the use of 'hydrogen breakthrough iron technology' (Nurdiawati and Urban, 2022; Öhman et al., 2022). The success of this project, which produced fossil-free steel pellets in 2020 and is now scaling-up its production, has proven the capabilities of hydrogen production in Sweden, for the benefit of all industries. As two actors, speaking about the use of in aviation, reflected,

> "We have a very good possibility to use hydrogen because […] we can produce it from wind and solar energy. And we have lots of places in Sweden where we can do it and we can store it and use it." – Aviation Sustainability Consultant (in interviews, April 2021)
>
> "We see similar development in other sectors as well that can give hydrogen economies of scale because it's used in other sectors." – Research in Industrial Transformations (in workshop, September 2021)

As in the narrative for electric aviation, the development of hydrogen fuels links to expected developments in other sectors and both the narrative for electric aviation and hydrogen-based fuels emphasise the suitability of Sweden for their use due to the relatively low electricity generation.[13]

Electrofuels, also known as power-to-liquid fuels, dominate the narrative for hydrogen fuels in the near-term. These fuels are produced from the synthesis of hydrogen and captured CO_2 and, much like advanced biofuels, can be used as a drop-in fuel blended with fossil-based jet fuels (Drünert et al., 2020; Lai et al., 2022; Meckling and Biber, 2021). Electrofuels are the object of growing expectations, tied to recent advancements in hydrogen production and carbon capture and storage (Lefvert et al., 2022; Nurdiawati and Urban, 2022). As one actor said,

> "There's a lot of power-to-liquid initiatives going on with hydrogen, carbon dioxide and electrolysis" – Sustainability Executive in Major Airline (in interview, May 2021)

For example, in November 2021, the airline SAS, state-own power company Vattenfall, fuel supplier Shell, and technology

[11] To be fuelled by sustainable aviation fuels (the collective term for advanced biofuels and electrofuels)

[12] Jules Verne wrote about the use of 'green' hydrogen in his 1874 adventure novel *The Mysterious Island*: "Water will one day be employed as fuel, that hydrogen and oxygen which constitute it, used singly or together, will furnish an inexhaustible source of heat and light, of an intensity of which coal is not capable" (Verne, 1875).

[13] Electricity in Sweden is relatively low-carbon, with generation in 2020 from nuclear power (29 percent), hydropower (45 percent), wind power (17 percent), and solar (1 percent) (Swedish Energy Agency, 2022c).

developer LanzaTech announced a joint venture to explore the production of up to 50,000 tonnes of electrofuels in Sweden, with ambitions to commission a production facility by 2027 (Vattenfall, 2021). In early 2022, private companies Swedish Biofuels and COWI announced their partnership to build three production facilities for electrofuels in Sweden, able to deliver 400,000 tonnes equivalent to 40 percent of current annual demand (Swedish Biofuels, 2022). The construction of the first plant is supported by the European Commission, and planned to be sited less than 20 km from Sweden's busiest airport, Stockholm-Arlanda, and able to deliver up to 20,000 tonnes of electrofuels. Here we see commitment from private actors to electrofuels that we do not see for advanced biofuels, despite the fact that they are not included in the national reduction obligation (Ministry of Infrastructure, 2021). However electrofuels are included in the European Union 2025 blending obligation 'RefuelEU Aviation' (European Commission, 2021b). Given the ongoing joint ventures, industry actors believe that Sweden is in a good market position to export fuels and competences around the world. Moreover, the alternative also overcomes the sustainability and availability concerns associated with advanced biofuels, as one actor explained,

> "Electrofuels are a way to solve the problem with raw materials for biomass which will be a scarce resource on a global scale. In Sweden we have it [e.g. forestry], but not on a global scale" – Aviation Sustainability Consultant (in interview, April 2021)

Liquid hydrogen is expected to be a carbon-free alternative aircraft fuel. Although the use of hydrogen in aircraft was largely abandoned in the late 1900s (Brewer, 1976; Piesing, 2022), liquid hydrogen has remained a signature fuel in the aerospace industry as a component of rocket fuel (Granath, 2017). In commercial aviation, the technology is being explored by the aircraft manufacturer Airbus, who announced three 'ZeroE' hydrogen-based aircraft concepts in 2020 for commercial release by 2035 (Airbus, 2021). Liquid hydrogen requires the re-design of aircraft as well as the systems for fuel delivery and fuel supply chain (Baroutaji et al., 2019; Dahal et al., 2021). This work will take time, and whilst Airbus aims for commercialisation by 2035, industry actors in Sweden are sceptical that this date is realistic. As one actors reflected,

