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Sustainable Solutions in the Aviation Industry

A scenario analysis of electrified aircrafts, sustainable aviation fuels and carbon offsetting

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Sammanfattning

Global uppvärmning är ett aktuellt problem som påverkar hela världen. Flygindustrin står för runt tre procent av de globala utsläppen och åtgärder behövs för att styra industrin mot en hållbar utveckling med ny teknologi och alternativa flygbränsle för att minska utsläppen. Idag finns det möjlighet för passagerare att kompensera sina flygutsläpp genom klimatkompensation. Syftet med denna studie är att undersöka hur flyg- samt klimatkompensationsindustrin troligtvis kommer att utvecklas i framtiden och hur företag inom flygindustrin kan tillämpa den kunskapen för att påverka utvecklingen mot en mer hållbar flygindustri. Med hjälp av kunskapen ska klimatkompensationsalternativ kunna anpassas utefter dem nya förutsättningarna i framtiden.

Den empiriska data för denna studie består av intervjuer med intressenter från flyg- och klimatkompensationsbranscherna samt en politiker. Industrirapporter och en litteraturrecension har använts i kombination med empiriska data tillsammans med teorier såsom industriell dynamik, nätverksinnovation och scenario analys som resulterat i ett troligt framtidsscenario för industrierna. Vidare följer en slutsats samt ledningsliga implikationer och rekommendationer för en flygprisjämförelsesajt.

Slutsatserna från denna studie är att utveckla redan befintliga samt etablera nya nätverk för att dela kunskap från många olika intressenter inom flygindustrin och använda sig av deras förmågor för att föreslå ändringar i lagstiftningen samt förbereda flygindustrin för hållbara lösningar i framtiden. Nätverk bör också använda deras samlade makt till att lobba för beslut som driver utvecklingen av en mer hållbar flygindustri framåt. Den breda expertisen som dessa nätverk besitter kan användas för att informera och förse kunder med kunskap om fördelarna med klimatkompensation och öka intresset för att klimatkompensera en flygresa. Marknadsföring och information om klimatkompensation behöver vara transparent för att kunder ska förstå effekterna det har på klimatet. Biobränslen och elektrifierade flyg är hållbara lösningar som är mer troliga för framtiden då priset på biobränslen är väldigt högt idag och elektrifierade flyg är långt ifrån redo att ersätta dagens jet-flyg. Därmed är klimatkompensation det bästa alternativet för att reducera nettoutsläpp idag.

Kortsiktiga rekommendationer för en prisjämförelsesite är att vara involverande i övergången till mer hållbara bränslen genom att erbjuda kunder ett alternativ till att köpa biobränsle i kombination med att klimatkompensera. För att styra industrin i en mer hållbar riktning bör en flygprisjämförelsesite ge stöd i form av investeringar och samarbeten med organisationer och företag som arbetar med hållbara framtidslösningar som exempelvis utveckling av elektriska flygplan. Långsiktiga lösningar är att kontinuerligt hålla sig uppdaterade med den senaste forskningen och kunskapsexpertisen inom industrin för att anpassa sitt klimatkompensationsalternativ i framtiden.

Denna studie ska betraktas som en informell grund för företag inom flygindustrin att påverka en övergång till en mer hållbar flygindustri samt utveckla sitt klimatkompensationsalternativ i framtiden. Studien innehåller ej empiriska data från alla intressenter inom flygbranschen och skall därför ses som begränsad.

Nyckelord: *Flygindustrin, klimatkompensation, flygprisjämförelsesite, scenario analys, elektriska flygplan, biobränsle*

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Master of Science Thesis TRITA-ITM-EX 2020:270

Sustainable Solutions in the Aviation Industry:
A scenario analysis of electrified aircrafts, sustainable aviation fuels and carbon offsetting

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Abstract

Global warming is an issue that affects the entire world. The aviation industry accounts for around three percent of global emissions, and actions are needed to help steer the industry towards a sustainable transition with new technologies and alternative aviation fuels to reduce emissions. There are options today for passengers to compensate flight emissions through carbon offsetting. The purpose of this report is to investigate how the aviation and carbon offset industries are likely to develop in the future in order to provide knowledge that an air travel comparison site can use to adapt its carbon offset alternative to new market conditions.

The empirical data in this study consist of interviews with stakeholders in the aviation and carbon offset industries as well as a politician. Industrial reports and a literature review were used in combination with the empirical data and analyzed with theories such as industrial dynamics, network innovation and scenario analysis to result in a possible future scenario of the industries. Further, conclusions with necessary actions in order to develop a more sustainable aviation industry and how carbon offsetting can be renewed due to a sustainable aviation transition. Additionally, managerial implications for an air travel comparison site followed with suggestions on how they can contribute to this transition.

The conclusions from this study are to develop existing networks and establish new ones to share knowledge from many different stakeholders in the industry and use their capabilities to propose regulatory changes as well as prepare the industry for sustainable solutions in the future. Networks should also use their collective power to lobby for changes that will drive the transition towards a more sustainable aviation industry forward. The broad expertise that these networks possess can be used to provide customers with knowledge to make the option to carbon offset a flight more attractive. It is important that knowledge and marketing of carbon offsetting is transparent to inform customers of its effects on the climate. Biofuels and electrified aircrafts are sustainable solutions more suitable for the future due to the high price of biofuels and electrified aircrafts not ready to replace regular jet-aircrafts. Thus, carbon offsetting is the best option to reduce net emissions from a flight today.

The short-term recommendations are for an air travel comparison site to be involved in the transition towards more sustainable aviation fuel by offering customers the option to purchase biofuel together with or as an alternative to carbon offset when booking a flight. An air travel comparison should also support organizations and firms working with sustainable solutions such as introduction of electrified aircrafts, through partnerships or investments to help steer the industry in a sustainable direction. The long-term recommendation for an air travel comparison site is to continuously stay updated with the latest research and knowledge expertise within the industry to adapt its carbon offset alternative to new conditions in the future.

This study is to be considered as an informational foundation for an air travel comparison site to adapt its carbon offset alternative to a dynamic aviation industry. However, the study does not include empirical data from all stakeholders within the aviation industry hence the information used in this study is limited.

Keywords: *Aviation, carbon offsetting, air travel comparison site, biofuel, electrified aircrafts, scenario analysis.*

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Preface

This master thesis has been conducted during 2020 at the division for Industrial Management at KTH Civil and mechanical engineering. We want to thank our supervisor, Thomas Westin and our examiner, Anna Jerbrant at KTH who have provided us with support and guidance during this study. We also want to thank our fellow students who have participated in seminar sessions and contributed with ideas and suggestions to improve this study. A special thanks to our supervisor Mattias Nyman at Flygresor.se who gave us the opportunity to be a part of Flygresor.se's team and provided us with valuable information during our research. Daily, we had the opportunity to ask questions about the company and the travel industry which provided us with valuable knowledge. We also want to thank all respondents who have participated in this study and provided empirical data during our research.

All mentioned above have given us insights, knowledge and inspiration to finish this study and we wish everyone good luck with future studies and work.

Stockholm, June 2020

Niklas Jönsson and Fredrik Hillesöy

1. Introduction

This chapter includes a background to the problem this study investigates in followed by a problem formulation, purpose, and a research question for the study. Delimitations are presented as well as introduction of the case company and contributions for the study.

1.1 Background

The worldwide commercial air traffic accounts for around three percent of the world's CO_2 emissions (Söderberg and Wormbs, 2019, 48). These numbers have rapidly increased over the years. Between 1990-2017 has the total number of passengers in Sweden increased with 120 percent (Naturvårdsverket, 2020). A trajectory from the United nations' International Civil Aviation Organization (ICAO) expects that aviation emissions could triple by 2050 compared to today's level (Graver et al., 2019). Further, a substantial increase of flight passenger kilometers around the world are estimated to grow by around 4-5 percent between 2019-2038 (Mazareanu, 2019). This means that commercial aviation will have an even greater climate impact in the future than today, unless more sustainable and efficient greenhouse gas (GHG) emission solutions are developed (Cames et al., 2015).

In 2015, the Paris agreement came into force at the United Nation climate change conference, which aims to strengthen the global response and ability of countries to deal with the impacts of climate change (UNCC, 2020). The Swedish government has stated that Sweden should be fossil free in 2030 which includes domestic flights, and that all flights starting at Swedish airports should be fossil free by 2045 (Föreningen Svenskt Flyg, 2017). In order to reach these goals, the aviation industry needs to act and find solutions to decrease the GHG emissions. The aviation sector worldwide has since the Paris agreement improved their climate governance but is still lagging compared to other transport sectors. Aircrafts have become more energy efficient over the years and new projects have been created with the purpose to reduce GHG emissions from the aviation industry. Alternative fuel options and new technology have been introduced in order to create a more sustainable industry (ICAO, 2020b). However, some of the largest airlines in the world are likely to not reach the Paris agreement goal unless major changes are made to reduce GHG emissions (TPI, 2019).

The aviation industry is currently working to increase the commercial adaption of Sustainable Aviation Fuels (SAF) such as biofuel in order to reduce the climate impact. SAFs produces up to 80 percent less CO_2 over its lifecycle, compared to jet fuel. However, the economically competitive feedstock supply is a challenge to sustain production (ATAG, 2017), even though, progress have been seen the last couple of years. According ICAO, the commercial production of SAF increased from an average of 0.29 million liters between 2013-2015 to 6.45 million liters per year between 2016-2018 (ICAO, 2019). Additionally, several ongoing worldwide projects have been started to develop hybrid and electrified aircrafts. Many of those projects targets to have certified aircrafts ready for service from the mid 2020's. Recently in 2020, the Slovenian aircraft manufacturer Pipistrel, announced their 2-seated aircraft as the world's first type certified electrified aircraft (Pipistrel, 2020).

To reduce CO_2 emissions affected by flying, the idea of carbon offsetting was introduced a few years back (Kronholm and Kärnbo, 2019). A traveler can carbon offset their flight through e.g. airlines, travel agencies and air travel comparison sites, in order to compensate for the emitted CO_2 emissions by air travelling. However, debates thrive concerning uncertainty with the mathematical models and the variation in how different companies and organizations calculate CO_2 emissions of air routes, which creates misunderstandings amongst air travelers with the option to carbon offset (Patay, 2019). One of the factors that is

questioned whether it should be included in calculations of CO_2 emissions from aircrafts is the high-altitude factor (Tricorona, 2019a). Studies have been made with different results of how the high-altitude factor affects the climate impact which has resulted in different opinions if it should be included when calculating CO_2 emissions. Carbon offsetting is also a contentious issue where a common criticism is that it enables travelers to continue flying when they should fly less, which contributes to the increased amount of emitted CO_2 emissions (Kronholm and Färnbo, 2019).

In 2019, *Flygresor.se* (*Flygresor*) introduced a mathematical model which estimates and sort the amount of CO_2 emissions from flights in their travel comparison database (Schennings and Larsson, 2019). Further, the customer can sort flights from cheapest to most expensive including carbon offset in the price. This means that those travel agencies or airlines which do not offer the alternative to carbon offset via their booking site, will not be listed as an alternative on *Flygresor's* site (Flygresor.se, 2020). An air travel comparison site such as *Flygresor* are often the first contact when customers are booking a flight which creates a close connection between an air travel comparison site and the customers. *Flygresor* aims to affect customers to travel more sustainable where the alternative to carbon offset through their site is one step towards it. Additionally, they want to act and be a part of a sustainable transition within the aviation industry. (Nyman, 2020).

1.2 Case company

Flygresor is an air travel comparison site that sort and filter flights from over 1000 online travel agencies and airlines all over the world. They help customers to compare flight routes between different travel agencies and airlines which can be sorted after cheapest, quickest, best rated and least emitted net CO_2 emissions. When customers have chosen a ticket, they are redirected to the booking site. (Flygresor.se, 2020)

1.3 Problem formulation

CO_2 emissions from commercial air traffic have increased over the years and will continue to do so in the future if not a transition towards new technology and sustainable fuel alternatives will happen. Achieving a sustainable transition in the aviation sector is an essential part in meeting the international climate targets set forth in the Paris agreement. Moving towards more use of SAFs and introducing electrified aircrafts could be solutions that makes the aviation sector reach those targets. However, obstacles remain such as high production prices of biofuels and technological challenges to introduce commercial electrified aircrafts at this point. If the aviation industry and stakeholders connected to the industry wants to affect a sustainable transition, it is important to know what actions necessary and what knowledge can be applied, in order to affect the transition towards a more sustainable industry. Due to relatively early adoptions of solutions, there is no clear path of how the future will look like and how the development of the transition will evolve. This uncertainty creates challenges for stakeholders to have a suitable strategy of how to be a part of a transition towards a sustainable industry and what actions are necessary to take.

An important factor to decrease the CO_2 emissions is that customers make better choices when flying where carbon offsetting has become an option. One of the actions recently adapted by *Flygresor* is the alternative for customers to carbon offset for travels at their site. A mathematical model that sort flights according to estimated CO_2 emissions, creates an option for the customers to easier find more climate friendly routes and carbon offset purchased tickets. However, possible new technology and other fuel alternatives such as SAFs and electrified aircrafts developed in the aviation industry could lead to new factors

that needs to be considered in order to estimate CO_2 emissions from air travels in the future. Additionally, criticism against carbon offsetting has emerged since it encourages travelers to continue instead of decreasing their flying. Thus, to have a suitable carbon offset alternative, an updated version needs to be developed during the transition in order to have an eminent sustainable impact. Challenges arises of how the carbon offset alternative should be changed and when it can be timely, due to new technology and fuel alternatives in the future.

1.4 Purpose

The purpose of this study is to investigate how stakeholders can affect the transition towards a more sustainable aviation industry, both in a current state and in the future due to both an incremental and disruptive transition in the industry. More profound is the purpose to identify necessary actions and knowledge that can be applied for stakeholders to be a part of the development of a sustainable aviation industry. Further, an investigation of how carbon offsetting will be developed and how it can be renewed due to new technology and fuel alternatives. This will provide with knowledge that can be applied by stakeholders within the travelling industry to adapt their carbon offset alternative.

1.5 Research questions

To fulfil the purpose based on the background and problem formulation, the research questions of the study are:

- *What actions are necessary to develop a more sustainable aviation industry?*
- *How can carbon offsetting for air travelers be renewed due to new aviation technology and fuel alternatives?*

1.6 Delimitations

This study is focused on opportunities and existing projects within sustainable solutions for stakeholders in the Swedish aviation industry and Swedish stakeholders in the carbon offset industry. Therefore, only laws and regulations within Sweden and the European Union (EU) will be considered. Due to the complexity of including all emissions related to a flight, only emissions from when an aircraft is in the air will be considered in this study. Hence, emissions from e.g. the production of fuel, batteries for electrified aircrafts and transportation of fuel is not regarded in this report.

Due to uncertainties in predicting when future states of the aviation and carbon offset industries will occur, different timeframes are used in the scenario analysis rather than specific years. The report presents an overall view of the industries and how they are likely to progress. Technological aspects are considered but not developed. Therefore, technological developments are discussed but not explained in detail. Due to this study conducting research for a holistic view of the industries, mathematical models and algorithms to calculate emissions are not used in this report.

1.7 Contributions

This report evaluates the aviation industry and the outlook of how it is transitioning towards a more sustainable future in order to provide knowledge for stakeholders within the aviation and carbon offsetting industry. Additionally, the link between carbon offsetting and the aviation industry is investigated and how they are likely to evolve to find potential opportunities for adaption of carbon offsetting. This study contributes with empirical knowledge regarding sustainability of the aviation industry from multiple participants within

the aviation and carbon offset industries, as well as practical knowledge from an air travel comparison site.

2. Sustainability in the aviation industry

This chapter presents an overview of different stakeholders and organizations in the aviation ecosystem with both internal and external pressures affecting sustainability in the aviation industry. With this chapter, a holistic view of how the industry is build is created to understand what is being done and by how when it comes to sustainability. This part is categorized into a PESTEL analysis. The PESTEL framework is an acronym for six external factors. It creates a multidimensional view of the macroenvironment and provides an understanding of how these external factors affect an industry. The analysis is a useful tool to understand the current state of the aviation industry.

2.1 Political factors

The aviation industry is the most climate-intense form of transport with one of the fastest growing rates of GHG emissions. Thus, the aviation industry is facing challenges to meet the targets of the Paris agreement to limit an increase of global temperature to 1,5 degrees Celsius (Transport & Environment, 2016). The International Air Transport Association (IATA), whom is the trade association of the world's airlines and represent 82 percent of the total air traffic, has adopted several targets in order to reduce the carbon emissions from the air transport (IATA, 2019a). More specifically, a few of the aims are to improve the fuel efficiency with 1,5 percent every year between 2005 to 2020, a carbon neutral growth from 2020 and a reduction in net aviation CO_2 emission of 50 percent by 2050, compared to 2005 levels (IATA, 2020b).

The International Civil Aviation Organization (ICAO) is a United nation specialized agency that manage the administrative and governance of the convention of international civil aviation with 193 member states (ICAO, 2020b). In 2016, ICAO adopted the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) which aims to ensure that any rise in international aviation emissions above 2020 levels are compensated through carbon offset projects elsewhere (IATA, 2019a). Airlines with emissions above the 2020 levels will have to carbon offset those increased emissions compared to 2020. However, the emissions in 2020 so far have been extremely low due to the outbreak of the SARS CoV-2 virus, known as COVID-19. This is likely going to result in a significant increase of emissions the next coming years if the flying habits goes back to normal, which means that airlines will need to pay high amounts for carbon offsetting due to the CORSIA regulation. Further, COVID-19 has led to financial difficulties for airlines and therefore, IATA will postpone the CORSIA regulations to 2021 instead of 2020 (ERA, 2020).

The financial difficulties for airlines due to the outbreak of COVID-19 have led to domestic political support in European countries. The French government have offered a financial aid package for *AirFrance-KLM* with 7 billion euros to support the airline through the crisis. However, they also put pressure on *AirFrance-KLM* to fulfill environmental conditions if they want to receive the financial support. The government stipulates that *AirFrance-KLM* must not compete with the railway on shorter distances. The airline will not be allowed to sell domestic tickets on routes that takes two and a half hours or less with train. Additionally, in 2025 at latest, at least two percent of the fuels needs to be SAFs (Lindblad, 2020).
Since 2005, EU have established the first international trading system (ETS) for CO_2 emissions inside the European area, and from 2012 the CO_2 emissions from the aviation

industry are included. The system has reduced the carbon footprint from the aviation sector with more than 17 million tons per year since 2012 (European Union, 2020b).

The Swedish government has introduced a roadmap for Swedish aviation to become fossil free by 2045. To reach this objective, the government has analyzed possibilities to develop electrified aircrafts with the purpose to promote the transition to a fossil free transport sector. Further, propositions including requirements for compulsory blending of renewable fuel for aviation will be inserted. The government also stated that propositions including taxes for business travelling will be considered in order to reach the goals stated under the Paris agreement and to become fossil free by 2045. (Regeringen, 2020)

The Swedish government has developed a proposal, based on an investigation of a new reduction duty scheme that will most likely start to apply in 2021 (Svenska Flygbranschen, 2019). The reduction duty scheme implies that there will be demands for blending of biofuels in aircrafts. The demand of blending will rise every year until 2030, when a new investigation will take place. The proposal includes about five percent blending of biofuels in 2025 and about 30 percent in 2030 (Naturskyddsföreningen, 2019). In Norway, a similar reduction duty scheme has already started to apply and discussions in other European countries are taking place today. Furthermore, a flying tax in Sweden was introduced in 2018 which the government now wants to increase in order to finance a new reform. The increased flying tax would increase the tax prices of a ticket from 60 SEK to 75 SEK within European borders e.g. (Lindblad, 2020).

In 2019, The Nordic council of ministers consolidated a platform between the Nordic countries in order to accelerate the introduction of electrified aircrafts. The platform is called The Nordic Network for Electric Aviation (NEA) and the main objectives is to standardize the infrastructure, develop business models, develop aircraft technology and create a platform for global collaborations for electrified aircrafts (NEA, 2020). Additionally, The Research Institutes of Sweden (RISE) has developed a project called ELISE which coordinates the development of electrified aircrafts in Sweden. Their main objective is to have an electrified aircraft, produced by *Heart Aerospace*, certified by 2025 (RISE, 2020).

2.2 Economic factors

The aviation sector in the European Union contributes with 300 billion euro which corresponds to 2,1 percent of the European GPD every year (European Union, 2020a). Since the global air transport is expected to grow annually with 5 percent until 2030, the economic growth of the aviation sector is expected to grow as well (European Union, 2020a). Based on a forecast from IATA, one percent of the total world GPD will be spent on air transport in 2020 (IATA, 2019c). However, as mentioned above, COVID-19 has led to less flying due to the current travel restrictions. This has resulted in passenger revenues going down with 98 percent since the virus outbreaking at this point which affects the financial situation negatively for the aviation industry (ERA, 2020).

The fuel costs are expected to decline from 188 billion US dollars in 2019 to 182 billion US dollars in 2020. The slightly lowered oil prices and increased fuel efficiency saves the industry 3.2 billion dollar, which represents a saving of 17 million tons of CO_2 per year. These are the main reasons for the expected decline in fuel costs (IATA, 2019c).

The large difference of production costs between jet fuel and biofuel is primarily the reason why biofuel is not used to a larger extent. The cost difference between jet fuel and biofuel can be different depending on production location. *Föreningen Svenskt Flyg* (2020) claims that biofuel is three to four times more expensive while International Renewable Energy Agency (IRENA) claims that biofuel is about two times more expensive. The fuel cost accounts for about 30 percent of the total operating cost for an airline (IRENA, 2017).

Electrified aircraft manufacturers states that efficient cost will go down drastically with electrified aircrafts compared to regular aircrafts. According to *Heart Aerospace*, electric motors will contribute to a reduction of 90 percent in maintenance costs and reduced fuel costs with 50-75 percent (Heart Aerospace, 2020). Now, electricity cost per passenger for a 400 kilometers flight costs around 3 euro which is far lower compared to the replaced jet fuel costs (The Atlantic, 2019). The electrified aircraft Alice, developed by *Eviation* will decrease the total reduction costs by 70 percent according to *Eviation* (Intelligent Aerospace, 2019). The production costs and investment cost for an electrified aircraft becomes mostly speculative. Recently, *Ecaravan* test flew the biggest electrified aircraft today. The 30-minute flight would have cost 6 dollars in electricity while the compared to 300-400 dollars in fuel expenses (Slutsken, 2020). However, new technology such as electrified aircraft, is usually more expensive in the beginning and becomes more affordable when the demand increases. One can expect that electrified aircrafts will most likely be more expensive in the beginning compared to regular flights today (IATA, 2019c).

