Chapter 1
A Short Review on Electric Aircraft Development and Futures, Barriers to Reduce Emissions in Aviation

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1.1 Introduction

The yearly quantity of carbon dioxide emitted into the atmosphere by aircraft stationed in the middle of aviation is estimated to be half a billion tons (Reuters 2019). To assume that a factor of this size would have no impact on climate change (Gössling and Upham 2009) and global warming (Johnson et al. 1992) is irrational. The potential threat of running out of fossil fuels is made clearer by such a large number, which also reveals fresh insights into the connection between resource usage efficiency and consumption volume (Bringezu and Bleischwitz 2017). The threat of depletion of fossil resources and the degradation of the environment have led scientists and researchers to explore environmentally friendly technologies that are also very effective (Dincer 2000). The aviation sector is attempting to shoulder the weight of scientists and researchers in the hunt for green and efficient technology, given its continuously expanding and highly favored qualities among the transportation sectors due to its many benefits (Hasan et al. 2021; Lee and Mo 2011). Electric aircraft concepts, put forward by researchers and scientists in search of minimizing the effects of the aviation industry, attracted the attention of the public and quickly became popular in the press (Brelje and Martins 2019).

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1.2 Electric Aircraft Development Futures

To address some of the most pressing issues of our time—including pollution, climate change, and global warming—the aviation industry is actively exploring new technological frontiers (Fuad et al. 2021). There is a position in the literature for electric aviation, which is regarded as a ground-breaking innovation with a variety of different multidisciplinary study themes (Karakoc et al. 2022). Electric aircraft are being proposed as a solution to the challenges that humans are aware of, which include climate change and global warming (Pinto Leite and Voskuijl 2020). In the content of the solution proposal, one of the outstanding issues is that it does not produce greenhouse gas emissions (Adu-Gyamfi and Good 2022), which are harmful to both humans and the environment, arising from flight operations in terms of the atmosphere. As a result, it does not create a pollution load on the biota and ecosystem (Seeley et al. 2020). The most environmentally friendly kind of aviation, therefore, is electric flight, which has emerged as the result of recent technological developments (Naayagi 2013). It is anticipated that in the not-too-distant future, electric aircraft, which is now the focus of study in the field of technology, will quickly infuse the market with new competitors (Adu-Gyamfi and Good 2022). Particularly, the realized form of electric aircraft designs is planned to fulfill its mission in the sky in a very short period of time (Prapotnik Brdnik et al. 2019). Of course, electric aircraft designs with new technological breakthroughs are getting ready to enter our lives in light of international regulations (Adu-Gyamfi and Good 2022).

Electric aviation is anticipated to not only minimize the aviation industry's environmental impact but also bring financial advantages to enterprises that choose electric transportation (Erzen et al. 2018). In the literature, financial benefits are classified into two groups and summarized as follows (Brelje and Martins 2019):

(i) Reduction in operating and maintenance costs incurred during flight operations with conventional aircraft propulsion systems.
(ii) and profitable investments that can contribute to the advantages of electric transportation, which has emerged as a new market area.

The first issue, which is one that is anticipated to result in a reduction in the overall expenses of running a flight operation, relates to the fuel costs that are brought about as a direct consequence of the switch from kerosene, which is the fuel used in aircraft, to electrical system architecture (Dahal et al. 2021). It is reported that the unit cost of electricity is less than that of kerosene per liter (Brelje and Martins 2019). Additionally, a brand-new market is opening up for companies that can provide practical and effective solutions in the field of electric aviation technology, as well as those that can transform their fleet of current fossil-fuel-powered aircraft into high-end electric aircraft (Schäfer et al. 2019).

Electric aircraft are operated with propulsion systems of various topologies (Rohacs and Rohacs 2020). The main goal is to reduce or minimize the need for kerosene without reducing the required thrust of a fossil fuel-powered turbojet, turboprop, turbofan, and turboshaft engine. Electric aircraft concepts provide a reduction or complete absence in the amount of fossil fuel needed in aircraft propulsion systems by hybridizing. Adu-Gyamfi and Good present the hybridization anatomy of the electric aircraft propulsion system in their research as follows (Adu-Gyamfi and Good 2022):

(i) The architectural structure that does not require batteries and is powered by an electric generator powered by a gas turbine engine: Turbo-electric (Barzkar and Ghassemi 2020; Epstein and O'Flarity 2019; Rendón et al. 2021; Schäfer et al. 2019; Welstead and Felder 2016).
(ii) Architectural structure in which the thrust needed in flight operation is provided by both gas turbine engine and batteries: Hybrid electric (Bravo et al. 2021; Cameretti et al. 2018; Economou et al. 2019; Gesell et al. 2019; Glassock et al. 2017; Hiserote and Harmon 2010; Voskuijl et al. 2018).
(iii) Architectural structure in which the thrust is provided only by the batteries: All electric (Borghei and Ghassemi 2021; Cronin 1990; Epstein and O'Flarity 2019; Schäfer et al. 2019; Schefer et al. 2020; Viswanathan and Knapp 2019; Wheeler 2016).