> "We don't have aircraft that can cater for hydrogen at the moment. So we will need completely new aircraft and new distribution systems. And if you look at the safety issues and the time it takes to develop new aircrafts, we don't see them in operations before 2035" – Aviation Sustainability Consultant (in interview, April 2021)

Nevertheless, in the longer-term, liquid hydrogen is perceived to be a sustainable solution and "one of the different building blocks that can be used to achieve fossil-free flights in the future" (Sustainability Strategist at Major Airport, in interview, March 2021).

5. Discussion

In this study we analysed contemporary transitions in the aviation industry, drawing on a case study of Sweden. Taking a durational perspective inspired by Garud and Gehman (2012), we employed argumentative discourse analysis to understand the construction of narratives by industry actors working for change within aviation. We found narratives to be grounded in the discourse that a 'sustainable' future can and will be achieved through technological innovation, i.e., the development of alternative aircraft fuels and technologies, building on industry's technology-based innovative history and working towards a future of fossil-free aviation by 2045.

We found three narratives, each of which presents a technological alternative to the 'problem' of fossil-based jet fuels. These alternatives are advanced biofuels, electric aircraft, and hydrogen-based fuels. Each narrative bridges memories of the past, recollecting lessons learnt and abandoned practices, and expectations for the future. The narrative for advanced biofuels builds from the blending of ethanol and gasoline in passenger cars as a practice to allow for the continued operation of existing aircraft and therefore maintain the function of aviation as a means of global mobility. Similarly, the narrative for electric aircraft draws on ongoing innovation in passenger cars with the growth of electric vehicles. With the expectation that electric aviation will have a lower operating range and carrying capacity, actors return to the past with the idea to reintroduce airstrips and airports pre-dating deregulation in the early 1990s to build a regional electric air market in Sweden. For hydrogen, Airbus' experimentation marks the return to an abandoned practice fuelled in turn by expectations for hydrogen as a future energy carrier. Each narrative delivers a future of fossil-free aviation and is grounded in a shared understanding that technological innovation can mitigate the climate impact of aviation by developing alternatives to fossil-based jet fuel.

However, while actors share in this problem-definition, solutions may be re-narrated with new memories of the past, new circumstances of the presents and new expectations for the future. We can, for example, observe such re-narration for advanced biofuels, hydrogen-based electrofuels and electric aircraft. Actors' narrative for advanced biofuels has shifted from being an alternative to carbon offsetting to being a temporary solution due to concerns for sustainability. Meanwhile, the narrative for hydrogen-based electrofuels has become more visible over time, echoing the growing interest in green hydrogen production and carbon capture and storage in Sweden. However, these narratives are not necessarily in conflict. Actors' have positioned advanced biofuels as a shorter-term solution to bridge the gap between the present and an expected future where the production of electrofuels will be in commercial volumes. The narrative for electric aircraft has stabilised this further with changing expectations from the commercial release of an all-electric aircraft in 2026 to reserve-hybrid aircaft in 2028. With this new concept, Heart Aerospace will likely use advanced biofuels or/and electrofuels as an alternative to fossil-based jet fuels. In this way, narratives appear to be complementary to one another and in relation to other sectors, revealing the balancing act in which actors position themselves as creating, maintaining, and disrupting transitions simultaneously.

Complementarities amongst narratives, privileging continuity from the past to the present and into the future with a variety of technologies over a relatively longer time span, enable various actors such as airlines, fuel suppliers and airports to engage with the future. In the case of aviation, narrative complementarities and actors' continuity into the future may be key to make the narratives more convincing since the aviation industry is highly capital-intensive and has high entry barriers. Imagining a future where the established actors can co-exist makes narratives more persuasive and contributes to the dominance of the industry's discourse. From our own analysis, the industry discourse remains much the same as an analysis from Gössling and Peeters (2007) in which industry actors argue for the social and economic importance of the transport mode and the development of new technology to reduce "the environmental harmfulness of aviation" (ibid, p. 413). However, the plurality within narratives is a challenge for policymakers. Whilst, expectations often act as a basis of decision-making resources for industry actors to coordinate activities, motivate resource mobilisation and create legitimacy (Alkemade and Suurs, 2012; Konrad et al., 2012) policymakers must contend with their uncertainty. As Peeters et al. (2016) discuss, visions for the future of aviation contain multiple technologies and strategies, making it difficult to question and monitor progress, and so policymakers are hesitant to assign resources, despite calls from the industry. Whilst the industry constructs broad narratives to allow for flexible interpretation amongst themselves, their openness and inclusivity makes it challenging for policymakers to determine which technological option is most likely or most attractive and so they face a paradox of choice.