2.3 Social factors

Since 2010, the annual increase of global air passengers is between 4-9 percent, including both international and domestic flights. Looking only at international flights, the annual increase of global air passengers is slightly higher compared to both international and domestic flights (ICAO, 2018). IATA forecast a steady global growth of air passengers, especially in the Asia-pacific region. Countries such as India and Indonesia are expected to almost double their air passenger growth between 2020-2037 (IATA, 2020a). However, in Sweden, domestic air passengers decreased with about 9 percent and about 2 percent for international air passengers in 2019 compared to 2018 (Swedavia, 2020). According to *Transportstyrelsen*, these numbers are expected to increase between 2020-2025. Domestic flights are expected to grow annually with around one percent and international flights with between 3-4 percent annually between 2020-2025 (Transportstyrelsen, 2019). However, because of the ongoing outbreak of COVID-19, air passengers have decreased drastically in 2020 both globally and domestically. This means that the expected growth of air passengers from 2020 will most likely be postponed until earliest 2021 (IATA, 2020d).

When the young Swedish climate activist, Greta Thunberg, in 2018 started to demonstratively use other transport alternatives such as train instead of aircraft, *flight shame* gained recognition around the world (Hasberg, 2019). Well into today in 2020, debates around *flight shame* and the refusal of using aviation as a mean of transport is triggered in e.g. publications, articles and social media. Those that experience *flight shame* and can point out reasons why they want to stop flying, still tend to have difficulties to go from insights to behavioral change. One of the reasons why some have difficulties to change their behavior could be because of social barriers and external expectations (Söderberg and Wormbs, 2019).

The normality to fly seems to overcome the potential social pressure of *flight shame* according to Söderberg and Wormbs (2019).

Carbon offsetting aims to change the preferences of individuals and rely on the willingness to pay to reduce their carbon footprint. Thus, carbon offsetting depends on personal responsibility of individuals for the emissions they have contributed to (Kuhn and Uler, 2019). This type of offsetting has faced some criticism, such as individuals paying others to compensate instead of taking even more responsibility themselves. This can have a negative connotation, and the procedure could encourage individuals to travel more which results in more greenhouse gas emissions instead of reducing them (Lange et al., 2014).

Since the late 2000's when carbon offsetting picked up, the amount of CO_2 offset has increased dramatically and in 2017, it peaked at 62.7 million tons of CO_2 emissions according to a report from Ecosystem marketplace (2018). The report also shows the price range of the transactions for carbon offsetting. The most common price range is between 0-1 dollar/ton CO_2 emissions (tCO_2e), followed by a price range between 4-5 dollars/tCO_2e which is around half the number of transactions compared to 0-1 dollar/tCO_2e. The average price of a transaction was 2.6 dollars/tCO_2e (Ecosystem Marketplace, 2018). These numbers of transactions are reported between January-March 2018.

2.4 Technological factors

From a technological perspective, the aviation industry has seen improvements when it comes to energy efficiency, innovations, aircraft performance e.g. Although projects regarding the development of electrified aircrafts are in progress, sustainable fuel produced by bio-based feedstocks are more relevant for commercial aircrafts today (EASA, 2020b). A total replacement from jet fuel to biofuel in aircrafts is far away from being a reality and challenges exist to make it happen. One of the challenges is that the production of biofuel is limited today in the scope of the aviation. The efficiency of the manufacturing process is still low in order to fill the aircrafts fuel need (Naturskyddsföreningen, 2020). Biofuel is made of the biodegradable part of products, residual waste and residual products of biological origin from agriculture and forestry (Regeringskansliet, 2019). In order to blend the biofuel with jet fuel, certain standards need to be fulfilled according to ASTM D1655 (Organ, 2016). The biofuel needs to be a so-called drop-in fuel which means that there is no allowance for mixing it with ethanol, fame, or biogas e.g. Today, it is allowed to blend maximum 50 percent of drop-in biofuel with fossil fuel due to safety policies (Organ, 2016). Europe is an important player to produce biofuel with several commercially sized plants currently in operation. EU relies on a certain number of production plants with a capacity to produce around 2.3 million tons biofuel per year which stands for about 4 percent of the European aviation fuel demand (EASA, 2020b).

Renewable electricity, water, and CO_2 have good opportunities in the long run to produce CO_2 neutral fuel on a large scale, so called electrochemical fuel. This is produced by splitting up water in hydrogen and oxygen by using electricity, and then blending the hydrogen with CO_2 (Sveriges Riksdag, 2019). In 2018, there was only one commercial producer of electrochemical fuels located in Iceland and some test plants in Germany (Bergqvist, 2018). The Swedish fuel company, PREEM are currently running projects that in the long run could create opportunities for producing electrochemical fuels in Sweden. However, due to regulations, it will most likely take about ten years before production of it can start in Sweden

(Bergqvist, 2018). To use hydrogen as a fuel source could potentially be an option in the long run as well. However, hydrogen would demand an expensive transformation of the aviation sector, where new aircraft types and fuel production would be needed which makes it difficult to reach the sustainability goals in time (Åkerman, 2019).

As mentioned earlier, projects exist today regarding the development of electrified aircrafts. Several electrified aircrafts are in the manufacturing process and some have already been built. However, existing technology does not allow electrified aircrafts to fly longer distances nor with a large capacity of passengers. Battery density, efficient electrical system, effective system integration and effective regulation are some of the barriers the aviation industry are facing (Roland Berger, 2020).

The combination of high battery storage and low weight is a crucial part and a challenge for the development of higher electrified aircraft performance. For commercial electrified aircraft routes to take place, the electrical system needs a battery density of at least 700-2000 Wh/kg (Schäfer et al., 2019). Lithium-ion batteries are the most attractive types of batteries on the market today due to their density capacity. Roland Berger's projection of the lithium-ion density roadmap performance indicates that a 500 Wh/kg battery will not be available until after 2025 (Roland Berger, 2018). Furthermore, an 800 Wh/kg electrified aircraft could potentially have the same performance as an Airbus A320-sized aircraft which has a range of 1111 km (Schäfer, 2019). Additionally, The Swedish company, *Heart Aerospace* claims that their electrified aircraft has battery packs with a density of 250 Wh/kg and a range of 400 km with a capacity of 19 passengers (Heart Aerospace, 2020). *Pure Flight* is another electrified aircraft manufacturer located in Czech Republic, that has developed a two seated electrified aircraft with a flying range of 2,5 hours and minimum charging time of 20 minutes (Pure Flight, 2020).

Although battery density is not enough for commercial electrified aircrafts today, hybrid aircrafts are closer to become a reality within the next ten years for both small and larger aircrafts (Reimers, 2018). Hybrid aircrafts are powered by a combination of electricity from batteries and an internal combustion engine. The combustion engine can work as an energy reserve oppose to a full electrified aircraft where only batteries handle the extended routes. Basically, hybrid aircrafts rely on a mix of fuel and electric energy (Brelje and Martins, 2019). The combustion engine could be used for take-off and landing when the energy requirements are at its peak, while the electric power from batteries could be used at its maximum while cruising and during ground movement (Roland Berger, 2017). Additionally, in the early 2020's, *Zunum* is planning to have its hybrid electrified aircraft ready with a power density of 500 Wh/kg, a range of around 1126 km and a capacity of 12 passengers (Reimers, 2018).

2.5 Environmental factors

In 2018, The Intergovernmental Panel on Climate Change (IPCC) published a report concluding that in order to stabilize the warming at 1.5 Celsius degrees, the human CO_2 emissions have to decline with 45 percent from 2010 levels by 2030, which is one of the targets from the Paris agreement in 2015 (IPCC, 2019). The air traffic is projected to grow with 42 percent between 2017-2040 (EASA, 2019). Thus, the climate change is a major challenge for the aviation industry.

Biofuel could potentially be a part of the solution in order to reduce greenhouse gas emissions. However, the emission reduction of biofuel differs between 50-90 percent

compared to fossil fuels depending on the production process (European Directives, 2015). The handling of biofuel risks causing environmental damage during the production process. Today, the production of biofuel requires large ground areas and natural environments, which can potentially risk pushing away food production. The preparation and transportation of biofuel is also energy intensive (Kättström, 2019). Thus, improvements of the production process are required in order to make the use of biofuel more effective. However, biofuel is classified as renewable fuel and considered to be climate neutral. Waste products from different sectors are used and the energy is utilized from it (Kättström, 2019). There is an uncertainty of how biofuel affect the high-altitude effect compared to jet fuel. According to NASA, practical tests showed that biofuel produce cleaner emissions from the jet engine to the atmosphere compared to jet fuel. Thus, blending biofuel with jet fuel has a positive impact on the high-altitude effect compared with only using fossil fuel (Silberg, 2017). However, according to Naturskyddsföreningen (2019), biofuels have about the same impact as jet fuel on the high-altitude factor.

The use of commercial electrified aircrafts can be a solution to face today's environmental challenges for the aviation industry. Since electrified aircrafts do not use a combustion engine, there are no carbon emissions during the flying time. Hybrid aircrafts can cause emissions when flying even though it is lower compared to a regular aircraft. However, since hybrid aircrafts are flying on a lower altitude, the high-altitude effect is not affected by the emissions from hybrid aircrafts (LFV, 2018). Although electrified aircrafts do not generate any emissions when flying, producing lithium-ion batteries have a negative impact on the climate. According to Swedish Environmental Research Institute, calculations from 2019 showed that emissions from producing lithium-ion batteries are 61-106 kg CO_2 per produced kilowatt-hour. Thanks to efficiency in the production process, these numbers have almost halved since 2017 (Swedish Environmental Research Institute, 2019).

From an air passenger's perspective, one way of having an impact on the climate is to carbon offset a trip. Carbon offsetting projects could be developed in different areas and through different activities. According to *Forest Trends* (2018), the most usual areas or categories of carbon offsetting projects took place in between 2008 to 2018 were energy efficiency, renewable energy and waste disposal around the world. Most projects exist in Asia with more than half of all projects, followed by North America with almost 20 percent of the projects (Forest Trends, 2018). In 2008, *Energimyndigheten* published guidelines and recommendations regarding carbon offsetting. These guidelines and recommendations states that carbon offsetting should be performed through either European allowances or FN certified projects, one who offsets should do a proper review of the supplier, demand proof of deliver and sign an agreement with the party in charge of the project (Tricorona, 2019b).

Airlines and travel agencies can be members of carbon offsetting programs to offer their customers the alternative to offset their travel. As of now, over 30 IATA member airlines have introduced an offset program into their web-sales (IATA, 2020c). As one of few, if not the only price comparison site for air travel, flygresor.se lists airlines that offers carbon offsetting and sort the alternatives that includes carbon offsetting in the ticket price. A survey from *Svenska Dagbladet* (2018) showed that only a quarter of the biggest companies' carbon offset their air travels. The Swedish travel agency, TUI, removed their carbon offset alternative on their webpage in 2018 due to low customer interest in it (Aktuell Hållbarhet p7, 2019). The Swedish airlines, BRA and SAS have instead marketed their carbon offsetting alternatives in order to get more customers to carbon offset (Alestig, 2019).

2.6 Legislative factors

When a new aircraft model is built, it must obtain a certificate from the responsible aviation regulatory authority before it is used for operation (EASA, 2020a). The Federal Aviation Administration (FAA) are responsible for aircraft certifications in USA. Additionally, FAA are responsible for safety regarding air traffic and airports in USA (FAA, 2018). Further, The European Union Aviation Safety Agency (EASA) is responsible for the certification of aircrafts in EU and some countries outside EU. EASA is also responsible for safety regarding air traffic and airports in Europe (EASA, 2020a). In Sweden, *Luftfartsverket* (LFV) are responsible for all concerns regarding aviation safety in Sweden (LFV, 2019). However, aircraft manufacturers in Sweden still needs to be certified by EASA since they have the certification responsibility in EU.

The American Society for Testing and Materials (ASTM) develops and publish technical standards, classification of materials for aircraft construction, and approval of raw materials for jet fuel and renewable fuel such as biofuel, electrochemical fuel and hydrogen. Additionally, ASTM decides the maximum allowance of blending renewable fuels with jet fuel. Standards regarding aircraft construction and maintenance is provided by ASTM. Those standards address the directives of organizations such as FAA and EASA (ASTM, 2020). EU is responsible for most rules and laws regarding emission rights in Europe. The EU ETS are the most incumbent system in Europe for trade with emission rights today (Finansdepartementet, 2016). The International Civil Aviation Organization (ICAO) decides about rules regarding safety and sustainability for civil aviation. In 2018, ICAO implemented CORSIA which will start to apply in 2021 (cause of COVID-19, it could possibly postpone to 2022) in order to regulate the CO_2 emissions from airlines (ICAO, 2020a).

3. Theoretical Framework

This chapter presents and explains the theoretical frameworks used for this study. It also includes previous literatures, theories and research regarding topics that encircle the problem formulation for this paper. Existing theories and models are studied and analyzed in order to situate the work of this paper to existing knowledge.

The theoretical frameworks start with a description of dynamics in industries and how sustainable transitions are integrated with the industrial dynamics and how multi-level perspective is related to it. Thereafter business model adaption is studied to understand the effects and changes that needs to be made due to transitions in industries. This is followed by a presentation of innovative ecosystem strategy where different roles of an ecosystem in industries are explained and the importance of them. Thereafter, network innovation is presented where different strategies and approaches are explained to have a successful network. This is followed by more marketing and consumer behavior studies to understand the importance of it for a company, product, or service. Then, PESTEL and scenario analysis is explained and described how it can be used in a research. Lastly, carbon offsetting and the high-altitude factor are presented to understand what it really is and how it is being used today.

3.1 Industrial dynamics

Industrial dynamics studies the processes in which industries change over time. It describes how an industry is organized right now, how it has been reorganized from before and what forces have played a part in the reorganization. Industrial dynamics as a term include the driving forces of industrial evolution and how the processes are linked together (Carlsson, 1992). The goal of industrial dynamics is to promote economic growth and strengthen competitiveness for an industrial firm through creating and diffusing knowledge within the industry (Smelser and Baltes, 2001).

Industrial dynamics is important for understanding how an industry works and what forces are central for its functioning. It involves analysis of why and how some firms are involved in a variety of activities while other firms are more specialized. It can be used to gain knowledge about firms in the industry and provide guidelines for industrial and macroeconomic policies (Krafft, 2002).

To study industrial dynamics, a permanent sound connection between facts and theories are required. In order to understand the forces that determine the dynamics of an industry, systematic data gathering, and carefully selected information is essential (Krafft, 2006). Industries are organized by the dynamics that shape horizontal and vertical configurations. Horizontal dynamics includes entry, growth, exit, firm size distribution, survival and growth of firms, and stability of market shares. Vertical dynamics includes vertical integration/disintegration in the division of labor and industrial dynamics in upstream/downstream sectors (Bonaccorsi and Giuri, 2001). Vertical disintegration is common when growing industries, while vertical integrations is common when declining industries (Carlsson, 2012).

3.1.1 Sustainability transitions

A field of research that derives from industrial dynamics is sustainability transitions. Sustainability transitions are long-term, multi-dimensional and fundamental transformations of socio-technical systems that moves towards more sustainable consumption and production

(Markard, et al., 2012). Human population growth together with a growth in wealth per capita put a lot of pressure on nature with resource-intensive consumption patterns of developed regions (EEA, 2019). To prevent nature from breaking down, large societal changes in all sectors of the economy and society are needed (Tukker and Butter, 2007). To achieve a sustainable transition, governmental support through new policies and regulations are essential (Ryszawska, 2016).

Policy coordination and policy integration can be useful to make sure policies and actions work coherently for a systemic change to happen. Policy coordination refers to the reconciliation of different objectives and measures in policy areas to achieve an optimal policy mix (Meijers and Stead, 2004). Policy integration promotes coherence and refers to both horizontal sectoral integration between different departments or positions in public authorities, as well as vertical integration between different levels of government (Meijers and Stead, 2004).

To promote transition, a policy mix can be used that initiates innovation and enable new ideas and approaches to change economical structures that are beneficial and produce fair outcomes. The policy mix needs to include policy domains such as economy, environment, climate, education, welfare and research and innovation (EEA, 2019).

Advanced economies in the world are going to require major improvements in environmental performance through fundamental transformation of the systems to protect ecosystems and meet essential needs such as food and electricity. Production-consumption systems such as these have a large impact on the environment due to harmful emissions and intensive use of resources, but they are also a part of important elements including cultural, socio-economic, institutional, and technological. Resources are interlinked with multi-functional systems such as social, economic, and environmental that influence human interest and sustainability outcomes. There are strong economic and social incentives for these multi-functional systems that steer society to meet its needs in specific ways.

System transitions can help create new job opportunities, higher quality of life and green growth. However, it can be challenging for policy makers to impose regulations and policies in accordance with long-term sustainability goals if they are met with resistance from businesses or the public due to the system transition impacting certain sectors by disrupting established jobs, investments and behaviors. (EEA, 2019). To initiate companies to restructure their economic priorities and transition toward sustainability, environmental costs can be included as a part of activities related to production (Geels, 2010). Since future regulations and policies might affect investments and customer attitude towards sustainable solutions, some firms can be uncertain about investing in sustainability. Being early with investing in sustainable technology can be of advantage though, since a firm can benefit from being a first mover and position themselves in the market to gain an advantage over competitors (Geels, 2010).

3.1.2 Multi-level perspective

Multi-level perspective is an approach to analyze sustainable transitions in a system to understand the complex dynamics of sociotechnical change. It consists of three interacting levels; niche, regime, and landscape (Geels, 2002; Grin 2008). On the niche level, radical innovations are usually generated. Niches act as an incubation room for radically new technologies to develop due to different market selection criteria from the regime level. Niches provide location for learning processes such as learning by doing, using, or

interacting. Niches also provide room for social networks important to an innovation such as supply chains and relationships between users and producers. (Geels, 2002; Grin 2008). Some diffusion of technologies will only occur if they align with current conditions in related regimes and landscape. To promote diffusion, external drivers such as changes in the regime or landscape as well as internal drivers such as economic and socio-logical drivers need to be in favor of it (Geels, 2006).

The success of an innovation depends on the process in the niche as well as development in the existing regime and sociotechnical landscape. Opportunities for new technologies to generate from niche-level can be created from landscape and regime levels. Changes at the landscape level such as cultural changes, demographic trends and political changes, can influence the regime by putting pressure on it which can open for new technologies (Geels, 2002). The multi-level perspective is illustrated with the following figure 1.

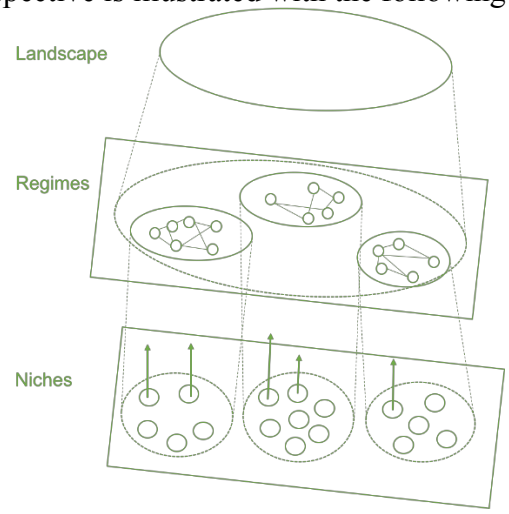

Figure 1. Multiple levels as a nested hierarchy (Geels, 2002).

3.2 Business model adaption

Changes in industries due to factors such as new regulations, innovations or other external changes can entail new opportunities and threats. Customer demand might change, and firms needs to be flexible and adapt their business to meet these changes to stay competitive (Saebi et al., 2017; Stålbrand and Khokar, 2016).

Business models are used by firms to identify the products or services they offer, which market they intend to target and the expected expenses in order to make profit. A business model is defined by four major elements that together create and deliver value (Johnson et al., 2008). The first one is the value proposition of the firm, which describes what value they will deliver to their customers (Johnson et al., 2008; Fielt, 2013). The second element is profit formula which includes a revenue model and cost structure to define how the firm creates value for both itself and its customers (Johnson et al., 2008). The third element is key resources which includes assets such as people, products, facilities, technology, and channels that are needed to deliver the value proposition to the targeted customers. The fourth element is key processes and includes recurrent tasks such as training, manufacturing, budgeting, planning and sales. Successful firms use these processes to deliver value in ways that they can repeat and increase in scale (Johnson et al., 2008; Fielt, 2013). Firms need to choose a suitable business model to stay long-term competitive (DaSilva and Trkman, 2014). When choosing a good business model, there are three criteria to use. The first one entails that it needs to align with the goals of the company. The second one implies that the business model

should be self-reinforcing for executive decisions to be supplementary qualified with each other for internal consistency. Thirdly, the business model should be strong enough to fend of potential threats (Casadesus-Masanell and Ricart, 2011).

According to Balboni and Bortoluzzi (2015), customer needs, market misalignments and realizing new technological potential are drivers to improve business models and meet new market demand and technological advancements. To stay competitive, firms need to focus more on the customers and re-evaluate their value propositions to suit the customers (Stålbrand and Khokar, 2016).

The planned outcome of using business model adaption is to attain alignment with the environment (Foss and Saebi, 2015). In times of high economic uncertainty, firms tend to achieve higher flexibility trough partnering models or outsourcing parts of their operations (Giesen et al., 2010). Partnerships can help a transformation. In the aviation industry, new distribution models can include partnerships to differentiate themselves and build stronger bonds with retail and corporate customers (Borgogna et al., 2016). Distribution actors can benefit from partnering with airlines by taking advantage of their brand name as well as access to their customer base. Airlines should carefully plan what partnerships would be best suited for them to solve strategic travel distribution issues, such as targeting larger customer segments across multiple geographies through partnering with online travel agencies (Borgogna et al., 2016). To seize new opportunities in new airline travel distributions, airlines should invest in capabilities such as *customer knowledge* (holistic view of customer data to offer personalized products and services), *commercial capabilities* (ability to transform customer insights to products and services), *digital channel capabilities* (market offerings through direct channels and preferred social media channels), *loyalty offering* (lucrative, value-adding offerings to loyal customers to keep them loyal to the airline) and *technology environment* (Effective use of direct channels through technology while moving away from old technology and enterprise architecture not relevant anymore) (Borgogna et al., 2016). Airlines can master a new environment and sell more to their customers in less competitive, direct channels if they can build on the capabilities and build a customer-centric organization with an appropriate customer strategy and customer-oriented service culture.

It is vital for airlines to continuously build brand awareness through offline and online advertising and should therefore work with online marketing partners such as air travel comparison sites as well as maintaining direct relationships with customers. The use of air travel comparison sites serves as a catalyst to stimulate further primary research with airlines which incentives a beneficial collaboration for airline companies. Air travel comparison sites can incentive customers to search with them through e.g. favorable prices and different services. (Holland et al., 2016).