Figure 1.1 describes the electric aircraft development and barriers to resolving the emission problem. The electric aviation sector, where expectations are high, is confronting many hurdles in transitioning from existing propulsion systems to next-generation propulsion systems. Particularly, the weight of the batteries in the hybridization architecture, which can correspond to the required thrust, is about 30 times the weight of the currently needed kerosene (Larsson et al. 2019). Unfortunately, one of the barriers to electric aircraft is the unappealing look of the weight that comes with the batteries since an increase in weight in aviation equals an increase in fuel consumption (Finger et al. 2019). A further barrier is the financial strain that businesses will incur when they replace conventional aircraft fleets with electric aircraft. As an alternative to hybrid systems, propulsion systems that can directly use hydrogen as a fuel are another possibility (Khandelwal et al. 2013; Petrescu et al. 2020). In contrast to the propulsion systems in which batteries are included in the architecture, hydrogen-powered propulsion systems will not be included in the range limitations. The generation of hydrogen without the use of fossil fuels is presented as a requirement to be ecologically beneficial for systems that utilize hydrogen as a fuel (Midilli and Dincer 2007). In the use of hydrogen as a direct fuel in aircraft, the water vapor discharged from the exhaust may present another danger over time (Yılmaz et al. 2012), while at the same time, hydrogen production facilities and an airport's internal or external hydrogen distribution system are needed to provide the amount of fuel needed by a completely renewed fleet using hydrogen as fuel (Jones et al. 1983; Thalin 2019).

There has been a recent increase in the number of projects started to build urban air mobility. A number of modifications have been required for an electric aircraft to fly with electric energy to support aircraft systems. These systems must be powered autonomously by a flying aircraft. When engines convert fuel to electricity, more thrust is required. Most improvements in this field aim for a middle-city diameter,

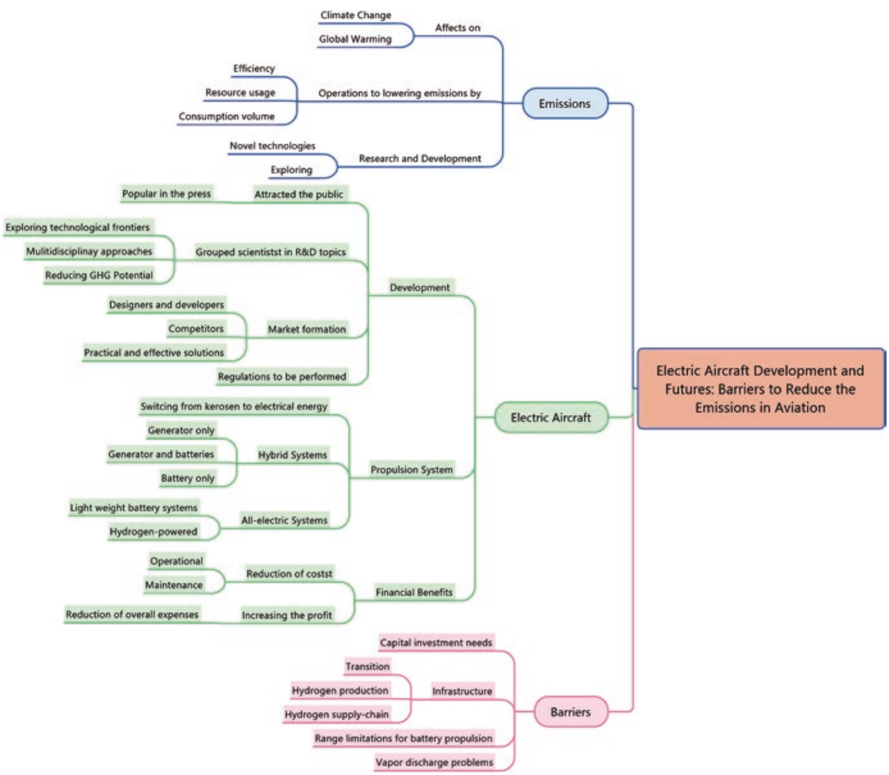

Fig. 1.1 Development and futures for electric aircraft barriers to reduce the emissions

the ability to takeoff and land vertically, and electric propulsion to cut down on noise pollution and get rid of pollutants (Thapa et al. 2021). Expanded efforts should define improved measuring methods/procedures to support noise legislation and community noise effect and collaborate with electric aircraft manufacturers on low-noise approaches and takeoff procedures for human and unmanned operations. Predicting and monitoring the fleet noise consequences of electric aircraft and evaluating additional parameters for audibility and annoyance will let the public adapt (Rizzi 2014).

1.3 Conclusion

The radical transformation and adoption of the above-mentioned breakthrough technologies by businesses will not happen in the near future. Currently, it is thought to be very challenging for numerous multinational businesses to go through a world-wide change with great collaboration. Reducing emissions (noise and gas) originating from flight operations is among the emergency action plans of international organizations. Therefore, besides the conceptual discussion of the term electric aviation, it is desirable to determine the advantages and disadvantages of electric aviation in a remarkable way to reveal acceptable advantages over other technologies (alternative and renewable fuels — hydrogen, biofuels, and so on) and to take action globally to reduce the environmental impact of aviation. As a result of advancements in battery technology, specifically specific energy, more electric general aviation aircraft will fly at the turn of the decade. It might take another decade or two to develop mature and power-dense electrical solutions for larger aircraft for short- and long-distance flights. Even so, these aircraft may be exclusively hybrid-electric.

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