We find narratives to be more than just a beginning of transitions, as understood by Bauer (2018), but an integral part of transitions. By enabling the simplification of discourse and translation of meaning between actors, narratives provide a way in which to think *across* time (Garud et al., 2016). The durational perspective draws attention to temporal agency (Emirbayer and Mische, 1998) and how actors are "orientated toward the past, the future, and the present at any given moment" (ibid, p. 964), continuously re-narrating sustainability transitions as they unfold. In doing so we open up a new way of thinking of sustainability from an intertemporal perspective, although is not without methodological challenges and in need of further theoretical refinement. We can only offer a snapshot of narratives at the moment of analysis. A further avenue for research would be to look across other narratives and discourse-coalitions, as our analysis is limited to the narratives of industry actors who seek to reproduce the existing system of aviation and normalised practice of air travel (Ullström et al., 2021). Understanding that there are a diversity of pasts, presents, and futures available to us (Stirling, 2009), it would be fruitful to broaden the focus, including perspectives of other actors across the socio-technical system for an analysis of competing discourse-coalitions, such as those which call for reducing air travel consumption (Åkerman et al., 2016; Gössling et al., 2019), to highlight further discursive struggles.

6. Conclusion

This paper has analysed sustainability transitions in-the-making in aviation, taking a durational perspective to understand the construction of narratives by industry actors working for change within the socio-technical system of Swedish aviation. The durational perspective is not new to the research field of sustainability transitions, but has had limited theorisation and operalisation to date (Köhler et al., 2019; Susur and Karakaya, 2021). By taking such a perspective to assess contemporary transitions, we find industry actors in aviation to draw on their recollections of the past simultaneously with their expectations for the future in the context of the present to work for transitions, constructing narratives for advanced biofuels, electric aircraft, and hydrogen-based fuels. These narratives are continuously re-narrated with the emergence of new memories of the past, new presents and new futures, engendering revisions in sustainability discourse and solution narratives. In this way, narratives are more than an initiator of transitions, but constitute paths in-the-making, highlighting the agency of actors in enacting change in the present and shaping ongoing sustainability transitions.

CRediT authorship contribution statement

Emily Christley: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft, Writing – review & editing. **Emrah Karakaya:** Conceptualization, Writing – review & editing. **Frauke Urban:** Writing – review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix

Appendix A. Details of interviewees and participants of workshop

Business Area	Position	Interview Date and Duration	Participant in workshop?
Airlines	Sustainability Manager in Charter Airline	Apr-21, 49 mins	No
	Sustainability Executive in Major Airline	May-21, 75 mins	Yes
Airport	Sustainability Strategist in Major Airport	Mar-21, 50 mins	No
	Sustainability Strategist in Major Airport	Apr-21, 42 mins	Yes
	Executive Manager in Regional Airport	Apr-21, 67 mins	No
	Executive Manager in Major Airport	–	Yes
Aircraft Fuel Supplier	Executive Manager in Biofuels Distributor	Mar-21, 58 mins	Yes
	Executive Manager in Biofuels Producer	May-21, 31 mins	No
	Executive Manager in Biofuels Producer and Distributor	-	Yes
	Hydrogen Development Project Leader	–	Yes
Industrial Networks and Consultancies	Airport Sustainability Project Leader	Mar-21, 25 mins	Yes
	Aviation Sustainability Consultant	Apr-21, 75 mins	Yes
	Aviation Research Consultant	Apr-21, 42 mins	Yes
	Aviation R&D Project Leader	May-21, 78 mins	No
	Representative of Aviation Industrial Network	May-21, 26 mins	Yes
	Aviation Sustainability Consultant	May-21, 43 mins	No
	Representative of Aviation Industrial Network	May-21, 29 mins	Yes
Research and Academia	Aviation R&D Project Leaders	Apr-21, 45 mins	No
	Aviation R&D Project Leader	Apr-21, 31 mins	No
	Researcher in Industrial Transformation	–	Yes
	Researcher in Sustainable Aviation	–	Yes
	Researcher in Transport Systems	–	Yes
Aircraft Manufacturing and Engineering	Engineer in Aircraft Component Manufacturer	–	Yes
Government Agency	Policy Advisor in Transport Agency	–	Yes