3.3 Innovative ecosystem strategy

The term “ecosystems” is used in various platforms and can be defined differently depending on the context where it is being used (Autio and Thomas, 2014). In management research, “ecosystems” refers to a network of interconnected connections which are linked to a company or an organization (Iansiti and Levien, 2004a; Moore, 1993; Teece, 2007). For this study, the definition of innovative ecosystems refers to an explanation by Autio and Thomas (2014) in a management research platform as: *a network of interconnected organizations, organized around a focal firm or a platform, and incorporating both production and use side participants, and focusing on the development of new value through innovation*.

Innovative ecosystems have existed for several years and in the beginning of their existence, it was primarily high technology companies that used these types of platforms. However, in recent years, innovative ecosystem platforms have been more widespread into different sectors. Today, larger companies have challenges not only with creating an innovative ecosystem but also to maintain it since there is a larger number of participants involved in the ecosystem now compared to the early existence of it. (Zahra and Nambisan, 2011)

When discussing different insights around the nature of innovation ecosystem that arise from interaction between participants are mostly about; boundaries, structure, and dynamics (Autio and Thomas, 2014). Further, ecosystems could be a broad concept where participants in an ecosystem includes community of organizations, institutions, suppliers, regulatory authorities, research institutions etc. (Teece, 2007). Hence, ecosystem is seen as a dynamic network where participants co-create value (Adner and Kapoor, 2010). Defining the boundaries of an ecosystem is difficult because of the variety of participants. Hence, boundaries are open, and the limit is hard to be drawn within an ecosystem. However, Adner and Kapoor (2010) includes only participants within suppliers, complementors (products or services which complements and adds value to the main service or product) and customers, whereas Iansiti and Levien (2004a) emphasized a broader and wider community of participants in the ecosystem. Bearing this in mind as a participant, knowing where to position oneself becomes important.

Further, Iansiti and Levien (2004a) have created a framework to understand the management of innovations and operations in business ecosystems. The developed framework consists of three roles that can be placed in the biological ecosystem to influence the ecosystem evolution. The three roles are defined as keystone, niche player and dominator to provide a useful framework for analyzing the pattern of decisions made by firms or organizations in an innovative ecosystem. (Iansiti and Levien, 2004a)

<u>Keystone strategies</u>
Keystones are explained as the regulators of an ecosystem. They create a stable platform which other members of the ecosystem can rely on. Keystones improve the hole ecosystem in order to ensure their own survival. A removal of a keystone could adventure the ecosystem and would most certainly have major consequences (Iansiti and Levien, 2004a). Multiple keystones can be identified in one ecosystem where innovations could be created on both a system and individual level (Adner, 2012). Keystones enhance productivity and simplify complex tasks by connecting the participants in the ecosystem with each other (Iansiti and Levien, 2004a).

<u>Dominators</u>
Like keystones, dominators shape the behavior and has an influential role of the ecosystem. However, the difference between keystones and dominators is that dominators over time takes the leading role in the system. Thus, dominators eliminate participants and niche players gradually within the ecosystem and then move on to new niches (Iansiti and Levien, 2004a). Dominators grow their presence over time on the expense of niches, whereas keystones capture and grow niches within the ecosystem. According to Iansiti and Levien (2004b), dominators are harmful for the health of an ecosystem as they reduce the diversity.

Niche players

Iansiti and Levien (2004a) define niche players as an organization or a company whom exhibits the level of connectivity with ecosystem participants. It can appear as if niche players have a minor role within the ecosystem, but this is not always the case. An ecosystem includes mostly niche participants where they often are the foundations to new innovations. Thus, new products or services developed by niche players leads to new markets being explored. Niche players are crucial for the ecosystem health and in difference to dominators, they create diversity to the system (Iansiti and Levien, 2004a). Niche players usually have an expertise and are specialized companies working with one part or more of the technology. They also use a large resource allocation to know their customers. Hence, niche players usually have deeper marketing skills compared with keystones and dominators. However, they lack knowledge of the broader perspective compared to the system leaders (Zahra and Nambisan, 2011).

3.4 Strategic network innovation

The definition of network innovation has a wide-range explanation in previous literature where it could be explained as a type of innovation process where collaborative actions are taking place (Swan and Scarbrough, 2005). What separates network innovation from other innovation processes is that innovation processes are primary driven by hierarchal and market-based mechanism such as top-down organizational change initiatives according to Hardy et al (2003). Swan and Scarbrough (2005) explains that network innovation focuses on collaborations that includes joint ventures, alliances, associations and consortiums. Additionally, network innovations focus on collaborative networks that the primarily objective is innovation.

Knowledge for environmental change

Industries where technological uncertainty exist, or diffusion may occur requires organizations that seeks more exploration learning compared to industries where the technological shifts are stable and incremental (Levinthal and March, 1993). This cause for organizations to develop networks that reinforce new knowledge and capabilities in order to be prepared for an environmental change. However, many organizations tend to develop existing knowledge instead of exploring new resources. Thus, making organizations more vulnerable for technological shifts forcing them to explore new environmental grounds. (David, 1985). In order to be flexible and develop new knowledge in areas where the experience is limited in a dynamic turbulent environment, organizations needs to be prepared to change the traditional organizational structures and processes (Callaway and Hong, 2016).

Drivers for an open network

A major driver for open innovation network is globalization simply because of a more global landscape for innovation today (Callaway and Hong, 2016). In order to stay competitive, firms need to have an open mind for external ideas since globalization causes changes in the current market reality (OECD, 2008). Increased multi-technological innovations generate organizations to have a network with other organizations (Narula, 2004). Further, a rapid technological advance has led to shorter product life cycles. Thus, organizations are forced to innovate in a quick speed and be more effective when it comes to develop products or services (Callaway and Hong, 2016). This recalls for organizations to be open for network externalities in order to have the right knowledge in place to adapt for new technologies (OECD, 2008).

Network management

Network management could be described as a managerial approach for managing and designing networks (Huuskonen and Kourula, 2012). Kohl, et al (2015) provides an approach for network management, describing three steps where processes defining future targets for inter-organizational networks (Cap et al., 2016). The first step is about assessment of the current collaboration status of the respective network as perceived by its actors. The second step is about assessment of a potential future collaboration status for collaboration potential perceived by the network actors. These two steps include ratings of collaboration and level of density. Additionally, a view on several weak and strong ties should be performed. Both steps basically involve the same processes. The difference is that the first step takes a current perspective whereas the second step takes a future potential perspective. The last step is about defining the collaboration gap. This means the difference between current collaboration status and future potential status of fully leveraged collaboration potential, including difference between level of density, numbers of weak and strong ties. The result of these three steps provides an overview of network actors, current and future collaboration status. Further, the steps create an image of an organization needing to extend or minimize their networks for future collaborations (Kohl et al., 2015). Figure 2 illustrates the three steps and results of it provided by Kohl et al (2015).

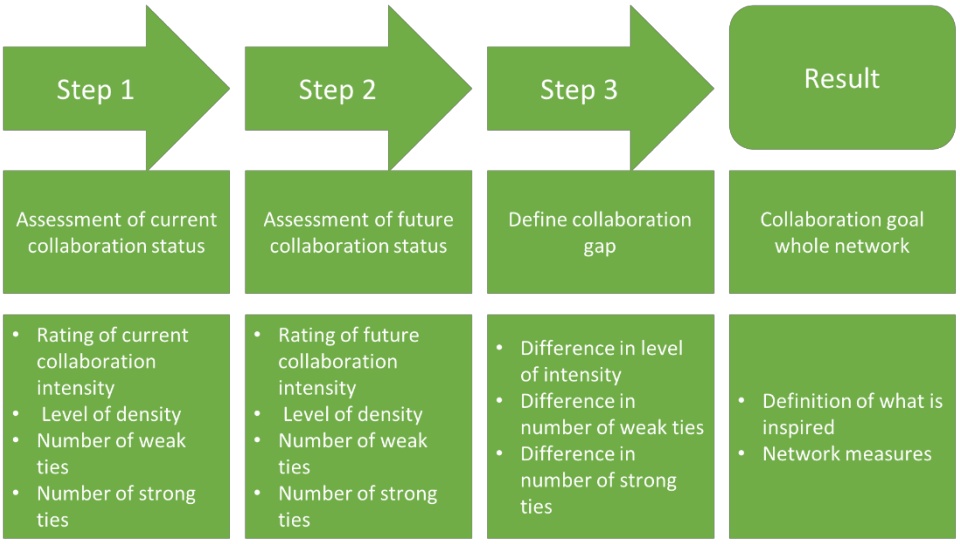

Figure 2. Three steps of a managerial approach for network management (Kohl et al, 2015)

Strategic political network

When it comes to sustainable innovations, creating political cooperation's could be useful in order to gain governmental support. Further, governmental support could possibly lead to settings of new standards for sustainable technology which is important for sustainable innovation (Bohnsack et al., 2016; Sarasini, 2013). Governmental support is especially important in the early stages of sustainable technology when the processes are still depending on legislative factors which delays the development of technologies (Fisher et al., 2017; Markard et al., 2016). Organizations in the same industry might have different interests where some want to push for sustainable technologies whereas others want to slow it down. This creates a space for strategic political networks. With a legislative governmental support, firms that push for sustainable technologies could pose a threat against firms that rely on unsustainable technologies (Markard et al., 2016).

No matter how a firm wants to pursue, governments often stand in the center of a firm's strategic goal when it comes to sustainable innovation. There are different ways and options a firm can be politically active or influence governments (Hillman and Hitt, 1999; Kolk and Pinske, 2007). Firms can act politically on different levels to influence governments such as local or national levels, respectively. Additionally, firms can act by themselves or go together with other firms and organizations (Bonardi and Keim, 2005). Different types of tactics can also be pursued by firms. They could connect directly with governments through lobbying or do it in a more indirect way by establish standards that aims to becoming an industry norm (Bohnsack et al., 2016).

3.5 Innovative marketing

Innovative marketing is a concept in which the innovation management activities to promote the market success of new products and services are communicated and targeted towards a specific group of customers (Hengsberger, 2018). The concept includes research into customer needs, behavior and trends, concept and prototype tests with customers and market the product in a unique place with a unique price to make sure that the new product or service is designed for the market and the customers (Hengsberger, 2018; Farooq, 2019). Innovative market strategies enable customer and market orientation which is significant for the success of an innovation. An innovation is at the risk of failing if there is a lack of market research and the wrong customers are targeted, or the customer needs are not fulfilled. An innovation may also fail to sell if it is not marketed properly. Therefore, innovative marketing is important for the success of a product or innovation (Farooq, 2019). There are multiple innovative marketing techniques a firm can use to increase brand awareness and attract new customers including word of mouth marketing, social media marketing, show your expertise and brand repositioning (Farooq, 2019).

Worth of mouth marketing

Worth of mouth marketing is a form of advertisement where customers share their satisfaction of a brand which has exceeded the customers' expectations (Mosley, 2017). This form of marketing is free in the sense that it is shared by the customers. Acquiring a new customer cost more than keeping a current one (Fordwich, 2010), hence it is important to satisfy current customers for them stay loyal and share their experience of the brand to other people (Warren, 2020; Farooq 2019). A company can then grow sales without spending more on advertisement as well as receive more funding from *Customer Acquisition Cost to Lifetime Value* from customers with high lifetime loyalty (Warren 2020). According to a Nielsen study (Nielsen, 2012), 92 percent of consumers trust recommendations from friends and family more than advertisements. One of the factors that can trigger a word of mouth reactions, is to provoke emotion for the customer since they are more likely to share their experiences if they had some sort of emotion triggered by it (Mosley, 2017). According to a study by Fractl (2016), people feel more confident sharing content that is interesting, makes them look good or is educational for their network (Fractl, 2016). Therefore, offering a product or service that is worth talking about might tempt customers to share It (Mosley, 2017).

Brand Repositioning

Successful brands are relevant and appealing to the customers, unique compared to the competitors and credible (EquiBrandconsulting, n.d.). If a brand lacks in any of these objectives, a brand can reposition itself. Brand repositioning is a strategy that a firm can use in order to change how the customers perceive the brand and what qualities they associate it with (Courtright, 2019; VanAuken, 2016) By repositioning the brand, a firm can increase its

brands competitive position and increase sales by acquiring market shares from competitive products (Wisdom Jobs, n.d.). When a firm repositions, there are four options to do it including image repositioning, market repositioning, product repositioning and total repositioning (Wisdom Jobs, n.d.). Figure 3 illustrates these four options for repositions.

- *Image repositioning* is when both the target market and the product remain unchanged and the image of the product in the current market space is changed instead.
- *Market repositioning* occurs when the product remains unchanged but is repositioned in a new segment of the market.
- *Product repositioning* is when the existing target market remains the same, but the product is changed.
- *Total repositioning* includes changes in both the targeted market as well as changes in the product (Wisdom Jobs, n.d.).

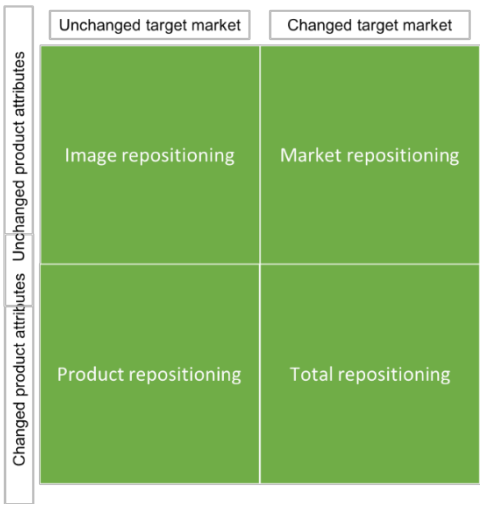

Figure 3. Four options for a firm to reposition themselves (Wisdom Jobs, n.d.)

3.6 Consumer behavior

Consumer behavior is a study of the process's consumers use when they purchase, use and dispose of products or services (Solomon, 2011). These processes include consumers mental, emotional and behavioral responses (Radu, 2019). The consumer behavior process consists of three phases which the marketer must understand the consumer needs for each one of them since value created during each phase can influence a consumer's behavior towards the product or service (Solomon et al., 2012). The three phases are pre-consumption, consumption and post-consumption. The pre-consumption phase includes how a consumer decides on purchasing a product or service and why they perceive it as superior to other products or services (Solomon et al., 2012). During the consumption phase, the marketer needs to consider situational factors affects a consumer purchase decision such as store display and time pressure (Solomon et al., 2012). During the post-consumption phase, the marketer needs to understand whether the consumer will be satisfied with the product and buy it again or not (Solomon et al., 2012). The consumer considers factors such if the product lives up to the expectations and the environmental impact of the disposal of the product (Solomon et al., 2012). If the consumer is satisfied with his/her experience of the products he/she might stay loyal to the marketer and tell others about their experience.

A study on consumer behavior in air travel showed that people who view CO_2 emissions from air travel as damaging to the environment tends to be more willing to compensate for

those emissions. The study also showed that consumers who believe pro-environmental behavior is important are more willing to compensate for CO_2 emissions from air travel as well (van Birgelen, et al., 2011). These consumers generally act in environmentally conscious behavior in areas outside air travel and their behavior seems to be pro-environmental across many domains (van Birgelen, et al., 2011).

Another study showed that most of the participants are concerned about the impact from unsustainable utilization. However, it showed that only most of the Europeans consume sustainably compared to the consumers from Asian and Arab countries (Bindu, 2013). The study argues that Asian and Arab internationals seem to be less educated, less interested and not as willing to spend more on sustainable purchases compared to Europeans.

3.6.1 Theory of planned behavior

The Theory of Planned Behavior (TPB) is based on the Theory of Reasoned Action (TRA) (Ajzen and Fishbein, 1980) to predict how a person behaves in a specific situation. The premise of the theories is that a person decides to behave in a specific way depending on the information available to them (Ryan and Carr, 2010). According to the TPB, both motivation (intention) and ability (behavioral control) are key for behavioral achievement (LaMorte, 2016). Behavioral intention is produced from a combination of three types of beliefs - behavioral, normative and control (Ajzen, 2002). Behavioral control depends on the person's perception of the how difficult it is engaging in the behavior (Ryan and Carr, 2010). Normative belief depends on a person's perception concerning social pressure and how others expect them to behave in specific situation (Yamamoto, 2016). The TPB describes six main factors to represent a person's control over the behavior.

1. Attitudes - A person evaluates performing a behavior by considering the outcomes from performing it.
2. Behavioral intention - The stronger an intention to perform a behavior, the more likely the person will perform it.
3. Subjective norms - A person considers if other people would approve on them engaging in a behavior or not.
4. Social norms - A person considers the code of a larger group of people or cultural context before engaging in a behavior.
5. Perceived power - A person perceive its behavior control of different factors that may facilitate or impede a performance of a behavior.
6. Perceived behavioral control - A person's belief of how easy or difficult it is to perform a specific behavior. This part was added to the TRA to make a shift to the TPB. (LaMorte, 2016).

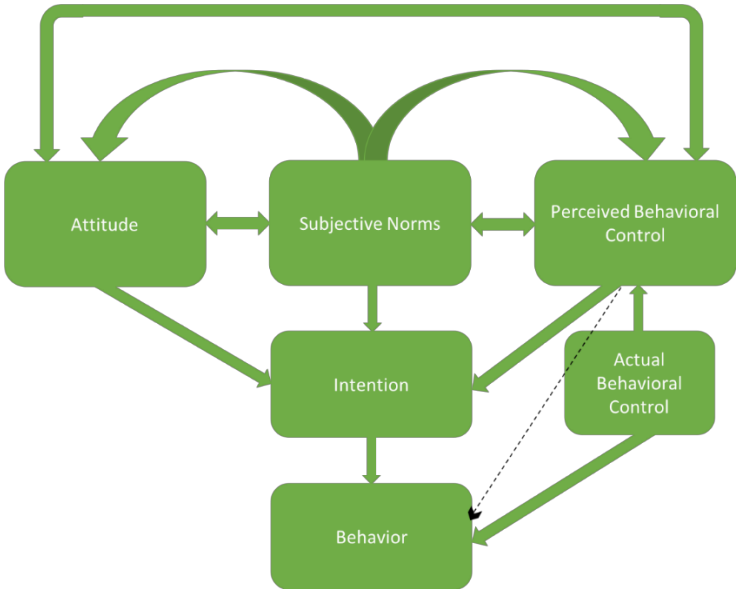

Figure 4. Main variables of the theory of planned behavior (LaMorte, 2016).

According to a study by Kim, Yun and Lee (2014), knowledge was found to positively influence the consumer's attitude and perceived behavioral control regarding sustainable consumption. An air travel comparison site can encourage more consumers to opt for carbon offsetting their air travel by providing more information about the carbon offset offered via their site. It is important to provide clear information on exactly how the consumers monetary donations will be used and the effectiveness of consumers' participation.

3.7 PESTEL

The PESTEL framework provides an analysis to identify macro-environmental forces that affect an organization. The framework analysis includes six factors: Political, Economical, Social, Technological, Environmental and Legal factors. These factors are out of an organization's control and an analysis can provide an organization with valuable insight of what impact they could have on its business. (Oxford College of Marketing Blog, 2020). Figure 5 illustrates the six factors within the PESTLE framework.

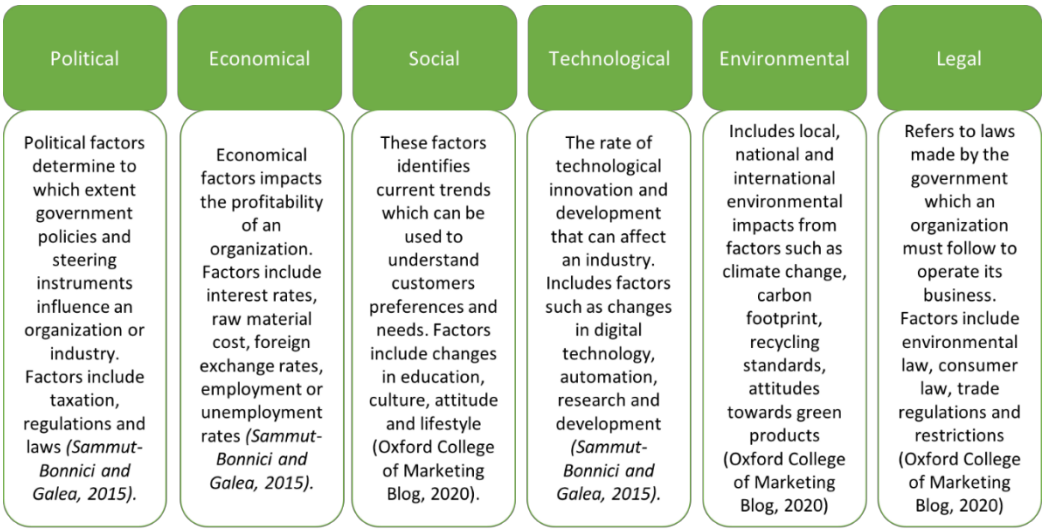

Figure 5. Factors within the PESTEL framework (Oxford College of Marketing Blog, 2020).

The PESTEL analysis identifies threats and opportunities for an organization which can be used to identify strategic management implications to ensure the business aligns with the factors for success. With the aviation industry facing various challenges, a PESTEL analysis is a strategic method to highlight sources outside the industry that affects business operations and show how external factors influence the industry. It helps diminish the impact and consequences of potential threats to an organization and provides a mechanism that enables an organization to identify and exploit new opportunities. It is also a useful tool to understand the business environment better and inspires strategic thinking (Rastogi and Trivedi, 2016).

Findings from a PESTEL analysis can be used by an organization to interpret them through a SWOT analysis as a part of the risk management process in order to identify an organizations internal strengths, weaknesses, opportunities and threats (Perera, 2017). The six factors included in a PESTEL analysis are very dynamic and a shift in any of the factors could change the result of the analysis drastically, making it difficult to anticipate developments of projects and predict the future of a business (Rastogi and Trivedi, 2016). Additionally, a disadvantage with the tool is that the data collected by PESTEL analysis can be based on unsubstantiated assumptions (Hopkin, 2014). An illustration of a PESTEL analysis applicable for the aviation industry is presented in figure 6.

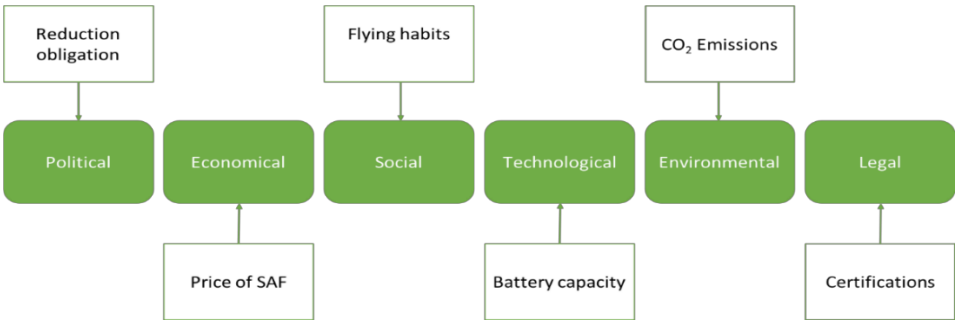

Figure 6. Illustration of a PESTEL analysis applicable.

3.8 Scenario analysis

Scenario analysis is a form of projection where a process of evaluating and analyzing alternative possible outcomes of the future rather than just one outcome. It can be useful for decision-making processes. To build a possible future scenario, there are steps to follow.
First, the focal question for the scenario needs to be identified (Metzger et al., 2010) as well as defining the scope of concerning factors such as timeframe and the need of knowledge and information (Schoemaker, 1995) Secondly, driving forces that influence the focal question needs to be identified as well as gather data. Driving forces that influence scenarios include *demographic drivers*, *sociopolitical drivers*, *economic drivers*, *science and technology drivers*, *cultural and religious drivers*, *climate variability and change*, *plant nutrient use*, *land conversion* and *biological invasions and diseases* (Puget Sound Nearshore, 2008). The key drivers can be ranked in importance and uncertainty to select the drivers that will define the most relevant future conditions to include in the final scenarios (Puget Sound Nearshore, 2008). Next step includes selecting the scenario logic (Metzger et al., 2010). This step includes creating a framework in which the scenario assumptions are developed by exploring the interaction of the most uncertain and important drivers. Further, scenario assumptions need to be described. Trends of the most important drivers can be used to describe the principles and assumption for possible future scenarios (Metzger et al., 2010).

Each scenario can be modeled with selected indicators from the key driving forces to assess how the focal question is impacted under each scenario. Implications and potential impacts of future scenarios can be assessed through storylines or based on numerical models. The predictions and projections of potential scenarios can then be used when planning a business to avoid parts of the business predicted to be the riskiest and instead commit to the parts that are predicted to be less risky (Free Management Books, 2020).

3.9 Carbon offsetting

Voluntary Carbon offset refers to voluntary project-based emission reduction plans, that an individual, company or country can purchase to pay for reduction of carbon from one place to another. In this study, voluntary carbon offsetting refers as only carbon offsetting since it goes under that category as well. Carbon offsetting that are not voluntary are referred as non-voluntary carbon offsetting. Usually, a project is carried out by a non-profit organization in a location where it is easier, cheaper and faster to reduce emissions compared to where the carbon originally was emitted from (Kollmuss, 2010). Carbon offsetting is not regulated by the government which could be the case with non-voluntary carbon offset. Compliance markets differ from carbon offset markets in the way that companies, governments or other entities buy carbon offsets to comply with emission caps, while voluntary carbon offsets are sold to customers wanting to offset their carbon footprint. Because of voluntary demands, the carbon offsetting market is smaller than the compliance market. Thus, standards for carbon offsetting projects are not as established and is cheaper compared to the compliance market (Kollmuss et al., 2008). Carbon offsetting could for example be when an air passenger pays extra for a ticket to fund non-profit organizations that is working with carbon-reducing projects in order to compensate for the emissions from the flight. Carbon offset projects are usually classified into three different types which are energy related, forest management and reduction of other greenhouse gas (GHG) emissions (Becken and Mackay, 2017).

Studies have shown that knowledge from air passengers about the environmental impact of a flight is very limited. Further, passengers receive little information on the environmental impacts of aviation and the concept of carbon offsetting from the airlines. Many airlines have taken actions to improve their environmental impact by fuel efficiency, optimizing flight routes, fund carbon offsetting projects and offer alternatives for passengers to carbon offset. However, these actions are usually not visible anywhere for the passengers. The scientific basis of carbon offsetting is often misunderstood which result in less passengers willing to fund carbon offsetting projects (Mackey et al., 2013). It has been proved that passengers that have more knowledge about the environmental impact and the concept of carbon offsetting are more willing to invest in such projects. In the context of vehicles, Lange and Ziegler (2017) showed in their study that individuals are more willing to use carbon offset if there is a higher sense of responsibility for CO_2 emissions in order to reduce the environmental damage. Airlines are facing a challenge to improve the awareness into passengers and reduce the knowledge gap between airlines and passengers about climate actions that can be done (Becken and Mackey, 2017).

There are certain standards in the carbon offsetting market that the projects need to follow in order to be accounted as carbon offset project. First, there must be evidence that the project is real and removes or prevent emissions. Second, it must be additional which means that reductions of the emissions would not occur without the project activities. Third, the emissions of project activities should be measurable. Lastly, a neutral, third-party auditor needs to verify the reductions of emissions. These standards are required for all carbon offset

projects around the world. However, other regulations and standards might occur depending on the location of the projects. (Forest Trends, 2018)

In order to generate offsets, standards previously mentioned need to be achieved. The process from producing a carbon offset project to selling it, could vary but most are following similar steps illustrated in figure 6. Once the project developer has decided on activities to fund, early - stage preparations are made by generating a project plan. These plans are then generated by a third-party auditor who validates the project plan (Forest Trends, 2018). Once the project plan is validated, a verification process takes place to make sure the project activities have been implemented. All these steps so far in the process is called issuances (Ecosystem Marketplace, 2018).

Once the issuances process is made, the project developers can start to sell the offsets. However, selling the offsets to a buyer is usually a multi-step process. A project developer can sell offsets directly to an end buyer, but most commonly, offsets are sold to retailers that resells the offsets to end buyers (Ecosystem Marketplace, 2018). The whole process where selling of offsets occurs is called transactions (Forest Trends, 2018). In the aviation industry, retailers are first and most airlines, travel agencies or price comparison sites whereas end buyers are the air passengers.

When the end buyer has purchased offsets, the last phase of the offset's life cycle take place which is called retirement. At the retirement phase, offsets that have been bought are no longer possible to be traded on the market. Thus, the offset representing reduction of emissions cannot longer be sold. (Ecosystem Marketplace, 2018)

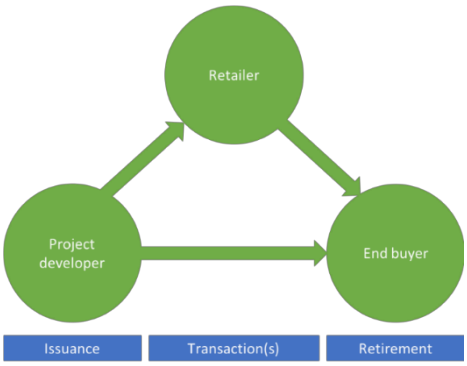

Figure 7. The process from producing a carbon offset project to selling it (Ecosystem Marketplace, 2018).

3.10 High altitude factor

Airplanes flying on high altitudes (8000m and above) emits more water vapor and NOx which affects the GHG effect more (Grankvist, 2019). This effect is called the high-altitude factor**.** Combustion on high altitudes are considered to have double the impact on the climate compared to the same combustion on ground level (Naturvårdsverket, 2020). When calculating emissions from flights, this effect needs to be considered with the CO_2 from combustion in the engines for a more accurate calculation. The high-altitude factor should be considered when calculating a flights total impact on the climate or when comparing emissions from different types of transports (Bruun et al., 2019). To calculate a flights impact on the climate, the total CO_2 emissions are multiplied with a Radiative Forcing Index (RFI) to account for the high-altitude factor in CO_2-equivalents (Pulselly and Marchi, 2015). There is no universal best-practice value of the RFI, and the values used by scientists usually differs from 1-2,7 (Jungbluth, 2013). According to a paper by ESU-services, the latest scientific

publications recommend using an RFI value of 2 when calculating the total CO_2-eqvivalent emissions (Ljungbluth and Meili, 2019). If calculations are done solely on emission in the higher atmosphere, a higher RFI value of up to 8.5 can be used (Ljungbluth and Meili, 2019).

There is a debate whether the high-altitude factor should be taken into account or not when calculating a flights impact on the climate due to its complexity and the fact that there is no consensus on how much effect it has on the climate (Tricorona, 2019a). The uncertainty about the value of the RFI is because the relation between CO_2 emissions and other important parts of the high-altitude effect such as water vapor, soot and clouds are described as uncertain or unknown (Lundell, 2018). A study by NASA (Northon, 2017) showed that pollution from jet engines are reduced with between 50 – 70 percent when using biofuel instead of fossil fuel. The high-altitude factor is likely to have less effect as well when using biofuel. However, the magnitude of the effect is uncertain and significant parts of the effect will still likely remain (Åkerman, 2019). The high-altitude factor is not covered by the EU Emission Trading System (EU ETS) (European Commission, 2020a), which result in not more than about a third of GHG emissions from flights within the EU are included in the emission trading (Åkerman et al., 2016). Using biofuel instead of fossil fuel will not solve the issue of the high-altitude effect. To make aviation more sustainable, increased fuel efficiency and fewer flights are needed together with the transition for sustainable aviation fuels (Åkerman et al., 2016).

4. Method

This chapter describes the outline of the project in order to answer the research questions. The chapter begins with a description of the research design where the method is explained as well as restating the research questions. This is followed by a data collection where the process of the collection is described. Additionally, an analysis of the data collected is presented and the process of it. Lastly, the quality of the research for the project is presented which includes reliability, validity and ethics.

4.1 Research design

This paper has used a qualitative method with an abductive approach to investigate the future of aviation technology, in order to find necessary actions that can be applied to develop a more sustainable aviation industry, and how carbon offsetting for air travelling can be renewed due to new technology and fuel alternatives. To answer the research questions, understand future aviation sustainability solutions and how a future adaption of a carbon offset alternative is probable to evolve, an intrinsic case study methodology is applied for this paper. An abductive approach is a combination of inductive and deductive approach and is advantageous to use when a research should add great responsiveness to the empirical material according to Blomkvist and Hallin (2015) and Saunders, Lewis and Thornhill (2009). The inductive approach was used in order to move from observations to theory and to gain more knowledge about the subject and formulate the problem formulation. Deductive approach was used to analyze the empirics and move back from theory to observations (Saunders et al., 2009). Figure 8 illustrates the abductive approach for this paper with both inductive and deductive reasoning.

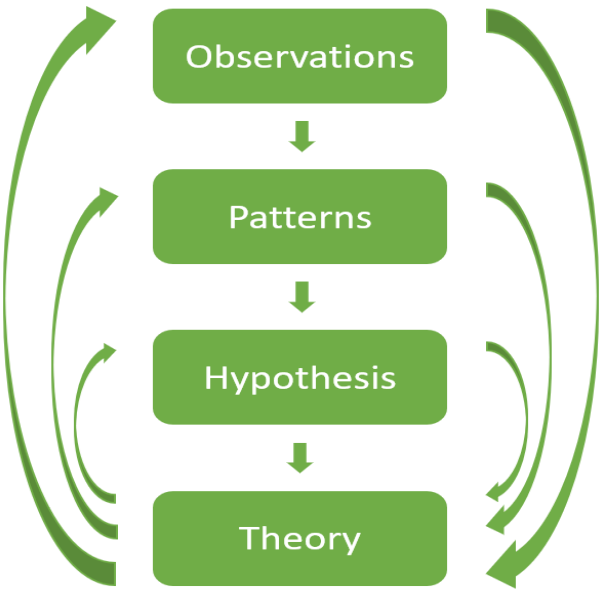

Figure 8. Illustrates inductive approach with deductive thinking.

Qualitative studies are usually associated with case study research, based on constructivist perspectives, which are suitable for gathering empirical data (Creswell, 2003). Qualitative research usually consists of semi-structured empirical collection with both soft and rich data which has been adopted for this study. Semi-structured empirical gathering of data often leads to knowledge of how individuals discuss around different issues. Further, new spreads

of dimensions about the research phenomena can be found through a semi-structured data gathering (Blomkvist and Hallin, 2015).

The selection of using an intrinsic case study is based on Stake's definition which suggest that when there is a genuine interest of a case and an intention to understand it better, the intrinsic approach is preferable (Jack and Baxter, 2008). Since the case itself is the general interest, Stake also suggest that the researcher should not compare with other cases when conducting a research in an intrinsic way according to Jack and Baxter (2008). An intrinsic case study also tends to create new dimensions when gathering data which follows Blomkvist and Hallin's (2015) purpose of having an open character when gathering soft and rich data.
Another type of qualitative method considered for this paper was an exploratory case study which Yin (1994) suggest should be used to explore different situations when the intervention that is being evaluated has no clear or single set of outcomes (Jack and Baxter, 2008). The exploratory case study methodology seems to fit a more traditional comparative approach. Thus, this methodological type was excluded.

The structure of the report is illustrated in figure 9. The sustainability in aviation chapter is based on industrial reports from science, governments and organizations that are affiliated with the aviation and carbon offsetting industries. The theoretical frameworks are based on scientific articles and books within topics such as industrial dynamics, business model adaptions, ecosystem strategies, marketing, scenario analyses and carbon offsetting. It includes literature on the field of study and relevant concepts used to analyze and interpret the gathered data. The findings are an empirical analysis, based on interviews with people from different stakeholders within the aviation and carbon offsetting industry, as well as people related to governments, manufacturers of aircrafts and authorities.

Together with the industrial chapter, theoretical frameworks, and the findings, a scenario analysis has been developed in order to understand current state of the aviation industry and the carbon offsetting industry, and how it can progress in the future. The scenario analysis illustrates a current state, a short-term and a long-term outlook to consider probable future states of the industry within different time frames. With an uncertainty of when a product or legislation will be available, the scenario analysis does not specify years for each of the future states but rather the development of how the scenario will evolve. Further, the long-term outlook tends to be rather speculative than based on facts. To fend off speculations in long-term outlook, uncertainties that could affect outcomes are presented as well. Specific time frames of the future states are presented in the discussion chapter based on the findings of this report. The discussion chapter also discuss how the scenario can be linked with theories and literature. Further, the chapter discuss plausible actions for the aviation industry to become more sustainable and how carbon offsetting can be renewed based on the scenario parallel with support from theories and literature.

Based on the scenario analysis and discussion, conclusions are presented which presents propositions suggested by the researchers for this study. The propositions suggested for this study are constructed from the perspective of stakeholders that are related to the aviation industry such as an air travel comparison site to answer the research questions. The scenario analysis and suggested propositions are argued from the knowledge obtained during the research for this paper. To clarify the proposition, managerial implications and recommendations are followed which present a more detailed approach of how the propositions could be performed from a stakeholder's perspective.

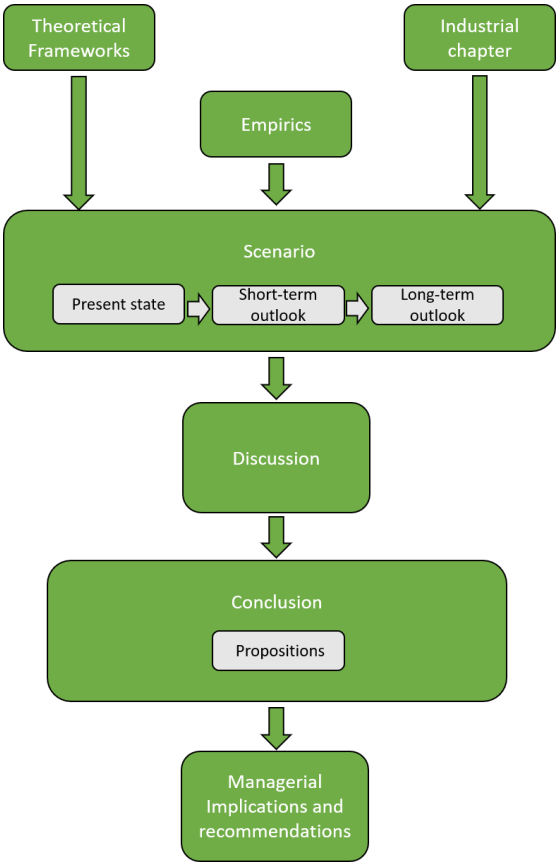

Figure 9. Structure of the report.

4.2 Data collection

This report follows the Giola method for data collection and analyses (Giola et al., 2012). The Giola method is commonly used for grounded theory development. However, regarding data collection and data analyses, the method seems to fit the outline structure of this report. The Giola method is a good place to start with in order to understand the experience of the informants and the temporal or practice dynamics in organizational life (Gehman, et al., 2017). Further, primary and secondary data have been used for this paper. Primary data consists of interviews conducted by the researchers which are unique and interpreted for the first time. Secondary data contains information originated from articles, journals, books, reports etc.

4.2.1 Primary data

Primary data has been collected using two types of sources for this paper. The majority of collected primary data consist of interviews with CEOs, managers and employees from stakeholders connected to the aviation and/or carbon offsetting industry. The other source of primary data includes observations gathered at the case company.

<u>Interview design</u>

The process of collecting data according to the Giola method starts by finding similarities and differences among emerging categories which this report has followed. The interviews followed a semi-structural approach with pre-arranged open questions, although the questions often lead to new discussions depending on the answers from the respondents. The questionnaire for this paper includes different topics regarding the aviation industry and carbon offsetting where the most emerging topics have been chosen to ask relevant questions

to the interviewees. More specific, the questions included challenges and opportunities regarding sustainable solutions and possible future scenarios with these solutions in the aviation and carbon offsetting industry. Most of the interviews were performed with the same questionnaire. Some exceptions were made where only a few of the topics were used from the questionnaire due to a variety of expertise amongst the interviewed participants. The questions have been open to give the interviewed participants a chance to explain their thoughts about selected categories as well as giving them a voice during the interview, which is the foundation of the Giola method. The questionnaire used for the interviews is found in appendix A. When new questions have arisen during the research process, some of the participants have been contacted a second time in order to have their opinion about the arisen issues. This has been an important factor since new issues have occurred during the data collection process. The data analysis follows an initial coding process and the interviews maintain their integrity throughout the process which follows the data collection process according to the Giola method.

Most of the interviews have been recorded to at any given time, listen and analyze the interview in depth. This adds credibility to the study as well and it can be reviewed by other researchers (Department of Sociology, Harvard University). However, a disadvantage with recording an interview could be that the respondent feels uncomfortable and an awareness of the possibility that others might listen to it can result in the respondent holding back on answering certain questions (Al-Yateem, 2012). To avoid this, the respondents were asked for permission to record the interviews before the interviewers started to ask questions from the questionnaire. The interviews that were not recorded included participants from the case company and other researchers where it was an open discussion regarding some or one of the topics from the questionnaire. Instead of recording those interviews, a transcription was made, and the respondents were asked if the material could be used for this paper. Participants who were contacted a second time received questions through e-mail and responded with their answers through e-mail as well.

The interviews were performed by both researchers where one was responsible for taking notes of the holistic observations. The other researcher was responsible for asking questions and guide the discussions. The interviewer responsible for asking questions may be more influenced by personal interactions whereas the interviewer responsible for taking notes have a more distant view of the discussions. Thus, it enables a multi-perspective analysis of the interviews (Eisenhardt, 1989). In studies involving multiple interviews, it is important that the data collection is performed in teams. It is especially important in the beginning of the process to increase the probability of a common research being used at all sites which enhance the reliability of the research (Voss et al., 2002).

Selection of respondents

For the selection of respondents, this paper has followed a four-point approach presented by Robinson (2014). First step of the four-point approach is to define the sample universe or in other words, deciding target respondent population. Second step is to decide upon a sample size and third step is to select a sampling strategy. Fourth and last step is sample sourcing which concerns ethical aspects such as avoiding biases. (Robinson, 2014)

When deciding on target respondents, an inclusion and exclusion criteria or a combination of both needs to be specified. Inclusion criteria entails that special attributes needs to be confirmed in order to be part of the study. Exclusion criteria entails that attributes needs to be specified to be disqualified for the study (Robinson, 2014). For this study, inclusion criteria required the respondents to be a part of or have a significant connection to the aviation

industry or/and the carbon offset industry. Additionally, to have respondents with deep knowledge of how their firm/organization are connected to the industries, they should have a high-ranking position at their firm/organization. The exclusion criteria for this report was used for respondents who did not represent a firm or organization but rather an individual. Respondents with different areas of expertise within the industries were contacted to collect data from a variety of respondents.

When deciding a sample size for a qualitative research, it is important to be flexible during the research progress (Glaser, 1978). For this paper, about 15 respondents were planned to be interviewed. Due to restrictions in availability and time scheduling of the researchers and respondents, some interviews could not be performed, and the number of respondents ended up at 13. After discussions with the supervisors at the research institute and the case company, 10-20 respondents seemed appropriate for this paper.

COVID-19 has also affected number of respondents. Due to the disease, respondents from Swedish airlines as well as technological experts from electrified aircraft manufacturers were not able to participate in this study. This might have affected the result since this study does not get their perspective and might have answered differently compared to the participated respondents. Those interviews that have been performed was before the outbreak of COVID-19. Their answers might have been different if the interviews were performed after the breakout of the SARS-CoV-2 virus since it has had a significant impact on the aviation industry.

Once the target population and the sample size are selected, a sample strategy should be decided. Purposive strategies are non-random where categories within the sample universe are represented. Furthermore, a quota sampling sets out a series of categories where a minimum number of each categories are decided. This paper used a quota sample list including requirements such as:

- At least one with aircraft technology expertise
- At least one working in the carbon offset industry
- At least one with politic expertise within sustainability issues
- At least one with sustainable fuels expertise

The difference between quota sampling and other purposive strategies such as stratified sampling and cell sampling is that quota sampling provides more flexibility of the final number of sampled data. By using a quota sampling, the strategy ensures that key groups are represented without deciding a fixed number of respondents before starting the interview process. (Robinson, 2014)

The final step of the four-point approach is sample sourcing which concerns ethical aspects of the selection of respondents. All respondents have been informed about the study's aim and ensured the voluntary nature of the respondents which needs to be considered. Another aspect that needs to be considered is that those that wants to be involved in the study might respond differently than those that refuse (Robinson, 2014). To deal with these issues, firms and organizations that might have different perspectives and opinions have been a part of the sampling for this paper.

Table 1 displays an overview of the interviewed respondents. The interviews do not follow a strategical order, but rather depended on the time availability for the respondent to participate.