Appendix B. Interview guide and workshop task

Interview guide

Introduction

- Background of respondent
  - What is your current role?
  - What is your organisations role in the aviation industry in Sweden?

Theme #1: Aviation today

- How has the aviation industry changed in recent years?
- What would you say have been/are the drivers of change?

Theme #2: Impact of COVID

- What has been the impact of the COVID 19 pandemic on aviation?
- What impact has this had on your short-term plans/goals, particularly in regard to sustainability?
- What are your expectations with regard to recovery from COVID 19 pandemic for the aviation industry? Do you have a timeframe in mind?

Theme #3: Future visions for aviation

- What do you see aviation to be in the future: 2030, 2045, 2050?
- What changes are needed if the aviation industry is to be fossil-free by 2030 and 2045?
  - What changes are you implementing in your organisation?
- Who is driving the transformation to fossil-free aviation?
  - What are the main challenges for change in Sweden? Globally?
  - What needs to change from a policy perspective to achieve fossil-free aviation in Sweden? Globally?
  - What needs to change from a financial perspective to achieve fossil-free aviation in Sweden? Globally?
- How could electric aviation impact existing aviation infrastructure, electricity network etc.? Consumer travel patterns? Airport operations (e.g. considering charging times)? Cost of travel?

Workshop task

Break-out session aims

- To gather visions for the potential future of aviation and role it may play in Swedish society in the next 25 years
- To gather ideas as to how these potential visions can be achieved, i.e., what are the steps that need to be taken to get there?

First Phase: Visions For Aviation - 25 Years In The Future

- Starter questions/prompters:
  - What will be the role of aviation in 25 years in Swedish society?
  - Is there a collective vision for the future?
  - What do you base your ideas on? Why do you think it’s going to be like this?
  - Do you think it’s possible? What do you think we have today that points to this?
- Reporting Back at Plenary:
  - Briefly present the visions put forward as discussed in each group, potential discussion of converging themes in visions

Second Phase: Achieving The Visions - What Needs To Be Done?

- Starter questions/prompts:
  - What must be done to achieve these vision(s)? What practical steps must be taken?
  - What can you (i.e. respondents) do to contribute to this vision?
  - What can researchers do to contribute to this vision?
  - What can others do, i.e., other industries/sectors, governments, etc.? Is there the potential for conflict?
- Reporting Back at Plenary:
  - Briefly present the steps to be taken to achieve these visions as discussed
  - Time for any final comments

Appendix C. Newspaper articles

Article No.	Publication	Original Article Title	Translation to English	Publication Date
1	Svenska Dagbladet	Far och flyg med flygskatten Dags för ny dans kring guldkalven? Rörelsehindrade kan få svårt att hinna över Nyanserad bild av små sjukhus behövs När ska brottsoffren räknas som utsatta? Bättre märkning av kött behövs	Go and fly with the flight tax. Time for a new dance around the golden calf? People with reduced mobility may find it difficult. A nuanced picture of small hospitals is needed. When should crime victims be considered vulnerable? Better labelling of meat is needed.	13/03/2006
2	Göteborg Posten	Miljön betalar högt pris för billigt flyg	The environment pays a high price for cheap flights	29/09/2006
3	Svenska Dagbladet	Kan vi fortsätta flyga?	Can we continue to fly?	19/11/2006
4	Svenska Dagbladet	Klimat för nya resvanor	The climate for new travel habits	03/12/2006
5	Svenska Dagbladet	Vätgas ignet förnyelsebart alternativ	Hydrogen isn’t a renewable alternative	24/02/2009
6	Svenska Dagbladet	Ska vi verkligen flyga ännu mer?	Should we actually fly more?	25/11/2010
7	Dagens Nyheter	Svenskarnas flygresor på väg bli största miljöboven	Swedish air travels on the way to being the biggest climate offender	14/02/2011