Table 1. List of interview respondents and classification

Respondent	Company	Title	Field of interest	Interview location	Type of interview	Date	Duration
R1	Transportföretagen	Chief of aviation	Innovation, policies, aviation industry	Phone	Semi-structured	5/2–2020	60 min
R2	Go Climate Neutral	Co-founder	Carbon offsetting	Flygresor.se, head office	Unstructured	10/2–2020	90 min
R3	Grön Flygplats	Project manager	Aviation industry, airports	Svenskt flyg, head office	Semi-structured	11/2–2020	45 min
R4	Fly Green Fund	CEO	Innovation, aviation industry, policies	Flygresor.se, head office	Semi-structured	12/2–2020	60 min
R5	RISE	Project manager	Aviation research	Phone	Semi-structured	14/2–2020	45 min
R6	EU Parliament	Swedish head member	Innovation, policies, carbon offsetting	Phone	Semi-structured	17/2–2020	40 min
R7	SAS	Head of sustainability	Innovation, carbon offsetting	SAS, head office	Unstructured	19/2–2020	60 min
R8	Luftfartsverket	Head of economics	Carbon offsetting, air traffic	Phone	Semi-structured	24/2–2020	20 min
R9	Luftfartsverket	Environmental specialist	Sustainable fuel	E-mail	Structured	25/2-2020	-
R10	Luftfartsverket	Aircraft specialist	Innovation, aviation specialist	Phone	Semi-structured	3/3-2020	25 min
R11	South Pole	Climate advisor	Carbon offsetting	South Pole, office	Semi-structured	25/2-2020	60 min
R12	Swedavia	Sustainability manager	Aviation industry	Phone	Semi-structured	28/2-2020	20 min
R13	SAAB		Innovation, aviation industry	Phone	Semi-structured	28/2-2020	25 min

Observations

To propose managerial implications for the case company based on the findings of this report, a daily observation with an outsider observer approach according to Eisenhardt and Graebner (2007) was conducted throughout the study. Observations around daily company decisions were made by spending time at the head office continuously during the research. Additionally, participation in meetings and discussions around business and market related issues where conducted during the research process. By having the case company's head office as the research location, both formal and informal discussions occurred that were helpful to propose managerial implications for the case company.

4.2.2 Secondary data

In this report, secondary data was used to obtain theoretical frameworks and a chapter about sustainability in the aviation industry. For the theory, primarily scientific articles were used, while industrial reports were primarily used for the second chapter of the literature study about sustainability in the aviation industry.

In this report, theoretical frameworks were used as a secondary data source. The theoretical frameworks were used to develop a deeper understanding of the area of research in order to generate knowledge and questions about it. Wider knowledge about the area of research also helped to articulate a research question that will be a valuable addition to existing literature. Further, by following an abductive approach, the theoretical frameworks were used to support or oppose findings from the empirics and enable feasible conclusions and implications.
Both researchers for this paper have collected data in order to enhance the creative potential and increase convergence of observation confidence in the findings. The team was divided into insider/outsider task responsibilities (Thomas et al., 2000), where one of the researchers was responsible for insider data collection including scientific articles whereas the other researcher was responsible for outsider data collection including industrial reports.

Relevant knowledge was gathered from areas such as *Electrified Aircrafts, Carbon Offset,* and *Sustainable Aviation Fuels.* The literature was used to understand the current research in in the areas and identify potential opportunities and complications. The literature used for this report was gathered from scientific articles, journals, books and reports. The most significant literature used was gathered from peer-reviewed sources and critically evaluated, hence perceived as trustworthy.

The scientific articles gathered as a supplementary qualification to the interviews were collected through scientific databases. Primarily, Google scholar, Web of sciences, KTH primo and Elsevier were used. Industrial and governmental reports were also collected through scientific databases, Google searches in relevant fields, advise from interviewed participants and annual reports from relevant organizations and stakeholders. When searching for literature, several different key words were used to find relevant publications. Key words used include *carbon offset, sustainable transitions, industrial dynamics, aviation industry, aviation ecosystem strategy, business model innovation, e.g.* Further, publications from 2010 and later have been prioritized because the aviation industry is constantly developing (IHLG, 2019) and therefore recent research is more likely to be relevant for the area of research. In order to ultimately select which publications to use for this study, the abstracts of publications found during the literature search were read. Abstracts with relevant content for the study were then selected.

Some non-scientific sources of data, such as newspaper articles, were used in this report. These articles either used scientific sources or were published by an organization or institute that are considered trustworthy after further research about them.

4.3 Data analyses

After the recording or annotation of an interview, a transcript process was conducted. The transcription followed an open coding technique where line by line from the recording or annotation material were analyzed in order to identify key words or phrases. After the first order open coding technique, a second order thematic analysis according to the PESTEL framework was performed. The PESTEL framework was used to categorize the findings from both the literature and the empirics. Business in the aviation sector is affected by many

different factors (Yashodha, 2012) and a framework that analyses multiple aspects of the macroenvironment was relevant for this study. Since the PESTEL framework is a useful tool to analyze the most relevant macro-environmental factors in general business that impacts an organization or industry (Yüksel, 2012), it was appropriate to use for this study in order to obtain a holistic view of the aviation industry. As the findings from both the literature review and the empirical study was analyzed using the same PESTLE framework, possible synergies and connections were identified, which improved the results as well as increased the validity. Additionally, a thematic analysis helps to see and make sense of patterns from numerous sets of interviews (Cooper et al., 2012).

Once the data was placed into a PESTEL categorization, a final assortment was made through three main topics that the researchers of this paper emerged before the interview process started. These main topics are electrified and hybrid aircrafts, sustainable aviation fuels, and carbon offsetting. Lastly, the findings from each topic are summarized and categorized in a table by opportunities, challenges, transitions, needs and complexity. A table of summary provides key information concerning the quality of evidence and gathered data (Schunemann et al., 2008).

After each interview, the recording material was divided into two parts where one of the researchers was responsible for the transcription process, coding, and categorization for one part whereas the other researcher was responsible for the other part. Some sentences or phrases from the open coding process could be argued to fit in several PESTEL categories. However, those sentences or phrases where placed in the category that was most fundamental or made most sense according to the researchers.

The sustainability aviation industry chapter includes scientific articles and industrial reports based on research from scientists, stakeholders, governments, e.g. It provides additional knowledge to the empirical research to build a scenario process of the aviation industry. To compare similarities and differences between the sustainability aviation industry chapter and the empirical research, both chapters are categorized according to the PESTEL framework. The theoretical framework is an additionally supplementary qualification to identify and apply relevant theories to build a scenario process and an outlook of the aviation industry. Additionally, sustainability of the aviation industry, empirical research, and the theoretical frameworks functions as a ground for the propositions given in the different time phases of the scenario analysis.

4.4 Research quality

High research quality is important to reduce the risk that the findings obtained are incorrect. To obtain high research quality, validity and reliability needs to be ensured. Data must consistently be gathered systematically through appropriate methods and reviewed in a critical way. (Saunders, Lewis and Thornhill, 2009, chap.5; Blomkvist and Hallin, 2015, pp.52-53). This section describes how validity, reliability and ethics have been ensured in this report.

<u>Reliability</u>

High reliability ensures that the same answers or results can be obtained if the same research methods under similar conditions are used again (Blomkvist and Hallin, 2015). The methods used should be appropriate for the specific research area and research type (Saunders, Lewis and Thornhill, 2009, p156-157; Blomkvist and Hallin, 2015). In qualitative research, replicability of the methods and results can be difficult and epistemologically counter-

intuitive. Therefore, it is important with consistency in qualitative research (Leung, 2015). According to Wilson (2010), a common issue with the reliability is that a researcher adopts a subjective approach towards the study. To avoid bias, reliable findings needs to be generated from the data gathering and analysis methods. The methods need to be transparent as well (Blomkvist and Hallin, 2015, pp.52-53; Yin, 1994, pp.32-38; Saunders, Lewis and Thornhill, 2009, pp.156-157). To avoid bias during the interviews, open questions were asked to allow more freely spoken answers opposed to questions indicating a right or wrong answer. The interviews were recorded, and the transcription of the interviews were categorized according to the PESTEL framework. When collecting qualitative data, it might be challenging to achieve reliability. The interviewers need a good structure to make sure the interviewees understand the questions. The structure used for interviews in this study is presented in appendix A. Further, the reliability might be affected by transparency in the interviewees answers due to the worry of divulging confidential information (Saunders, Lewis and Thornhill, 2009, pp.156-157).

Validity

Validity entails to study what is intended to be studied. Appropriate choice of methodology to answer the research question, a valid design for the methodology, appropriate analysis of data and valid results and conclusion for the sample of the context are all important for validity in a qualitative research (Leung, 2015). To increase validity, multiple types of independent sources of information were used to enable triangulation (Yin, 1994; Blomkvist and Hallin, 2015). Triangulation refers to the practice of using more than one source of data and method to collect the data. It is used to enhance the credibility of a study to assure validity using several methods to collect data on the same topic to gain more than one perspective on what is being researched (Salkind, 2010).

The different types of sources included semi-structured interviews, literature review, benchmarking and industrial research. Understanding the purpose of different sources was important to gather relevant information. Findings were discussed and analyzed to ensure that they were accurate. The data gathered was critically evaluated with errors and biases considered during the collecting of the data. Together with the use of multiple methods of data collection, the validity of this study was increased. According to Whittemore et al (2001), the concept of validity can be illustrated with the distinction between validity criterions and techniques. The criteria's can be divided into primary and secondary, where the primary criterions are necessary for all qualitative enquiry but not enough on their own. Such criterions include credibility, authenticity, criticality and integrity. Secondary criterions provide more benchmark for quality and are useful for contextual investigations that require evidence of criteria's such as vividness, explicitness, creativity, thoroughness, congruence and sensitivity (Whittemore et al., 2001). Techniques can be used in various ways and combinations to contribute to the validity in qualitative research. Contingent factors for specific situations contribute to the selection of which technique best reflects the validity criteria for the situation. Different types of techniques include *design consideration* (e.g. sampling decisions and triangulation), *data generating* (e.g. articulating data collection decisions), *analytic* (e.g. conducting literature review) and *presentation* (e.g. acknowledge the researcher perspective) (Whittemore et al., 2001).

Ethics

Ethical aspects are important to consider in general and nonetheless in this study to ensure that there is enough integrity between the researcher and the interviewees. To ensure that ethical aspects were followed during this study, the Swedish Research Council's four

principal requirements were taken into consideration. The four requirements include *information, consent, confidentially* and *good use* (Blomkvist and Hallin, 2015). The first requirement entails that the interviewees were informed about the purpose of the study and what the information gathered would be used for. To ensure that the second requirement of consent is fulfilled, the interviewees were asked before the interviews if the interviews could be recorded or not and if the information gathered could be used in this report.

The confidentially requirement have been fulfilled by handling the material collected with care throughout the study. Sensitive information gathered from the interviews were stored solely on the interviewers' phones and computers and not shared with others outside of the study. The interviewees identities have been kept hidden in this report upon request. In appendix A the interviewees with hidden identities are described with their roles and the description of the roles to keep the credibility high. Other interviewees are described with their role and what stakeholder they are working for. The fourth requirement about good use have been fulfilled by using the information gathered solely for the purpose of the study and not being manipulated or taken out of context.

6. Findings

This chapter will present findings from the empirical research including interviews with the aviation industry, environmental politicians and carbon offsetting industry. The findings are divided into three main categories which have been the topics throughout the interviews. These topics are electrified and hybrid aircrafts, sustainable aviation fuels and voluntary carbon offsetting. Each topic is then analyzed using the PESTEL framework.

6.1 Findings regarding electrified aircrafts

Following section include findings regarding electrified and hybrid aircrafts. These are divided into categories using the PESTEL framework.

Political

It is difficult to gain political support to speed up projects for electrified and hybrid aircrafts (R5). The Swedish government has possibilities to support the development of the aviation industry and, especially projects around electrified and hybrid aircrafts (R1). Innovations procurement and financial support for scientific work could be subject where support from governments are usable. A cooperation between governments, universities and firms could have a large positive impact for transport sectors (R1). Since aviation is a relatively low margin industry, it is hard to be a frontrunner for innovations without governmental support (R4).

Nordic Electric Aviation (NEA) is a Nordic cooperation for development of electrified aircrafts and the infrastructure around it (R1; R3; R5). NEA have tried to obtain an agenda for the governments in the Nordic countries which includes plans for the Nordic aviation system and development of electrified aircrafts. Economical support from the Nordic governments could have a large impact regarding technological knowledge for NEA (R1, R5).

A smaller airport like *Bromma airport* would be suitable to experiment and start the services with electrified aircrafts in the future. A political decision to shut down *Bromma airport* in 2038 could possibly harm the development of electrified aircrafts (R4). R6 states that Sweden has 12 airports, which are important to develop and improve for the future. Besides these 12 airports, tax money should go to the development of alternative transports such as trains. The European Union (EU) wants to invest in the European train system to make it more flexible for European train passengers (R6).

Economic

There is a distinct difference regarding operating and maintenance costs of electrified aircrafts compared to jet-driven aircrafts, which implies that electrified aircraft have the potential to be more economically profitable for airlines (R3; R5) as well as being available for regional, shorter routes (R1). Most airlines invest in larger aircrafts for economic profit today. There is not enough room for these aircrafts at the smaller regional airports and they cost too much to operate per chair. Smaller electrified aircrafts that can fly shorter routes will be better suited for regional airports (R3). Due to financial difficulties in parts of the aviation industry, about 40 flight routes in Norway were cancelled earlier this year which are routes that could be suited for electrified aircrafts (R13). Electrified aircrafts can enable new business opportunities between parties with obstacles such as water in between them and no train or road to travel around the obstacle with (R1; R10).

Sweden can benefit from becoming a world-leader in electrified aircrafts and export to other countries (R1; R13). However, according to R13 investing a lot of money in electrified aircrafts might not be optimal because it will take a long time before the technology has developed enough to change the industry to the extent that a lot of stakeholders believe it will.

Electrified aircrafts will be possible in the future. However, creating a business case for all parts of the value chain is complex and the future of electrified aircrafts is challenged by uncertainties (R10). Electrified aircrafts will likely follow the same pathway as for drones regarding business cases. The market of drones has accelerated in recent years due to new battery technologies and new connection possibilities with mobile phones which have created a business case for drones. Large investments will be needed to commercialize electrified aircrafts and it will require a lot of funding. There are a lot of costs associated with production and certification processes. Many projects are not finished in accordance with the timeframe and some projects might fail due to a high cost of delayed processes and lack of funding (R10). Even if the goal of the first certified electrified aircrafts in 2025 for Heart Aerospace is fulfilled, it will take a long time before enough aircrafts are produced for commercial use (R5).
Trains are a good option since they are already run by electricity. However, the construction of rail tracks requires a lot of land as well as material and maintenance are expensive. Every meter of rail track is funded by taxpayers, while every km of a flight is paid for by the passengers. (R1). With an increased awareness about the climate issue, the amount of people travelling with train will likely increase (R6; R11) and trains are better for the climate than flights (R6).

Social
The social acceptance of aircrafts has revolved a lot around noise and with electrified aircrafts, the noise will be significantly reduced (R4). With less noise and emissions, airports can be built closer to the cities. Most people would think it is cool with electrified aircrafts (R4). Although, a fatal accident in the early stages of commercial electrified aircrafts would likely get a lot of attention in the beginning, but most people would probably not think too much about it (R4). People that already have a fear of flying are likely to still be worried about flying after the introduction of electrified aircrafts for commercial use (R4). The train industry in Europe will likely continue to develop and more people will travel by train eventually (R11).

Technological
The aviation industry is constantly evolving and new projects regarding future aircrafts have started. Much of the focus is directed toward electrified aircrafts and to some extend hybrid aircrafts (R1; R4; R13). The technology and maintenance regarding electric engines are not as complex compared to jet motors (R3; R6). However, electrified aircrafts are facing other technological complexities, especially when it comes to battery technology (R6; R13). In order to fly with electrified aircrafts that can be compared to smaller jet-driven aircrafts, the battery capacity needs to be at 500 kW/h. Presently, the battery capacity is far away from that number. If an electrified aircraft should replace a larger jet-driven aircraft, the battery capacity needs to be at 1000 kW/h which will take many years to reach such capacity (R13).

A readjustment regarding infrastructure at airports needs to be made to have commercial electrified aircrafts in service (R1; R3; R4; R8; R12). Projects concerning power supply, energy demands and charging of aircrafts will have to take place in order to be prepared for

the introduction of commercial electrified aircrafts (R1; R3). Although infrastructure needs to be adjusted, aviation has an advantage compared to other transport sectors because there is no need of building transport roads. Infrastructure adjustments occur on airports compared to constructing new rail tracks which takes more time (R4).

The Swedish startup company, *Heart aerospace* plans to have an electrified aircraft certified by 2025 (R1; R3; R5). The technology development for their 19-seated aircraft with a flying range at 300-400 km is at place today (R1; R5). However, new aircrafts are facing long certification processes, hence the technological orbit takes time before it can be used for commercial purpose (R1).

Since a 19-seated electrified aircraft is relatively small compared to a regional jet-driven aircraft in Sweden today, it still needs larger aircrafts to replace todays regional routes. However, electrified aircrafts could change the way passengers are travelling today (R3; R4; R5). The first editions of electrified aircrafts will be small with less noise compared to regular aircrafts. Thus, there is an opportunity for using smaller airports located closer to the cities (R1; R4). This could lead to a new way of flying where shorter routes will be flown via smaller hubs (R1; R5). Shorter and new routes could be used, and a more commute way of travelling could be possible (R3). Sweden has around 200 airports where only about 40 are used for commercial flights today. An opening of airports located closer to cities, could open the opportunity to be used for electrified aircrafts (R1; R3; R4; R5; R10). Around 98 percent of all flights are via the capital cities in the Nordic countries. Electrified aircrafts could create an opportunity to fly directly to the targeted destination (R12). However, this is still speculative, and the flying routines will also depend on how other transport sectors, such as trains evolve (R10; R13).

It is important to look at the technological conditions and where electrified aircrafts could have the most potential to find space in the transport system, which is difficult to speculate about today. Drones have evolved since technological conditions have been in place. Electrified aircrafts will probably have a similar journey from a business perspective as mentioned earlier but also from a technological perspective. However, it becomes very speculate in how long it will take before electrified aircrafts act as a commercial service due to several external factors. (R10)

Planning the air traffic is complexed today and will demand a rearrangement once electrified aircrafts are introduced due to air congestion (R8; R10). Possible new routes created due to flying electrified aircrafts could potentially lead to more air traffic (R10). Once electrified aircrafts are at service for commercial flights, they will be smaller compared to jet-driven aircrafts which means that more flights will be needed to serve the same number of passengers today. This will be difficult to handle from an air traffic perspective (R10).

Airlines might not be interested in replacing one jet-driven aircraft with several electrified aircrafts for those routes that carries a smaller number of passengers per flight (R13). Air traffic is customized for jet-driven aircrafts today. Customizing the air traffic to make room for both jet-driven and electrified aircrafts could potentially be a challenge (R10).
One of Sweden's major contributions to the global aviation industry is to develop technological solutions. Sweden's technological progress does not only create new opportunities of flying in Sweden, but new technologies can also be exported to other countries (R1). Sweden is a relatively small country but could still affect other countries to fly more sustainable by exporting technologies such as electrified aircrafts (R3).

Regarding hybrid aircraft solutions, some skepticism has been raised (R6; R13). Since most of the battery technological demands are critical during the landing and starting phase, hybrid aircrafts will most likely decrease the CO2 emissions compared to regular jet aircrafts (R6). However, it might be more effective to develop Sustainable aviation fuels (SAFs) such as biofuels for larger aircrafts flying longer routes and electrified aircrafts for new and shorter routes (R13).

Environmental

The vision of an aerotropolis where cities and infrastructure are centered around airports is possible with today's technology, but a reduction of noise with 50-60 percent is likely needed for it to become a reality (R1). Electrified aircrafts will significantly reduce noise and emissions from an overall perspective (R1). However, electrified aircrafts will not solve all the problems environmentally when considering the production of batteries (R13).

Legislation

One of the major reasons why the development of electrified aircrafts does not progress faster, is because of the long certification process due to safety of the aircrafts (R1; R3; R5; R12). The aviation industry is highly regulated from a safety perspective. Proof of a high safety factor is needed for aircrafts to be at service which means that it takes time with new technology to be used (R3; R13). The manufactures must prove that safety for electrified aircrafts are as safe as regular aircrafts today (R1). An example is Heart Aerospace which will have their first test flights in 2022. They plan to be certified in 2025 which means that they are counting with a three-year process of certification before they can sell it (R3). Safety around aircrafts is and should be important (R1; R3; R5). Certification processes should be the main prioritization to make sure aircrafts are safe (R5). However, since electrified aircrafts are a new type of product compared to jet-driven aircrafts (R5), regulations concerning certification processes for electrified aircrafts should be adapted for that type of product in order to make the certification processes faster (R13).

Safety issues regarding airports is another factor that comes along with electrified aircrafts. There is an uncertainty about whether it is possible to charge an electrified aircraft next to a regular aircraft with jet fuel tanks (R4). Today, The Network for Nordic Aviation (NEA) investigates standards for charging electrified aircrafts at airports which includes the fire accident risk of charging next to a jet-driven aircraft. Smaller airports are facing some challenges since they have less space to place their aircrafts and distinguish electrified aircrafts from jet-driven ones (R3).

6.1.1 Summary of Findings from electrified aircrafts

In table 2, findings from electrified aircrafts are sorted and summarized into five identified themes.

Opportunities	Challenges	Transitions	Needs	Complexity
Maintenance costs are much less than for traditional jet aircrafts. Sweden can export new technologies to other countries and have an impact on the aircrafts they use. Electrified aircrafts reduce noise and overall CO_2 emissions.	Battery technology needs to improve further to be used for larger electrified aircrafts. Airports need to adjust their infrastructure to serve electrified aircrafts. Certification processes takes a long time due to high safety requirements, which affects the speed of the development. There are safety issues regarding both elect rified- and jet aircrafts operating at the same airports.	Electrified aircrafts can incentive the creation of new business models. Noise reduction can make electrified aircrafts more sociable acceptable than traditional jet aircrafts which may enable construction of airports closer to cities. New, shorter routes and a more frequent flying might be possible with electrified aircrafts.	Governmental support can help speed up the development of electrified aircrafts. Large investments are needed to commercialize electrified aircrafts.	Air traffic will be more crowded with more aircrafts in the air.

Table 2. Summary of findings from electrified aircrafts

6.2 Findings regarding sustainable aviation fuels

This section includes findings regarding the use of sustainable aviation fuel (SAF) in aircrafts. A categorization is made through the PESTEL framework.

<u>Political</u>

The production of biofuels has been growing lately. Countries like USA, Holland, Norway and Sweden have started to produce more over the last couple of years, and the demand is growing as well. There is also an increased interest in Asia to produce more biofuels (R4). However, to expediate the use and production of biofuels, policy instruments needs to be put in place (R3; R4; R9). The main reason why biofuels are not used to a larger extent is because of the high price, which is why policy instruments are needed to regulate the price (R3; R9).

A reduction obligation that will start to apply in 2021 in Sweden with a target to have 30 percent blending of biofuels by 2030 and 100 percent by 2045, will assist the use of more biofuels (R4; R5). Additionally, the reduction obligation observes the entire life cycle analyses of the fuels. This signifies that more biofuels need to be purchased in order to obtain the right amount of CO_2 emissions. The quota obligation existing today only consider the volume of fuel used and not the entire life cycle (R3).

With the reduction obligation, and an increased aviation tax that will soon take place, air ticket prices will likely increase. (R3). There is not a lot of resistance against the aviation taxes in the aviation industry. However, the financial income from the taxes should be used towards the development of a more sustainable aviation industry which is not the case today (R3; R4; R5; R12). The aviation tax that exist in Sweden today, results in a climate gain at

90-180 thousand ton of CO_2 emissions which generates SEK 1.8 billion to the Swedish government. If that money would have gone to using biofuels instead, 200-250-ton CO_2 emission extra could have been reduced (R4). Further, the aviation tax today does not differ from aircraft to aircraft which means that it could be more expensive to fly domestic flights compared to international flights (R3). There is a political opportunity to introduce policy instruments that favor those who fly sustainable and invest in biofuels (R3).

R6 states that the aviation tax should be taxed in the same way as for fuel and diesel in cars. Although, aircrafts differ from cars since they are part of a more multi-international business regarding traffic. With most domestic taxes regulated by each country, the taxes within aviation should be regulated by the EU e.g. (R6)

The production and use of biofuels will most likely increase over time with or without new policy instruments (R4; R5; R9). Recently, an investigator from *Miljöpartiet* proposed a requirement of more blending of biofuels and financial support for production which could possibly increase the speed even more, regarding the use of biofuels (R9). Political decisions will affect the travel habits of passengers in the future (R13). Sweden and Norway do currently have leading roles in political decision regarding regulations and taxes for CO_2 emissions. The future will tell us how it affects the rest of the world and especially Europe (R13).

Economic

Countries with a lot of forest area such as Sweden can profit from biofuel production. There is a lot more energy available than needed for the aviation industry and can therefore be a good industry for export (R12). The main challenge of using more biofuel for aircrafts today is the cost of it (R1; R3; R9; R12; R13), which is a result of lack in production (R4; R12). This causes a Moment 22 where price is high due to limited production. Large investments in production plants are needed and there is no quick turnover in the investment (R4). There have been several biofuel production plant projects that have not been completed due to lack of funding (R4). An increasing demand for biofuel can attract investments in production plants (R1; R4; R12) which people can contribute to through buying an equivalent amount of biofuel for their trip (R1; R4). With a currently high cost of biofuel, an alternative for consumers who cannot afford buying enough biofuel to cover their whole trip, is to buy biofuel for a part of it and carbon offset the rest (R4; R12).

A possible higher price of flight tickets will hopefully result in climate actions such as producing and using greener fuel (R4). More fuel-efficient aircrafts are beneficial both economically and for the environment (R3). The industry has generally been late with the climate issue but have aimed to increase fuel efficiency for a long time due to financial reasons which consequently benefits the climate as well (R4). Focus should be on reducing emissions from an airlines' own business and invest in sustainable aviation fuels. Flight routines will depend on our economic state (R13).

More money should be invested into trains and the same booking options should be available for trains as for flights (R6). In the future, hydrogenated fuels are a possibility but there will be a need for economic incentives to drive the research and development of hydrogenated forward (R13).

Social

People will continue to fly in the future if flights are the fastest way of transportation. With a generation shift to a more climate concerned one, flying on especially shorter distances in e.g. Europe where the train sector has come a long way might decrease (R13). *Flight shame* can create a state of paralysis which will not help solve the problem. It is better to invest in biofuel than not talking about the problem of emissions (R5). Investing in the development of the aviation industry to reduce the emissions is better than stop flying completely, since people will still have to meet in parts of the world that are too far away to travel with train or other types of transport (R12). There is a willingness to pay for biofuel today and many people and firms have invested in biofuels from *Fly Green Fund* without advertising for their organization. When *Fly Green Fund* starts advertising, more people are likely to purchase biofuel (R4).

There is a negative focus in the media on the aviation industry and its emission compared to other parts of the transport sector which does not always reflect emissions per passenger. It is important to start working on solutions and if the media coverage on the progress in developing a more sustainable aviation industry would be more positive, more people would likely be encouraged to take on the challenge. (R4)

Technological

There are technological challenges to making aircrafts more fuel efficient today. An aircraft engine has 30 percent more fuel density compared to cars e.g., which makes it hard to decrease CO_2 emissions with regular jet fuel today (R13). An advantage with biofuels and synthetic fuels from a technological perspective is that the infrastructure at airports and aircraft engines can handle it today (R3; R13). Test flight have been done with 100 percent biofuels with no technical problems (R4; R13). In 2019, 0.1 percent blending of biofuels were mixed in aircrafts flying from Swedavia's airports which includes ten of the largest ones in Sweden. The goal is to have a 5 percent blending within the next few years (R12). Recently, Boeing had a test flight with more biofuel blended than usual which will likely have a positive effect for the use of biofuels (R4). How the use of biofuels will evolve also depends on the development of other transport sectors. If the road transport becomes more electrified, there might be more biofuels left to use for the aviation industry e.g. (R10).

To increase the use of biofuels, the production technology needs to evolve and become more efficient. Today, no one is taking the leading role of the production of biofuels (R5). Sweden uses biofuels to a large extent compared to other countries. However, Sweden could develop their own production instead of buying from USA and Finland which is the case today (R5; R12). ST1 and PREEM are planning to start a production plant in Sweden which will hopefully start in 2022 (R12). Even if the production process evolves in the future, there will probably not be enough biofuel to replace all the regular jet fuel that is being used today (R1; R6). The purpose however is not to replace all jet fuel with biofuels (R1). During the time electrified aircrafts are under development, biofuels will serve as a supplementary qualification to reduce emissions for longer distance flights and regional domestic flights (R1; R3; R5; R6; R9). Additionally, countries like Denmark with less forest compared to Sweden, have the potential to develop other sustainable fuels such as electrochemical fuels (R5). Further, electrochemical fuels have almost no emission and have the potential to grow globally to a high extent (R5).

Another sustainable aviation fuel that could be used as a supplementary qualification to biofuels and electrochemical fuels is hydrogen (R1; R12). However, hydrogen is not as

relevant today as biofuels and electrochemical fuel, but could be a future alternative (R5, R13). The industry has started to look at fuel cells with electric maintenance and jet engines that can handle hydrogen (R13). From an infrastructure perspective there is some complexity regarding hydrogen. To produce a container that keeps all the hydrogen in place is tough today (R13). It is hard to know when it will serve as an aviation fuel (R4) but possibly around 2030-2035 (R13).

Environmental

Sometimes, calculations of emissions per passenger can be deceptive (R1; R3; R4). A route between Stockholm and Visby could arguably be discussed whether flying is a better alternative compared to other transports from an environmental perspective (R3).
Biofuels reduce the CO_2 emissions at the source (R1; R3; R4). If the commodities for biofuel are produced in a sustainable way, there are no negatives to using it (R5; R9). It is difficult to know exactly how much impact biofuels have on the environment and their effect on the high-altitude factor. Biofuels lacks sulfur dioxide which significantly reduces greenhouse gases (R9) and contrails (R3; R4; R5). NASA and the German Aerospace Center (DLR) have conducted studies on the high-altitude factor which have shown that the fuel needs to reduce soot particles with least 50 percent to affect the high-altitude factor (R9). According to R6, biofuels are good for shorter flights that do not reach the height where the high-altitude factor has an effect. However, it still has a negative affect when reaching the high-altitude factor, close to the impact of jet fuel (R6).

There is enough raw material for production of biofuels in Sweden to satisfy the national need (R3; R4; R9) and it can be exported to other countries as well (R4). Import of biofuel from California has an emission reduction of 70-80 percent after the transportation to Sweden (R4). If the production were done in Sweden, the emission reduction would be 90-95 percent (R4). Fossil fuels imported from other countries share the same issue with losses in the transportation (R3).

Airlines such as SAS, BRA and British Airways invest in biofuel and carbon neutral projects (R1; R3; R4). As a passenger, it is better to buy a corresponding amount of biofuel for a flight than carbon offset for it since it reduces the CO_2 emissions from the source and has an immediate impact on the climate (R1; R3; R4; R13). Better to invest in long-term than short term projects in order to make the aviation sector more environmentally friendly (R8; R12). Products that result in negative emissions should be used instead of fuels that are carbon neutral (R6). Biofuels do not solve all problems, but it reduces CO_2 and NOX which affects the climate (R13).

There are prognoses that flying will increase in growing economies, e.g. in Asia and it is therefore important to help them fly more sustainable (R8). If Sweden cannot supply them with enough biofuel, it can make an impact through developing greener technologies and help other parts of the world to fly more sustainable (R4).

Legislation

Regarding biofuels, the raw material needs to go through a certification process to make sure it is produced and used in an environmental favorable way (R1; R4; R5). Since different raw material emits different types of fuels, it is important to make sure that the right raw materials are being used (R5), even if the process takes time (R4). Traceability and transparency are extremely important concerning biofuels. The aviation industry cannot afford debates about whether the fuels are good or not good for the environment (R4). Thus, from a safety

perspective, Sweden would have an advantage of producing its own biofuels instead of buying from USA. *Fly Green Fund* purchase their biofuels from SkyNRG. World Wildlife Fund (WWF) then evaluate the biofuel ordered by *Fly Green Found* and has a veto to decline the purchase if they believe it is not sustainable enough. If the biofuel is not approved, *Fly Green Fund* are not allowed to buy it (R4).
From a technological perspective, 100 percent of biofuels can be used in an aircraft today. However, the certification restrictions allow maximum of 50 percent blending of biofuels (R1; R4; R9). From an environmental perspective, it is important to push towards an allowance of 100 percent blending of biofuels (R9).

6.2.1 Summary of Findings from Sustainable aviation fuels

In table 3, findings from sustainable aviation fuels are sorted and summarized into five identified themes.

Opportunities	Challenges	Transitions	Needs	Complexity
Sweden could gain economic benefits from expanding the production of biofuels. Time efficiency is important when it comes to travel alternatives which is an advantage for air travel. The technology to use 100 percent blending of biofuels and synthetic fuels is in place today. If other transport alternatives become more electrified, more biofuels could be available for aircrafts. Using biofuels reduces emissions of CO_2 and NO_X. To produce and use biofuels from Sweden reduces emissions compared to importing them from other countries. Sweden could supply growing countries with SAFs to guide them to a more sustainable way of flying.	The costs of biofuels today are the major threshold to increase the use of it. Production efficiency of biofuels needs to improve to increase the use of it. Now, the technology is not in place to use Hydrogen as an aviation fuel. Certification of raw material for SAFs is a long process today.	With a better train system, travelers might choose the train for shorter routes instead of flying. SAFs should be a supplementary qualification to electrified aircrafts.	To lower the prices of biofuels and increase the production, policy instruments could be useful. Financial income from air taxes should go to the development of a more sustainable aviation industry. Financial investments to the train sectors could help the development of train systems.	Fuel-efficiency has always been an economical issue. To know the exact reduction of emissions for SAFs is hard to calculate. How biofuels affect the high-altitude factor is uncertain.

Table 3. Summary of findings from sustainable aviation fuels

6.3 Findings regarding voluntary carbon offsetting

This section presents findings regarding voluntary carbon offsetting and are divided into categories using the PESTEL framework.

Political

Clean Development Mechanism (CDM) carbon offsetting projects which are supported by The United Nations (UN) have received some negative criticism lately since they invest in future projects. The additionality, which is the most central part for carbon offsetting, becomes tough when talking about future projects. Furthermore, CDM projects do not always consider people that could be negatively affected by the projects. Gold standard does not only support contemporary projects, but also tries to consider affected people near the projects and must meet at least one of the UN's sustainable development goals (SDGs). (R2)
Another difference between Gold standard and CDM projects is that Gold Standard projects are more transparent. This applies to Verified Carbon Standard (VCS) projects as well where Gold Standard can be described as another layer on top of VCS projects. (R2)

Economic

Carbon offsetting is much cheaper than purchasing biofuel today which creates competition between them (R4). The reason why carbon offsetting is cheaper is because the investment made is just enough to fund the project enough to realize it (R2). Not all carbon offset projects are profitable and some of the projects generate losses because the project owner cannot deliver the required amount and therefore will not receive credits to sell (R11). There is criticism against the industry that some people strive to profit from carbon offsetting (R1; R2; R11).

The cost of carbon offsetting is likely to increase due to a higher demand for it. It is important that the price is high enough to make people feel like their making a difference, but not too high to refrain people from carbon offsetting (R11). Carbon capturing is a good alternative to carbon offsetting, but it is very expensive, and focus should be on making the aviation industry more sustainable (R4).

Social

The decrease of Swedish people flying in recent years is probably because of several different factors such as the weak currency in Sweden, aviation taxes, high fuel costs and warmer weather in Sweden the last few summers (R1; R4). *Flight shame* is likely to have influenced the decrease in flying as well (R1; R3; R4; R5; R8; R11). It has likely served as a catalyst for the adoption of more environmentally conscious mindsets (R5). Increased awareness and concern about the climate issue have likely made people consider their travelling choices more (R1).

The price of carbon offsetting is too low. It is important to change our behavior to make a difference (R5; R6) and a higher price could force that change to happen (R6). Large firms that change their policies and flight behavior can have a large impact (R6). It is important that carbon offsetting projects are certified and legit since poor projects might cause a longer time for people to change their behavior (R5). Today, almost 100 percent of *South Poles* customers are firms (R11) and not individual people. To encourage more individual people to carbon offset, it is important to spread knowledge about it (R11) and clearly communicate where the money goes to (R12). To make the most out of carbon offsetting, projects in developing countries should be invested in, since more of the UN Sustainable Development Goals will benefit from a global perspective (R11). Projects in Sweden are more expensive

and are recommended if one wants to overcompensate. The will to carbon offset have increased in recent years due to fronting of carbon offsetting (R11).

There are two sides of the climate debate. One side includes extreme climate activists who have the opinion of us against the world, while the other side believes that the impact from our actions are to low make a difference. We cannot have such a mindset when considering the climate (R11).

Technological

In order to have a legitime project according to Gold Standard's rules, there are four steps a project needs to go through. The first step is that a project needs to show that the project has climate benefits and reduce emissions in the located area. If it fulfills those requirements, a contract is written in cooperation with Gold Standard. The second step is building and start up the project. The third step includes inspectors from an impartial organization that verify if demands are met according to Gold Standard's rules and check how much fossil fuel is being saved. The amount of fossil fuel saved from the project is correlated with the amount of credits that the projects receive from firms that sponsor Gold Standard projects. The fourth and last step makes sure that the credits received are cancelled after use which implies that the same credit cannot be used again. (R2)

It is common that people believe that money paid for carbon offsetting goes to projects that do not exist, which is often a misunderstanding (R11). Some projects such as wind projects in China can be questioned. But these risks are being minimized and projects that do not serve any climate benefits today, should not be rewarded with credits (R11). Additionally, an impartial third-party verification minimizes the risk of unserious projects.
Future projects will probably involve more forest related projects and focus more on the reduction of emissions instead of just compensation. Since the sea binds more CO_2 than the forest, sea area related projects will receive more attention in the future. Sea related projects, called *Blue Carbon*, are currently something *South Pole* is investigating for future projects. However, new technologies such as Carbon Capture and Storage (CCS) needs to evolve. Today, it is extremely expensive, and it would be a preferable method if it becomes more cost efficient. The technology is available, but no one is willing to pay for it. (R11)

Environmental

87 percent of the electricity worldwide is fossil-based, and it will be a great challenge to redirect the electricity production. A lot of resources and innovation will be needed to decrease the current levels of CO_2 in the atmosphere. (R2)

Carbon offsetting is a good initiative and better than doing nothing (R4; R8). A lot of large emission sources in the world needs to be addressed (R12). It is important to keep track of the whole chain and use the highest degree of certified carbon offset project to demand evidence that the money invested is used for the purpose of carbon offsetting (R1; R4; R12). However, it is more important to invest in the development of a more sustainable aviation industry than carbon offset (R4; R8). Carbon offsetting can be done in eternity without solving the root of the problem (R4). The focus should be on reducing CO_2 emissions and therefore investing in biofuel is a better option (R13).

R6 states that the high-altitude factor can be calculated as carbon equivalents when calculating an amount to carbon offset but not when calculating the impact on the climate. According to scientists who have found the high-altitude factor to be 1.9 historically, the

number should not be used when calculating a flights impact on the climate since each and every flight are different with a lot of different factors contributing to the impact (R4). Therefore, it is wrong of companies to sell twice the amount to carbon offset since the actual amount is uncertain and contrails that are a result of the high-altitude effect only exist for a short amount of time (R4). The high-altitude factor should be acknowledged and considered, but rather calculated as something else than carbon dioxide equivalents (R4).

A lot of carbon offset projects involving renewable energy are done in Asia. Most of them are power plants for wind, water and biomass (R11). Some carbon offset project not only have a positive impact on the climate, but also fulfill other UN SDG's involving human well-being (R11). Projects involving tree plantation can be problematic due to not having an immediate effect on the climate but rather in the future (R4; R11). *South Pole* not only invest in carbon offset projects, but also offer their clients to help improve their climate strategies to make their business more sustainable (R11). Many companies are desperate to show that they are concerned about the climate issue and carbon offsetting is a good way for them to show that they are doing something for the climate (R2).

Legislation

Gold Standard has tightened their criteria's lately, especially on energy efficiency projects (R11). Third party organizations report their sample of tests on projects to the UN. Then the UN has the final word in deciding on credits for the projects (R11). Organizations that support projects want to be as transparent as possible. However, firms that carbon offset have an integrity they want to protect. Thus, it is up to firms to declare their carbon offsetting numbers in order to become more transparent (R11).

Emission allowances and regulations is starting to show results in Europe. CORSIA will probably have a positive effect on emissions in Europe, both in the voluntary and non-voluntary markets (R2). The International Civil Aviation Organization (ICAO) explained that CORSIA is good regarding carbon offsetting. However, ICAO also mentioned that in three years' time, a plan for emission rights needs to be introduced and not only focus on carbon offsetting (R1).

6.3.1 Summary of Findings from carbon offsetting

In table 4, findings from carbon offsetting are sorted and summarized into five identified themes.

Opportunities	Challenges	Transitions	Needs	Complexity
Gold Standard has a good impact on the climate, consider people affected by the projects and must meet at least one of the SDGs. Carbon offset is cheaper than buying biofuels. Due to fronting, carbon offset has increased over the years. Carbon offset is a good initiative for the environment. CORSIA will have a positive effect on the climate when it starts to apply.	Criticism towards carbon offset organizations has been raised since they strive to profit from it. New technology is extremely expensive. Focus should be on emission reduction where some claim that buying biofuel is a better option than carbon offsetting.	Carbon offsetting will likely become more expensive in the future. Future project will include more forest and sea related projects. To become Gold Standard certified as a project, the process includes four steps which will most likely stay the same in the future.	Knowledge dissemination and transparency are important to encourage more people to carbon offset. New methods would be helpful to make technology more cost efficient. Important to use the highest degree of certified projects to show that the money invested goes to carbon offsetting.	Criticism has been raised to CDM for supporting future projects. Transparency is suggested, but there is an integrity issue with companies that carbon offsets.

Table 4. Summary of findings from carbon offsetting

7. Scenario

This chapter presents a scenario for the aviation and carbon offset industries and their development. The scenario is based on the information gathered from the findings which advocates for future development of a sustainable transition within the aviation and carbon offset industries. The findings together with the literature have been analyzed and interpreted by the authors of this study to present a scenario which provide valuable support for answering the research questions for this study. It will start with a description of the current state and then go on to possible future scenarios. With the aviation industry being dynamic where shifts in external factors affecting the industry can cause drastic changes, it is difficult to predict future developments with high certainty. Therefore, the long-term and short-term outlooks interpreted by the authors of this study might not be consistent with reality. Figure 11 illustrate a summary of the present state, short-term outlook, and long-term outlook of the scenario.

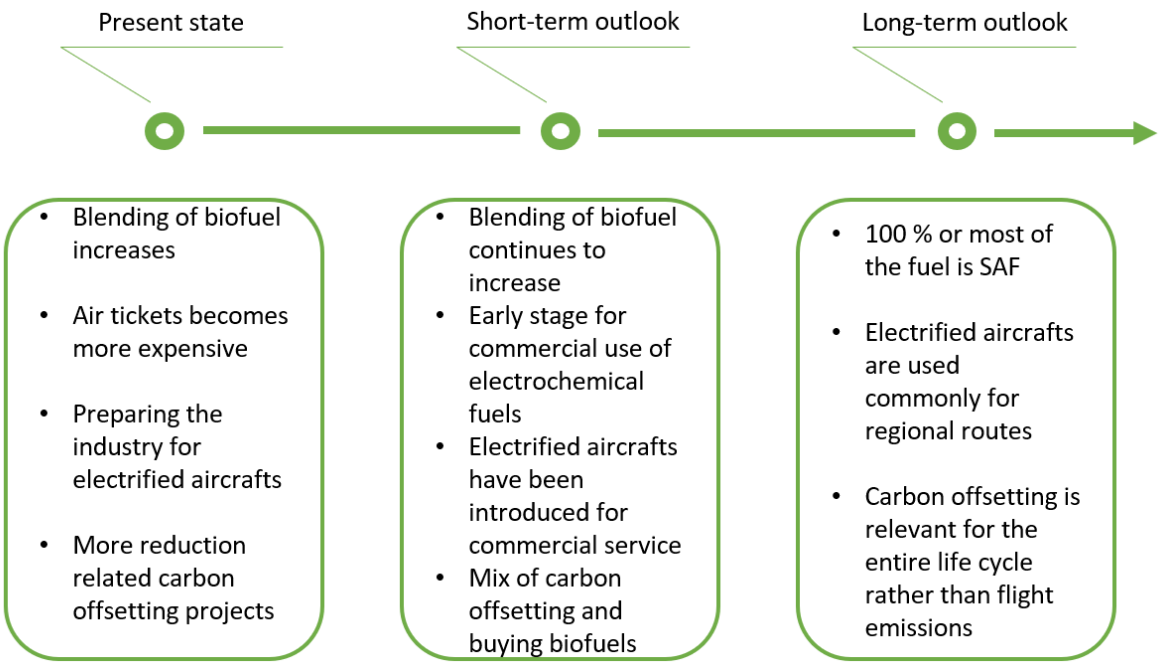

Figure 10. Summary of the scenario for this report.