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Article No.	Publication	Original Article Title	Translation to English	Publication Date
8	Svenska Dagbladet	Sverige bör satsa på elvägar	Sweden should invest in electric roads	18/11/2011
9	Svenska Dagbladet	Katapult ett lyft för flyget	Catapults adds a lift to flight	05/10/2012
10	Svenska Dagbladet	Chockhöjt bränslepris ger flyget eld i baken	Shockingly high fuel prices put aviation on fire	28/04/2014
11	Svenska Dagbladet	Är det rätt att lägga ned Brommaflyget?	Is it right to close down Bromma?	10/09/2014
12	Dagens Nyheter	Nu krävs kraftfulla åtgärder mot nötkött och flygresor	Strong measures are now required against beef and air travel	26/02/2015
13	Dagens Nyheter	LRF och Svenskt flyg svarar inte om klimatmålen	LRF and Svenskt Flyg are not responsible for the climate goals.	04/03/2015
14	Göteborgs Posten	Skatt på flyg ska utredas	Tax on flights to be investigated	05/11/2015
15	Expressen	Nya flygskatten förödande för norra Sverige	The new flight tax devastating for northern Sweden	21/06/2016
16	Svenska Dagbladet	Flygskatten är skadlig och utan nytta för klimatet	The flight tax is useless and harmful for the climate	01/12/2016
17	Dagens industri	Biodrivmedel kommer inte slås ut av eldrift	Biofuels will not be replaced by electricity	10/03/2017
18	Dagens industri	SAS, Norwegian och BRA: Detta är vårt alternativ till flygskatt	SAS, Norwegian and BRA: This is our alternative to flight tax	15/03/2017
19	Svenska Dagbladet	Blunda inte för flygskattens allvarliga konsekvenser	Don't turn a blind eye to the serious consequences of the flight tax	31/03/2017
20	Aftonbladet	Lövin jagar resenärer - och inte flygutsläpp	Lövin hunts the travelers - not the emissions	09/08/2017
21	Aftonbladet	Lööf: "Flygskatt ineffektivt - vi satsar på laddstolpar och biogas"	Lööf: "Aviation tax ineffective - we invest in charging stations and biogas"	08/10/2017
22	Svenska Dagbladet	Fyra klimatsaker du inte får missa	Four climate things not to miss	31/01/2018
23	Expressen	Ta flyget till Thailand - för klimatets skull	Fly to Thailand - for the sake of the climate	01/02/2018
24	Dagens Nyheter	Flyget måste byta bränsle - men inte till el…	Flying must change fuel - but not to electricity…	06/02/2018
25	Svenska Dagbladet	Fem klimatsaker du inte får missa	Four climate things not to miss	28/02/2018
26	Dagens industri	Flygbranschen: Så blir inrikesflyget fossilfritt om tolv år	The aviation industry: This is how domestic aviation will become fossil-free in twelve years	22/04/2018
27	Dagens industri	Flyget behöver biobränsle	Flying needs biofuels	26/04/2018
28	Göteborgs Posten	Vi vill minska utsläppen - inte resandet	We want to reduce emissions - not travelling	28/05/2018
29	Svenska Dagbladet	Flygbolagens dilemma - hur grönt är det att flyga?	Airline dilemma - how green is it to fly?	08/08/2018
30	Svenska Dagbladet	Forskare: Inför kvotplikt på biobränsle för flyget	Researchers: Introduce a blending quota on biofuel for aviation	27/08/2018
31	Expressen	Våra flygutsläpp - fem gånger högre än globala genomsnittet	Our air travel emissions - five times higher than global average	06/12/2018
32	Svenska Dagbladet	Cortus Energy och Swedish Biofuels projekterar tillsammans världens första biojetbränsleanläggning baserad på skogsråvara	Cortus Energy and Swedish Biofuels jointly project the world's first biojet fuel plant based on forest raw materials	05/02/2019
33	Svenska Dagbladet	Forskare om vätgas till flyg: "Ett av få alternativ"	Researchers on hydrogen for flight: "One of the few options"	26/02/2019
34	Dagens industri	SAS-vd:n om flygets klimatproblem - Köp mindre taxfree	SAS CEO on the problem of flying - buy less duty free	11/03/2019
35	Göteborgs Posten	Skambelägg inte flyget - att sluta flyga är inte lösningen	Don't shame flying - stopping flying is not the solution	15/03/2019
36	Expressen	Miljöpartiets flygskam räddar aldrig klimatet	The Green Party's flight shame will never save the climate	20/05/2019
37	Göteborgs Posten	Dags att byta ut flygskam mot flygvett	Time to replace flying shame with flying wisdom	15/08/2019
38	Svenska Dagbladet	Regeringen: Belöna klimatsmarta flyg	Governement: Reward climate smart flights	04/09/2019