7.1 Present state

Currently, the aviation industry is operating to have more fuel-efficient engines (IATA, 2020b). One of IATA's main targets is to have a carbon-neutral growth from 2020 and from there, focusing on reduction of CO_2 emissions (IATA, 2020b). Airlines have for a long time strived for better fuel-efficiency due to financial reasons but now it has become an environmental issue as well (R4). The reduction obligation scheme developed by the Swedish government (Svenska Flygbranschen, 2019) will most likely create pressure to use more biofuels for the aircrafts. With the reduction obligation scheme, one of the targets is that aircrafts in Sweden should be able to blend five percent of biofuels by 2025 (Svenska Flygbranschen, 2019). Policy coordination's such as the reduction obligation scheme is important to make sure actions work coherently to make a sustainable systematic change (Meijer and Stead, 2004). In 2019, only 0.1 percent of biofuels were blended in aircrafts at Swedavia's airports (R12) and the main reason why not more blending occur, is because of the high cost (R1; R3; R9; R12; R13). Governmental support to regulate the prices and

support biofuel production in Sweden is therefore needed to increase the use of sustainable fuel alternatives such as biofuels. This is supported by the literature as well which underlines the importance of governmental support to achieve a sustainable transition (Ryszawska, 2016).

With an expected growth of global air transport with 25 percent annually until 2025 (European Union, 2020) and a large amount of annual fuel cost savings (IATA, 2019c), the global aviation industry will be in good condition to finance a more sustainable industry. In Sweden, the air transport has slightly decreased in 2019 compared to 2018 (Swedavia, 2020). According to *Transportstyrelsen*, a steady annual increase of domestic air passengers is expected between 2020-2025. However, it is very hard to predict the future amount of air passengers due to many factors affecting it (R6). One external factor that recently has affected the numbers of air passengers is the COVID-19 pandemic which has led to a significant decrease of air passengers in 2020 (IATA, 2020d). Other factors could depend on the development of other transport sectors such as trains. A better construct train system for travelers in Europe will probably lead to competition between air and train transport in Europe (R6; R11). However, longer routes outside the European boarders will not be affected of a better train system since time efficiency for travelling is still important and will expectedly continue to be in the future (R13). The aviation industry needs to seek for knowledge of how other transport sectors are being developed in order to be flexible for changes and possible new competition from the train industry. This could possibly lead to organizational structure and process changes to stay competitive in the travel business (Callaway and Hong, 2016).

With an obligation to blend more sustainable fuels and an additional proposed flying tax (Lindblad, 2020), price of air tickets will probably become more expensive (R4). Although financial support and political instruments from governments could decrease the price of biofuels, the price of an air ticket will most likely increase due to more use of biofuels (R4). At this stage, it is important that the financial income from flying taxes are used to the development of a more sustainable aviation industry (R3). To gain governmental support, political cooperation and lobbying could be useful to push for sustainable solutions, such as biofuels (Markard et al., 2016).
Globally, electrochemical fuels have good opportunities to be developed and soon, more test plants and manufacturers will most likely start to produce them. However, due to regulations and the early stage of electrochemical fuels (R12), they will probably not be used as fuel for aircrafts in the short run, but more a long-term supplementary qualification to other SAFs such as biofuels (Bergqvist, 2018; R5).

Recently started projects to develop the electrification of aviation such as NEA and ELISE will prepare the industry for electrified aircrafts in the nearest future. The 19-seated electrified aircraft manufactured by *Heart Aerospace* (Heart Aerospace, 2020), will be certified and ready for service in 2025 (R3). Until then, projects such as ELISE and NEA will develop and prepare the infrastructure at the airports to handle electrified aircrafts in the Nordic countries. At this stage, it is important to gain interests from stakeholders and build a business model case to find investments and potential buyers which will be a challenge (R10). Manufacturers and stakeholders need to identify their key recourses and partnerships with airlines, which could be a solution to build strong bonds and gain access to their customer base (Borgogna et al., 2016). Keystones, dominators and niche players needs to work together and understand the importance of all roles in order to have a successful ecosystem for the electrification of aviation (Iansiti and Levien, 2004a).

Soon, a more standardized certification process could be developed in order to make the process faster for electrified aircrafts. However, certification will probably still be a challenge for the development due to safety issues (R3; R13). Geels (2010) explains that regulations and policies could affect the attitude of customers for the first movers, which creates an uncertainty for the investors. However, being a first mover could lead to a market position that gains an advantage over competitors.

The battery capacity needs to evolve during this period to develop and build larger electrified aircrafts. According to Roland Berger (2018) and R13, a 500 Wh/kg battery will not be available until 2025, and to fully replace a jet-driven aircraft with an electrified, at least a 700 Wh/kg battery density is needed (Roland Berger, 2018). Today, *Heart Aerospace's* aircraft has a battery density of 250 Wh/kg (Heart Aerospace, 2020).

Carbon offsetting has become more exoteric over the years (Ecosystem Marketplace, 2018) and will probably continue to do so the coming years. Marketing and knowledge spreading of how carbon offsetting is constructed and how it works will become vital in order to make more people carbon offset their travels (R11). Today, carbon offsetting is relatively cheap and there is a large possibility that the prices will increase soon (R11). How carbon offsetting projects are constructed as of now will most likely not change. Sea related projects could potentially become more attractive and focus on a more effective reduction of CO_2 emissions of the projects (R11). As biofuels become cheaper, purchasing biofuels could be a suitable alternative instead of or together with carbon offsetting in the upcoming years. Today, there is a large price difference between carbon offsetting and purchasing biofuels. Indications show that the price difference will likely decrease within the next few years. As the literature declares, it is complex to calculate the precise environmental impact of biofuels, and especially regarding the high-altitude factor (Åkerman, 2019). In the near future, research regarding the high-altitude factor and biofuels impact will be continued and a better understanding of it will likely be presented, such as the ongoing research from NASA (Sillberg, 2017).

7.2 Short-term outlook

The use of biofuels has increased due to the reduction obligation of 30 percent blending in 2030 (Regeringen, 2020; Naturskyddsföreningen, 2019). Due to technological advancements for production, political incentives to regulate prices (R4; R5; R9) and an increased demand for biofuel, the production efficiency has improved, and prices have decreased. With more use of biofuel due to higher demand and lower prices, the regulation of maximum 50 percent blending in biofuel have likely increased to 100 percent, which is already possible for engines to operate on (R4; R13). Sweden has started their own production of biofuels and are able to export to other countries (R4; R12). Although the price of biofuel has decreased, an increased demand together with new aviation taxes due to the pressure of reaching global emission goals, have resulted in continued increased price of flight tickets (R3). An increase in prices would likely affect the rate of passengers in Sweden, but the number of domestic air passengers are expected to increase according to *Transportstyrelsen* (2019). The global air traffic is also projected to continue to grow at this point (EASA, 2019; European Union, 2020).

According to the literature, to make a transition towards a more sustainable production, changes in all sectors of economy and society are needed (Tukker and Butter, 2007). Changes in policies to promote new ideas and approaches towards existing economical structures can

be helpful for making a sustainable transition (EEA, 2019). Governmental support is essential in the beginning of the process of a sustainable transition due to companies depending on legislative factors that might e.g. delay the development of new technologies (Fisher et al., 2017; Markard et al., 2016). To encounter potential resistance from businesses by interrupting sectors with new policies, environmental costs can be included as a part of production to initiate companies to restructure their economic priorities (Geels, 2010). These are factors that needs to be consider transitioning from jet fuel towards biofuel at this point for a smooth but quick transition.

The demand for other SAFs, such as electrochemical fuels have increased as well (R5). Countries with restricted opportunities to produce biofuel, such as Denmark, have instead started producing and exporting electrochemical fuels (R5). These SAFs are still in an early stage of adoption and will mainly serve as a supplementary qualification to biofuel at the point in time. At this point, there has been progress in the research and development of hydrogen as a potential fuel and substantial investments have been made (R13). Further, hydrogen will potentially start being used as a supplementary qualification for biofuel. Electrified aircrafts have become a reality and *Heart Aerospace* have their first electrified aircraft certified and ready for service (RISE, 2020; Heart Aerospace, 2020). *Zunum* have also introduced their first commercial electrified aircraft ready with a capacity of 12 passengers (Reimers, 2018).

Sweden has been progressive in the development of technologies regarding electrified aircrafts which has enabled opportunities to export new technologies to other countries (R1; R3). The development of electrified aircrafts has been rapid, and it has created a new niche in the aviation industry as its own product rather than compete with regular jet-driven aircrafts (R5). Electrified aircrafts traffic new, shorter flying routes with less passengers (R1; R3). The aircrafts have smaller passenger capacities but are likely to expand in size with the continuous development of technologies. Due to certification process, it will take a long time before larger electrified aircrafts are produced for commercial use. Since electrified aircrafts carry fewer passengers, biofuel and electrochemical fuel will mainly be used for larger, international aircrafts (R1; R3; R5; R6; R9).

For the more trafficked routes, hybrid aircrafts are used as a supplementary qualification to regular jet-driven aircrafts to fly a larger number of passengers. However, hybrid aircrafts are complex and not worth mass producing to replace large jet-driven aircrafts. It has instead created its own niche in the aviation industry, just like electrified aircrafts. Niches are crucial for the ecosystem health and create diversity to the system (Iansiti and Levien, 2004a). Due to a reduction of noise, the social acceptance of electrified aircrafts has enabled construction of new airports as well as the use of already existing airports built closer to the cities (R1; R4). Small regional airports that have previously been closed, might now be opened to serve electrified aircrafts. *Bromma airport* is a good option to serve electrified aircrafts. However, with a political decision to shut down the airport in 2038, electrified aircrafts flying to and from Stockholm would have to fly through *Arlanda airport* if the decision does not change or a new, smaller airport is not built.

Projects such as NEA and ELISE have assisted in standardizing infrastructure for electrified aircrafts at Swedish airports as well as pushed for the development of aircraft technology (NEA, 2020; RISE, 2020), which at this stage have lasted for several years. At this point, these projects might refocus on a more global standardization of electrified aircrafts. New

projects will most likely begin to prepare the global aviation industry for electrified aircrafts. Electrified aircraft technology has come far, but more progress, partnerships and fulfilled objectives are needed to create a successful ecosystem for electrified aircrafts. According to the framework developed by Iansiti and Levien (2004a), the evolution of an ecosystem is influenced by the roles of keystone, niche players and dominators. Hence, value in an ecosystem is co-created by participants (Adner and Kapoor, 2010) which can benefit from partnerships with other actors to make it successful (Borgogna et al., 2016).
The demand for carbon offsetting will continue to increase and therefore also the price (R11). Higher prices for carbon offset will assist in forcing a change in behavior and large environmental conscious firms will change their policies and strategies instead of just carbon offset to make an impact (R5; R6). With an increased price of carbon offsetting and a decreased price of biofuel, more people are going to purchase biofuel for their travel (R4; R12).

Due to the development of rail systems in Europe, flight routes in Europe will continue to compete with European rail routes. Additionally, with a more commercial use of electrified aircrafts for shorter and potential new routes, there might be more competition in domestic routes in Sweden between electrified aircrafts and trains. With a more global, connected world where people travel more, the number of travelers in Europe will be the same. In other parts of the world where developing countries are growing economically, the rate of flight passengers have increased. Due to a more climate concerned generation, trains are used more when travelling shorter routes e.g. in Europe (R13). However, due to time restrictions, aviation is still used more than trains for longer routes. Environmental conscious consumers will choose to travel with train instead of flying when possible since they believe it is less damaging for the environment and they tend to act in a pro-environmental behavior (van Birgelen, et al., 2011).

To attract people from younger generations to choose air travel over trains, marketing is important. A customer's response to a service or product depends on the mental, emotional and behavioral responses (Radu, 2019). Subjective and social norms, as well as the potential outcomes play parts in a behavioral response (LaMorte, 2016). Airlines and travel agencies should therefore reflect the sustainability aspects of biofuel and electrified aircrafts in their marketing. Most Europeans consume sustainably (Bindu, 2013), hence a more sustainable aviation industry would likely have more people opt for flying.

7.3 Long-term outlook

With an increased use of SAFs and electrified aircrafts, carbon emissions will decrease and there will be a 50 percent global reduction of CO_2 emissions by year 2050 compared to 2005 (IATA, 2020b). Sweden have achieved their goal of being fossil free by the year 2045 and use 100 percent sustainable fuel sources (Regeringen, 2020). New policy instruments and obligations have been introduced to eliminate the use of jet-driven fuels at this stage. Biofuels are the most common resource for aircraft fuels at this point. However, to fully replace all jet fuels today, other SAFs are needed as well since there is a risk that there will not be enough biofuels for the Swedish aviation industry (R1; R6). The global demand for other SAFs has increased and a change in regulations have opened to the production of electrochemical fuels in Sweden (Bergqvist, 2018). With an increased rate of air passengers in countries with developing economies, Sweden can impact the aviation industry by offering solutions for more sustainable aviation (R13). Research and development of hydrogen have progressed,

and hydrogen is used as a supplementary qualification for other SAFs (R13). As the literature advocates, to promote a successful transition, it is important that policies include different domains such as economy, environment, climate, innovation etc., which will be needed to fully replace jet-driven fuels to SAF at this point (EEA, 2019).

The price of air tickets has decreased after a period of increased prices. Thanks to lowered prices of biofuels and no longer need for flying taxes since aircrafts have a better environmental impact have resulted in a decrease of air ticket prices at this point.
There are standardizations for certification processes and infrastructure regarding electrified aircrafts, which speeds up the production of more aircrafts (R13). The technology has advanced enough to produce larger aircrafts to replace smaller, regional aircrafts. Electrified aircrafts will be used for flight routes between Nordic countries as well as new domestic routes, not financially suitable for regular jet-driven aircrafts. Due to lower operation and maintenance costs as well as an increased passenger capacity (R3; R5), electrified aircrafts will replace jet-driven aircrafts on some routes. Flight tickets will be lower due to lower costs and electrified aircrafts will therefore compete with trains on longer routes where infrastructure or distance do not favor trains. On shorter routes, trains are used to a larger extent with the development of unified signal systems and high-speed trains. Electrified aircrafts are widely used for regional flying and smaller airports closer to the cities are operating because of it.

At this point, the battery capacity is sufficiently developed to start flying some international routes with electrified aircrafts as well. At this stage, firms like *Heart Aerospace, Pipistrel* and *Zunum* have started to drive the electrification of aviation forward and to stay competitive, it is vital to have an open mind for external ideas. Further, increased multi-technological innovations encourages firms to be involved in a network with other organizations (Narula, 2004). An organizational network becomes important if firms such as *Heart Aerospace* want to stay competitive at this stage and move forward.

With the use of electrified aircrafts and SAFs, GHG emissions are reduced and the need for carbon offsetting has therefore decreased (R4; R8). Carbon offsetting can be useful with compensating emission from the entire lifecycle of production rather than emissions from the flight. If carbon offsetting should focus on the whole life cycle, it is important that there is transparency towards the customers and letting them know why since customers are more willing to carbon offsetting if they have knowledge about it (Lange and Ziegler, 2017).

7.4 Long-term outlook uncertainties

There is a possibility that new policy instruments and obligations have been introduced to eliminate the use of jet-driven fuels by the time Sweden have reached their goal of being fossil free and started using 100 percent sustainable fuel sources. There is a demand from stakeholders in the aviation industry for governmental support to promote sustainable aviation fuels. However, only time will tell whether the Swedish government will implement new policy instruments and obligations to support the use of 100 percent sustainable aviation fuels or not. Hence, there is an uncertainty of future governmental support in the aviation industry. If sufficient support is not provided, the use of 100 percent sustainable aviation fuels will likely not happen and Sweden's goal of being fossil free might not be met with the aviation industry continuing using fossil fuels. External factors can have a large impact on an industry and cause an urgent need for governmental support. In 2020, the French government stipulated an aid package to support *AirFrance-KLM* through the financial crisis following the COVID-19 outbreak (Lindblad, 2020). This example implies that governmental support

can have a large impact on an industry by financially helping an industry giant to survive the impact of a major crisis.

With electrified aircrafts having lower operation costs than regular jet-driven aircrafts, they are likely more financially suitable to traffic flight routes between Nordic countries as well as new domestic routes. What flight routes will be used by electrified aircrafts depends on factors such as the development and adaption of electrified aircrafts, infrastructure and air traffic management opening up the possibility of new flight routes. Shifts in external factors affecting electrified aircrafts could impact potential flight routes in the future. Thus, there is an uncertainty about when and what flight routes electrified aircrafts will traffic in the future. If the production of sustainable aviation fuels and electrified aircrafts has a large environmental impact, carbon offset might still be relevant for offsetting emissions from the entire lifecycle of the fuels rather than just from a flight. However, if the emissions from production instead are low enough to make carbon offsetting irrelevant, there is a possibility that carbon offsetting will not be used for services in the aviation industry in the future.

Air ticket prices will likely decrease if aviation taxes and price of sustainable aviation fuels are reduced. To reduce prices of sustainable aviation fuels, such as biofuels, there is a need for a sufficient production to meet an increased demand. If production does not generate enough supply to meet the demand, sustainable aviation fuel prices are still going to be high as well as air tickets prices because of it. Therefore, one of the factors which future air ticket prices will depend on is the development of sustainable aviation production.

8. Discussion

This chapter presents a discussion of the results of this study. It starts by a discussion of how the scenario was produced together with indications of when the different phases in the scenario will happen. Following, this chapter presents a discussion of actions and strategies that could be necessary in order to develop the transition towards a more sustainable aviation industry. Further, a discussion follows of the development of carbon offsetting and how it can be renewed due to the transition in the aviation industry.

8.1 Years and theory applied on the scenario

The presented scenario is built on a chain of events that are interdependent. This means that if something is changing or turns out to be different than what the scenario presents, it could affect future events as well. For instance, if biofuel blending does not become cheaper over time, the increased use of it might not happen as the scenario presented expects. Additionally, new types of SAFs or technology that are not applicable today might be more relevant in the future which would affect the outcome of the scenario as well. The findings of this report signify the importance of political instruments and financial investments to make the transition happen. Different circumstances such as safety issues with new technologies or material and political decisions which affects the travel habits, could delay the occurring of events. The outbreak of COVID-19 has led to financial difficulties for airlines on a global scale and affected the number of air passengers is another external factor that could potentially affect the occurring events in the presented scenario as well. These external factors could affect the time frame of the events, hence assumptions of specific years for each expected event have been excluded in the presented scenario. However, from the collected data, there are indications for when certain events and goals are planned to occur. Therefore, those points in time can be used as guidelines for estimating when other events are likely to occur. The points in time should be interpreted as guidelines and indicators for the different phases:

- Present state
    - Carbon neutral growth by 2020 is one of IATA's main targets
    - The first certified electrified aircraft in 2020 by *Pipistreel*
    - In 2022, CORSIA will start to apply
    - Reduction duty scheme will start to apply in Sweden in 2021
    - *Zunum* plans to have their first hybrid aircraft ready for service in early 2020's

- Short-term outlook
    - *Heart Aerospace* plans to have their electrified aircraft certified by 2025
    - One of the main targets with the Swedish reduction duty scheme is to have 30 percent blending of biofuels by 2030

- Long-term outlook
    - The Swedish aviation industry strive to be 100 percent fossil free by 2045
    - A globally reduction in net aviation CO_2 emissions of 50 percent by 2050, compared to 2005 levels

Based on the empirical research, the current state of aviation indicated that a trajectory towards a transition for SAFs and electrifications is plausible, but how it should be adopted and in what stages were not mentioned in the data. Therefore, a combination of theories was applied to structure the data and form a scenario. Sustainable transition refers to MLP (Geels,

2006) which can be strongly linked to the diffusion of electrified aircrafts and development of SAFs. The scenario analysis theory provided by Metzger, et al (2010) includes key drivers and steps to follow when a scenario analysis is performed. Therefore, the three stages of the scenario are based on sustainable transition theory, MLP and scenario analysis theory. However, these theories do not consider any specific innovations nor actions that needs to be taken in a certain industry for the events described in the scenario to happen. Therefore, other theories including business model adaption, ecosystem strategy, network innovation, consumer behavior and voluntary carbon offsetting were added into the scenario. The combination of these theories creates a holistic perspective that the individual theories do not provide.

8.2 Future of SAFs and electrified aircrafts

This chapter presents a discussion of possible actions that could be necessary to develop the transition towards a more sustainable aviation industry.

Aviation networks

Sweden has set a goal of blending 30 percent of biofuels in aircrafts before 2030. In 2019, only 0.1 percent blending of biofuels occurred at Arlanda airports and the goal for 2030 seems difficult to reach due to the high price and low demand of biofuels today. Even though the transition towards a more sustainable industry has started, and several stakeholders and organizations are working towards more use of SAFs and electrified aircrafts, a more unified aviation ecosystem could possibly speed up the development. The theory also shows indications that having innovative networks, will assist with faster sustainable transitions. Organizations such as NEA and RISE have recently started projects where one of their tasks is to create a network with different stakeholders, which would likely help the transition towards SAFs and electrified aircrafts. However, other stakeholders that are influential in the aviation industry need to actively be a part of these networks to make the networks more effective as well. Such stakeholders include air travel comparison sites, airlines, aircraft manufacturers e.g.

A question one can ask is: what do these stakeholders gain for being a part in these networks? One of the main targets with industrial dynamics is to promote economic growth and strengthen the competitiveness. Iansiti and Levien (2004a) emphasizes the importance of finding the right roles for those that are involved in networks. An air travel comparison site has the advantage of assisting a purchase for many air travelers searching for an air ticket. Therefore, an air travel comparison site could participate in a network and use their position to market sustainable or environmentally concerning options such as carbon offset and purchasing biofuels, as an addition to booking a flight. Iansiti and Levien (2004a) define roles where dominators, niche players and keystones are defined. It is important that stakeholders find roles where they can see potential economic growth and can strengthen the competitiveness when networks are created or renewed.

This could potentially involve a network where niche players include aircraft manufacturers or battery developers specialized in technology development. Keystones could include organizations such as RISE or NEA who creates a stable platform and connect participants in the ecosystem with each other (Iansiti and Levien, 2004a). Air travel comparison sites and airlines could adapt a dominator position due to their unique position to influence both stakeholders and customers. There is a risk that a growing presence of dominators can result in elimination of niche players over time. Aircraft and battery development are an important

part of the transition towards a more sustainable aviation industry; hence it is important to prevent the elimination of niche players from the ecosystem.

Preparation for new technology

Regarding electrified aircrafts, the findings show different opinions about when and how they will be used for commercial purpose. Most of the interviewed respondents believe that electrified aircrafts will be introduced in the future and several projects indicates that it will become a reality in the coming years. The main uncertainty from the findings is not if but rather when electrified aircrafts are going to be used for commercialized service. Some believe that *Heart Aerospace* will have their aircraft ready by 2025, which is in accordance with their own plan. However, others believe that it will take longer time before they are used for commercial air routes. Test flights have shown a large decrease of maintenance costs compared to regular aircrafts.

Following the development of an innovation through a multi-level perspective, electrified aircrafts will be defined as a niche in the beginning. Electrified aircrafts have the potential to take an important role for a long-term solution regarding sustainability in the aviation industry and make carbon offsetting obsolete by eliminating direct emissions from flights. Niches are less developed and far from market readiness compared to other roles in the multi-level perspective. Electrified aircrafts could potentially replace regular aircrafts in the future which would entail reaching emission goals more realistic. There is already support from some actors at the regime level of the multi-level perspective such as airlines and aircraft manufacturer to drive the development of electrified aircrafts forward, and continued support will be necessary to realize the goal of commercialized electrified aircrafts in the future. Some interviewees believe that they will not compete with existing air routes today but rather add new, shorter ones. For a country such as Sweden where distances between cities are relatively far, electrified aircrafts could be useful to travel with. Electrified aircrafts could potentially change the way people are travelling in the future where shorter distances are flown between airports built closer to the cities due to aircraft noise being heavily reduced.

How this can be related to multi-level perspective can be seen in multiple ways depending on how it is being interpreted. Travel preferences can be considered a part of the regime level, where the culture of more responsible consumption is on the rise in Sweden. More people are becoming environmentally conscious in their consumption habits and the demand for more sustainable flights will likely increase in the future. An important part of the regime level are the airlines themselves. They influence technological development through demand towards suppliers in the industry such as aircraft manufacturers. Therefore, airlines have a valuable opportunity to support the development of electrified aircrafts. Factors such as cost for the airlines and meeting travel preferences of the customers contributes to the decision of supporting a technological development or not. Hence, pressure from the landscape level such as climate change awareness might affect travel preferences further and push for airlines to provide more sustainable travel options, creating space for niches such as electrified aircraft manufacturers to provide airlines with these solutions.

Once electrified aircrafts are introduced, it is important that the infrastructure is at place. Airports are going require a functioning charging structure to handle electrified aircrafts. This correlates with the business model adaption theory which states that an important element to a successful business model is key resources such as facilities and channels. Firms that own electrified aircrafts need to find a successful business model in order to receive necessary financial investments to realize the commercialization of electrified aircrafts. One major

advantage with electrified aircrafts is that the maintenance costs of flying decreases with about 70 percent compared to regular aircrafts. Hence, there is a value for airlines to purchase electrified aircrafts. Additionally, since there is close to zero emissions when flying electrified aircraft, the customer value of flying environmentally friendly is high which is another key element of a successful business model. However, the empirical research indicates that it will be challenging and take time to find a successful business model for electrified aircrafts. One of the reasons is that there is no advantage to buy a plane that has a range of around 400 kilometers and a capacity of 19 passengers when a regular, short flight route requires more.

To speed up the development of electrified aircrafts, a successful strategic network would be necessary. The theory describes three steps where collaboration is evaluated in order to have a successful network management. For electrified aircrafts, many different aspects need to be considered such as batteries, charging of electricity, airlines, manufacturing, airports, safety issues etc. Having a successful network management with collaborations between different experts in all needed areas would therefore be a key element in order to commercialize electrified aircrafts as soon as possible. Creating a network requires someone to take a first initiative, which can be challenging if no one does it. Therefore, an alternative is for existing network organizations to bring along new partners. Many organizations tend to develop existing knowledge instead of exploring new resources. It is valuable to understand the importance of the different roles in a network and what knowledge they can contribute with. Potential partners could be convinced to take part of a network if they are aware of how their role is important to the organization and how their expertise knowledge will contribute to purpose of the network.

<u>Lobbying for political support</u>
The theory from industrial dynamics emphasize the importance of policy coordination and integration for a systematic change to happen. Policy instruments such as CORSIA and the Swedish reduction obligation are policies that will decrease the use of fossil fuels and increase the use of SAFs. However, the implementation of these may be pushed forward due to the outbreak of COVID-19. This delay could potentially make it more difficult to reach the emission goals in the coming years. At the same time, governmental support could help reach the goals in time. As mentioned earlier in the report, the French government offered financial support to *AirFrance-KLM* to survive the effects of COVID-19 where two of the conditions where to decrease their emissions and increase their use of SAFs. Since the air traffic of commercial aircrafts currently are low due to the COVID-19 pandemic, there is an opportunity for airlines to focus on flying more sustainable once the air traffic return to normal. However, the difficult financial situation for most of the airlines due to a substantial decrease in traffic could make investments on flying more sustainable a challenge for airlines. Political support was already needed before COVID-19 but will be critical for airlines now after the pandemic.

The empirical research indicates the importance of political support to increase the use of SAFs and speed up the development of electrified aircrafts. For a systematic change and a transition to happen in an industry, the theory also emphasizes the importance of political support. However, new regulations and rules could interrupt with already defined processes and established industry systems (EEA, 2019). This is a challenge where the governments could face resistance. An example is when the Swedish government introduced the existing flying tax which faced resistance both from the aviation industry and air travelers. For the aviation industry, it will be important to influence governments to make decision that

promotes the development of a more sustainable industry. Flight taxes result in a higher price which leads to less passengers flying, but the financial income from the taxes are not used towards supporting sustainable solutions for the aviation industry. To stop flying completely is not reasonable and will most likely not happen since there will be a future need for people travelling to countries where train or road transports are not time-efficient enough. Therefore, it is better for governments to support the development of a more sustainable aviation industry to reduce its emissions and decrease its impact on the climate.

The scenario of this study predicts an increase of air ticket prices in both the present state and in the short-term outlook due to an increased use of biofuels. This affects travelling firms such as air travel comparison sites and airlines since passengers can see the price of a ticket on their sites. Even though the price of an air ticket is likely to increase with more blended biofuels, *flight shame* and debates concerning people's environmental impact when flying could possibly wane. An increased price of flights tickets could potentially result in some passengers choosing not to fly. However, with reduced emissions and an improved climate impact, it could also have the opposite effect and attract more environmental conscious people to flying. The findings suggest policy instruments and financial support from the governments as actions to regulate the price of biofuels. This seems logic since the national governments together with international organizations such as EU have set up targets of a fossil free industry in the future.

When it comes to sustainable innovations, stakeholders and organizations can lobby and be politically active to influence the government to offer political support. The theory states that strategic political networks to push for sustainable technologies have an advantage compared to technologies where sustainability is not prioritized. Lobbying to gain governmental support for more sustainable solutions such as SAFs and electrified aircrafts could therefore have an impact on the transition towards a more sustainable industry. This could mean that an air travel comparison site lobbying for taxes paid by air travelers to be used to increase the use of biofuels or develop electrified aircrafts. It could also be lobbying for financial support for research and development regarding sustainable solutions within the aviation industry. Lobbying for political support could shift the focus from what the aviation industry can do itself to become more sustainable and include political support in its progress of a sustainable transition. If lobbying fails, one can argue that time has been wasted for nothing. On the other hand, the Swedish government has a goal of becoming a fossil free country by 2045. Thus, to have a fossil free aviation industry by then would likely be of high interest for the government. Therefore, lobbying for a more sustainable aviation industry could be useful for a sustainable transition to happen.

8.3 Future of carbon offsetting

This chapter presents a discussion of how carbon offsetting can be developed to increase the use of it and how it can evolve due to a sustainable transition in the aviation industry.

<u>Carbon offsetting versus biofuels</u>

How the future of the carbon offsetting industry will relate to aviation is interesting due to the transition of new solutions in the aviation industry. Today, carbon offsetting is arguably relevant when flying because of the high amount of CO_2 emissions from aircrafts. However, when more SAFs are blended and electrified aircrafts are introduced, CO_2 emissions will most likely decrease and eventually, be close to none. Thus, carbon offsetting becomes more irrelevant over time. From the empirical research, some believe that it is preferable to offer the option to purchase biofuel for customers instead of/or together with offering carbon

offsetting when booking an air ticket through an air travel comparison site or other booking sites. Although there is a steep price difference between purchasing biofuels and carbon offsetting, some believe that purchasing biofuels is more effective from an environmental perspective and helps the sustainability development for the aviation industry. It can also be argued that it is easier for the customers to understand where the money goes to when purchasing biofuels since it directly replaces fossil fuel used for the flight instead of supporting carbon offsetting projects across the world that customers have limited knowledge about.

The will amongst customers to carbon offset today is relatively low. However, offering a very small percentage of replacement of biofuels instead of carbon offsetting for the flight with 100 percent for the same price, could decrease the already low willingness amongst customers. To carbon offset 100 percent of emissions from a flight is within a price range most customers can afford today whereas purchasing biofuels is much more expensive. Thus, carbon offsetting seems to be the most reasonable option for customers today from an environmental perspective.

Transparency and marketing

Regardless if solely carbon offsetting is offered or together with biofuels as well, customers need to buy the offered services to make them useful. This study show that transparency and knowledge of a product or service is important make it successful, which might be easier with offering biofuels instead of carbon offsetting. The theory emphasizes importance of innovative marketing to be successful with a product or service (Farooq, 2019). Additionally, the theory also emphasize that more people are willing to carbon offset if they have knowledge about it (Kim, Yun and Lee, 2014). This is consistent with the findings which also emphasizes the importance of transparency and marketing to make carbon offsetting more exoteric. The consumer wants to know where the money used for carbon offsetting goes to and what impact it has. The fact that carbon offsetting is relatively cheap could be an advantage to get more customers to carbon offset. However, the empirical research states that it is almost too cheap for customers to believe that it will have any significant effect. This results in some customers choosing not to carbon offset because they believe that it will not make a difference. Those that are offering carbon offsetting alternatives such as air travel comparison sites and airlines could therefore use marketing with transparency of the environmental impact that carbon offsetting has.

If stakeholders within the travelling business site choose to market and be more transparent with their carbon offsetting alternatives, customers would likely buy more of it. However, to market a service or a product leads to financial costs. Why should firms from the travelling business put financial resources on something that most customers do not want to buy? One can argue that they might not gain any financial profit of it. On the other hand, both the empirical research and theory shows that carbon offsetting becomes more exoteric if it is fronted more. Additionally, potential customers who chooses to take alternative transports or do not travel long distances where flying is the only reasonable option, might change their mind if they have an option to carbon offset their flights.

Debates and uncertainties regarding carbon offsetting

Carbon offsetting has been a subject with two sides of opinions. One side believes that it is the best alternative today as a traveler to reduce emissions besides from not flying at all. The other side is questionable about the environmental impact of carbon offsetting. One of the reasons for being questionable could be that by having carbon offsetting as an alternative,

travelers will not change their flying habits since they have compensated for the emissions from a flight through carbon offsetting, even though the amount of emissions from the flight will remain the same regardless of carbon offsetting. In other words, those that do not consider carbon offsetting as a positive thing might see it as an escape to continue with the same behavior regarding emissions. Carbon offsetting is likely not the best solution for the future with a transition towards a sustainable aviation industry, but it is the best solution for an air traveler today for a reasonable price.

One of the reasons why this report does not present any numbers of the price different between 100 percent biofuel replacement versus 100 percent carbon offsetting of a flight route is because of the uncertainty of how to calculate emissions from a flight. One of the major uncertainty factors regarding calculation of emissions is the high-altitude factor. As mentioned in the theory, the RFI differs between 1-2.7 which is a large difference. This leads to an uncertainty of how much carbon offsetting is needed to compensate for a flight. Further, the environmental impact of biofuels regarding the high-altitude is uncertain as well. The findings show different opinions where some believe that it does not affect at all while others think that it has the same effect as fossil fuels. Studies from NASA showed that air pollution is reduced with 50-70 % with biofuels compared to fossil fuels. Either way, it is hard to know if the environmental impact of the high-altitude factor will come to a unified conclusion. If networks are created where different stakeholders are in cooperation to increase the use of carbon offsetting; agreements, or conformity about the environmental impact of the high-altitude factor is important to strengthen the transparency and minimize confusions towards customers.

Development of carbon offsetting

The empirical research for this study indicates that carbon offsetting will work the same way in the future as of now. A few differences could be that it becomes more expensive and focus more on sea related projects. Thus, one can argue that there is no need for a renewal of carbon offsetting in the future. Even though, the aviation industry is currently developing solutions to become more sustainable, carbon offsetting will most likely stay the same during this transition from the perspective of an air traveler or traveling business. Since most of carbon offset projects are in Asia, a future scenario of a renewal of carbon offsetting could be that projects are focusing on increasing the use of biofuels or other SAF alternatives for aircrafts in Asia. Studies show that Asia is one of the areas where air passengers will increase the most in the next coming years. Hence, it is vital that sustainable solutions for the aviation industry also reaches this part of the world. This would help the global aviation industry to become more sustainable, but it does not necessarily mean that it is the most climate effective way to reduce total global emissions.

It will not be possible to completely reduce the gross emissions of aviation until electrified aircrafts can replace the regular jet-aircrafts in use today. Since electrified aircrafts are far from replacing jet-aircrafts, the current best options to reduce net emissions are by using SAFs and carbon offsetting. With the much cheaper price of carbon offsetting compared to the use of SAFs, more customers can use the former option when purchasing an air ticket. Hence for the future, carbon offsetting should focus on projects which reduces the most amount of emissions. This could help air travel comparison sites, airlines e.g. from an environmental perspective as well if they offer carbon offsetting since it becomes the most climate beneficial option for travelers who decides to carbon offset.

9. Conclusion

This chapter will present conclusions as associated actions derived from the previous sections. The presented actions derived from this study includes establish networks, lobbying and marketing in order to develop a more sustainable aviation industry. Further, the conclusions include a proposition of how carbon offsetting can be renewed and evolve in the future.

Establish networks

This study shows that electrified aircrafts will be introduced in the near future and SAFs will likely become more established in the industry. However, there are uncertainties of how and when the use of these solutions will take place. A development of already existing networks and establishment of new networks will add knowledge and expertise that can influence the transition towards a more sustainable aviation industry. Capabilities and knowledge these networks would consist of could be used to collectively propose regulatory changes. They could provide customers with knowledge to make carbon offsetting more attractive to increase the use of it. Established networks could provide strength and legitimacy since all key areas of the industry would be included and taken into consideration. These networks should include stakeholders with different roles and expertise to be as influential as possible. There should be a clear and defined role for all participants to make it effective as well as having a joint vision of creating a more sustainable aviation industry. An established network can prepare the industry for new solutions such as electrified aircrafts where the infrastructure needs to be in place as well as a defined business model adaption before it is used for commercial purpose.

Lobbying

The findings of this study show that different stakeholders and organizations share the opinion that there are not enough governmental policies and political instruments ready to speed up the transition towards a more sustainable aviation industry. Regulations and policies regarding biofuels will be set up in the near future, but there are so far only speculations and no concrete proposals of how to lower the price of them. Further, the electrification of aviation is lagging compared to other transport sectors and it is still uncertain how its development will progress in the future.

This study highlights that there is a need to evaluate previously decided regulations and legislative processes to enable and facilitate new technology. There are smaller initiatives on national levels but there is a lack of a mutual line on an international level to lobby for common aims. The aviation industry is at an early stage for sustainable technology such as SAFs and electrified aircrafts which makes governmental support especially critical to make a transition happen.

Marketing

With global warming and climate issues being relevant topics today, a lot of people are environmentally concerned. The subjective norms of how others perceive a specific behavior, would likely encourage people to opt for carbon offsetting due to not only the environmental benefits but social benefits as well. This study highlights the importance of transparency and knowledge spreading to the customers to increase the use of carbon offsetting. Thus, marketing of carbon offsetting today and purchasing biofuel in the future will be important to make it more exoteric. This will be recommended, especially for stakeholders with close customer relationships such as air travel comparison sites and airlines. It will be necessary to

have a transparent, trustworthy and consistent marketing of carbon offsetting, biofuels or electrified aircrafts to increase the use of them.

Carbon offsetting today and purchasing biofuels in the future

Due to the steep price difference between carbon offsetting and biofuels, carbon offsetting is the best option to compensate for emissions from a flight today. Carbon offsetting projects do not have to change because of new technology or fuel alternatives within the aviation industry, but rather be replaced or mixed together with the option to purchase biofuels on air ticket booking sites once the prices are more equal. As a system, carbon offsetting projects should be located where they benefit the climate most and renewed with a continuous improvement of climate effectiveness.

10. Managerial implications and recommendations

Following recommendations aims to provide an air travel comparison site with actions to contribute to the development of a more sustainable aviation industry. The proposition demands an air travel comparison site to allocate recourses and develop their knowledge capabilities to drive the transition forward. Knowledge capabilities regarding regulations, policy advising, innovation, sustainability marketing and research needs to be included to create an overviewing expertise of different areas. On a regular basis, contact with stakeholders in the aviation industry and meetings needs to be performed where an air travel comparison site can act as a mediator between different stakeholders within the industry and air travelers.

10.1 Short-term recommendations

To support a transition towards an increased demand for carbon offsetting, an air travel comparison site can offer customers the option to carbon offset when booking a flight. Since the prices of biofuels are high as of today, purchasing biofuel to cover for a full trip is expensive and most people are likely not going to opt for it. Therefore, a combination of carbon offset and biofuel can be offered as an option when the price of biofuels are able to match the price of carbon offsetting. In order to offer an alternative compensation through a combination of carbon offset and biofuel, knowledge about the development of the industry is necessary. The knowledge can be generated from networks and partnerships with organizations and stakeholders within the aviation industry to understand how the industry evolves and how options for carbon offset and biofuel are impacted.

To contribute to the transition towards a more sustainable industry, we believe that supporting organizations and firms working with sustainable solutions is vital. An air travel comparison site can support through partnerships with such organizations or through investing in their projects. Supporting sustainable solutions will not only help steer the industry in a sustainable direction but can also be valuable for an air travel comparison site from a marketing perspective. An air travel comparison site has close relationship with customers and are well known amongst travelers. Thus, an air travel comparison site can act as the bridge between networks and air travelers to spread the knowledge of sustainable solutions within the aviation industry.

When it comes to lobbying for political support within the aviation industry, an air travel comparison site could lobby together with the established national network, towards agencies within aviation such as EASA, EU commission and the Swedish government to develop instruments, standards and regulation processes for the aviation industry. With high prices of biofuels coupled with the Swedish aviation tax and an increased price of an air ticket if carbon offset is added, there is an economic incentive to make aviation more sustainable. This is an area where an air travel comparison site can utilize their influential power to raise the question in a governmental context.

10.2 Long-term recommendations

Long-term recommendations for an air travel comparison site is to continue develop and adapt current propositions. To have a relevant and up-to-date network will be important to market and lobbying the most relevant subjects regarding sustainability. To have the right knowledge capabilities regarding what new technologies will be introduced in the future can be vital in order to have an up-to-date carbon offset and/or biofuel alternative. In a long-term sight, biofuels and electrified aircrafts are likely commercially adopted which affects the

carbon offset alternative regarding calculating the emissions for a certain air route flown by airlines. Thus, it is necessary for an air travel comparison site to stay updated about the latest research and knowledge expertise in order to have a current and correct carbon offset alternative. For instance, biofuels might be the main fuel used for aviation in the future which will lead to the carbon offset alternative used today being irrelevant. Emissions regarding the entire life cycle of biofuels might then be more relevant at that point or an alternative for customers to support the production of biofuels to produce more of it to an affordable price.

10.3 Future research and limitations

This study has investigated necessary actions to develop a more sustainable aviation industry and how carbon offsetting alternatives for customers could be adapted due to new aviation technology in the future. The findings provide implications for how the aviation technology and carbon offsetting industry could develop in order to become more sustainable. The research included both a theoretical and an empirical research consisting of interviews and secondary data collection. The study contributed with implications as to how an air travel comparison sites can participate and create value in the development of aviation and carbon offsetting. However, there is a gap of data collection from airlines and politicians. If interviews with airlines and more politicians were conducted, the study would have a higher validity and the findings could have turned out differently. Additionally, interviews were conducted before the outbreak of SARS-CoV-2. The result might have been different if the interviews were conducted after the outbreak of the virus. Further, the applicability of the implications might be limited in an international setting as the study is focused on Swedish actors in a Swedish context.

For future research, it would be beneficial to study airlines and a broader context of politicians' perspective to achieve a more accurate answer on how the aviation and carbon offsetting industries will develop over the years. Further, a more international perspective could be studied to compare the Swedish and international actors. In this study, a scenario analysis was performed. However, for future research, political decisions, external factors, and new science that affects the development of the aviation and carbon offset industries could be analyzed to update and evaluate the scenario analysis. Additionally, a case study of how airlines are prepared for future technology could be useful to further investigate necessary actions for the aviation industry.

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Appendix A: The interview protocol

The interview protocol is us as a foundation to the semi-structured interviews, where the purpose was to investigate the future of aviation, transition towards a more sustainable industry and, how carbon offsetting could be adapted today and in the future.

Allmänt:
Vad är din roll i företaget och vad gör ni inom flygindustrin?

Hållbarhet:
Vad arbetar flygindustrin främst med när det kommer till hållbarhet idag?

Vilka utmaningar/hinder finns det för flygindustrin just nu gällande hållbarhet?

Hur jobbar ni med hållbarhet?

Vad anser ni behöver arbetas mer med för att få en mer hållbar flygindustri?

Finns det någon del av hållbarhetsutvecklingen som ni tycker det läggs för mycket fokus på respektive för lite fokus på?

Vilka faktorer ska man ta hänsyn till när man ska beräkna utsläpp från flygplan?

Biodrivmedelbränsle/SAF:
Hur ser du på användningen av biobränsle/SAF för flygningar?

Vad är för och nackdelar med användning av biobränsle/SAF?

Vad är utmaningen för att flyg ska kunna använda mer utav biobränsle/SAF?

Elektrifierade flygplan:
Vad har du för tankar/åsikter kring elektrifierade flyg?

Hur tror du att marknaden för elektrifierade flyg kommer att utvecklas inom närmsta framtiden?

Vad är den största utmaningen för att elektrifierade flyg ska börja användas?

Framtiden:
Förutom användning av biobränsle och introduktion av elektrifierade flyg, kommer det finnas andra alternativ som kommer användas för en mer hållbar flygning?

Hur tror du flygindustrin kommer att se ut i framtiden, framför allt kommersiellt flygande?

Sociala aspekter:
Hur påverkar sociala aspekter er organisation och industrin (tex klimatångest, flygskam etc.)?

Hur ska man få resenärer och konsumenter till att få en positivare bild av flygindustrin ur ett miljöperspektiv?

Hur anser du att synen på flygindustrin har förändrats den senaste tiden och hur kommer den utvecklas tror du?

Klimatkompensation:
Vad är era allmänna tankar kring klimatkompensation?

Vilka typer av projekt går kompenseringen till hos er(klimatkompenseringsföretag)?

Anser ni att klimatkompensation är ett bra sätt att ta itu med miljöfrågan?

Tror du att klimatkompensering kommer fungera på samma sätt inom den närmsta tiden/åren eller kommer det förändras/ersättas på något sätt?

Hur ska man få fler att välja att klimatkompensera sina resor?

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