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Article No.	Publication	Original Article Title	Translation to English	Publication Date
39	Svenska Dagbladet	C: All flygtrafik och sjöfart fossilfritt 2040	C. All air traffic and shipping fossil-free by 2040	27/09/2019
40	Aftonbladet	C: All flygtrafik och sjöfart fossilfritt 2040	C. All air traffic and shipping fossil-free by 2040	27/09/2019
41	Svenska Dagbladet	Fossilfritt flygbränsle långt bort: "Dödens dal"	Fossil-free jet fuel far away: "Valley of Death"	29/09/2019
42	Svenska Dagbladet	Grönt flyg hotar skogen - yta som Belgien kan skövlas	Green flight threatens the forest - surface like Belgium can be razed	02/10/2019
43	Aftonbladet	De jobbar för framtidens eldrivna flygplan	They work for the electric aircraft of the future	04/10/2019
44	Göteborgs Posten	Klimatväxla inte bort det hållbara flyget	Climate change does not eliminate sustainable aviation	08/11/2019
45	Svenska Dagbladet	Swedavia kan öka flyget med gröna pengar	Swedavia can increase flights with green money	26/01/2020
46	Svenska Dagbladet	"Det verkligt billiga flygets tid är förbi"	"The era of truly cheap flights is over"	12/04/2020
47	Svenska Dagbladet	"Flygsektorn kommer att resa sig igen"	Aviation sector will rise again	15/04/2020
48	Göteborgs Posten	Flygplatsen laddar upp med stolpar för elflyg	The airport is charging up with poles for electric flights	14/06/2020
49	Dagens industri	Infrastrukturministern: Elflyg är framtiden	Infrastructure minister: electric flights are the future	17/06/2020
50	Göteborgs Posten	Sabuni (L): Klimatmiljard för elektriska transporter och fordon	Sabuni (L): Climate billion for electric transport and vehicles	14/09/2020
51	Aftonbladet	Använd inte pandemin för att lägga ner flyget	Don't use the pandemic to cancel flights	01/11/2020
52	Dagens industri	Vi vill göra Bromma till en fossilfri flygplats	We want to make Bromma a fossil free airport	04/05/2021
53	Aftonbladet	Sverige måste säkra tillgång på biodrivmedel	Sweden must secure access to biofuels	16/08/2021
54	Svenska Dagbladet	Den verkliga frågan har ingen ett säkert svar på	The real question no one has an answer to	31/08/2021
55	Dagens industri	Bolagen som ska fylla flyget med grönt bränsle	The companies that will fill the flight with green fuel	08/09/2021
56	Dagens industri	SAS undersöker möjligheter att producera hållbart flygbränsle	SAS is investigating opportunities to produce sustainable aviation fuel	03/11/2021
57	Göteborgs Posten	Därför är fossilfritt flyg en fara för miljörörelsen	Fossil free flights is a danger to the environmental movement	27/06/2022
58	Göteborgs Posten	Då kan resor med elflyg bli verklighet	Then trips with electric aircraft can become a reality	27/06/2022
59	Svenska Dagbladet	Utbyggnad av Arlanda blir inte avgörande	Expansion of Arlanda will not be decisive	27/07/2022
60	Göteborgs Posten	Vanligt folk ska inte känna flygskam	Ordinary people should not feel ashamed of flying	13/08/2022
61	Svenska Dagbladet	Dyrare resor när EU skärper klimatmål	More expensive trips when the EU tightens climate targets	19/12/2022
62	Svenska Dagbladet	Vi har sålt 230 plan - men det är bara början	We've sold 230 planes - but that's just the beginning	07/01/2023
63	Svenska Dagbladet	Porsche och SAS satsar på E-bränsle	Porsche and SAS invest in E-fuel	23/02/2023

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