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Preparing for Compliance

Exploring ReFuelEU Aviation Challenges and Opportunities from the Perspective of Icelandair and Stakeholders

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Abstract

The upcoming implementation of the ReFuelEU Aviation Initiative presents both challenges and opportunities for the European aviation sector. Starting January 2025, the EU's aviation fuel mix must include at least 2% Sustainable Aviation Fuel (SAF), leading to higher operating costs for airlines due to SAF's higher price than fossil kerosene. Additionally, the entire fuel supply chain will need to adapt, marking a significant step in the sustainable transition of European aviation. This study examines the impact of the EU SAF mandate on Icelandair, an airline operating at the edge of the European Economic Area (EEA), and its strategic stakeholders. Following a qualitative research approach centred on a single case study, the study combines interviews with practitioners and document analysis to provide a detailed perspective on the implementation of the mandate in Iceland and a broader view of the European aviation industry's preparations for this transformation. The results reveal a great uncertainty surrounding all parties involved. This uncertainty stems from the widespread ambiguity in the current implementation of the Regulation and the possibility that radically different scenarios could unfold, leading to opposing consequences, primarily for airlines. Carriers such as Icelandair could strengthen their competitive advantage at the expense of their environmental strategy if the flexibility mechanism established under ReFuelEU is implemented without any supporting measures. Contrarily, their competitiveness on transatlantic routes could be severely threatened if the EU mandate is implemented homogeneously across the EEA. In conclusion, to cope with the uncertainty that marks this preparatory phase of the mandate and to be prepared when the SAF is finally distributed across the EEA, airlines should take a proactive role in tackling climate change and seek to collaborate with strategic stakeholders to ensure alignment with the increasingly complex environmental policy landscape and the pursuit of their sustainability goals. Finally, there is a widespread consensus among stakeholders on the mandate's necessity and effectiveness in reducing environmental impact, alongside a call for a stronger policy mix to prevent loss of competitiveness.

Keywords: Sustainable Aviation Fuel (SAF), ReFuelEU, Icelandair, Sustainable Aviation, Policy Implementation, Climate Change

Executive Summary

Problem Definition

The imminent implementation of the EU SAF mandate for sustainable aviation fuel (SAF) introduces a fundamental policy instrument to reduce the aviation industry's reliance on fossil fuels. However, the mandate presents significant economic and operational challenges for various stakeholders in the SAF supply chain, including airlines, airports, passengers, fuel producers, and suppliers. SAF is considerably more expensive than traditional jet fuel, costing nearly 2.5 times more, which could adversely affect the competitiveness of EU-based airlines.

Academic research has explored various types of SAF, their potential to enhance aviation sustainability, and the technical and financial challenges in achieving the production rates needed to reduce aviation GHG emissions. However, there is a literature gap in understanding how individual airlines, particularly those with unique operational environments like Icelandair, will be impacted by and adapt to these new environmental policies. Icelandair faces distinctive challenges due to its strategic location and operational constraints, making its adaptation to the SAF mandate a critical case study in the broader transition towards sustainable aviation.

Aim and Research Questions

This thesis examines the challenges and opportunities for Icelandair, the Icelandic flag carrier, and its stakeholders in light of ReFuelEU and the EU SAF mandate starting in 2025. It focuses on the economic impact of higher SAF costs, potential loss of competitiveness, regulatory uncertainties, limited SAF production, and supply chain complexities. The study also analyses Icelandair's adaptation strategies and stakeholder perceptions of the SAF mandate, providing insights into the broader transition to sustainable aviation fuels in the EU.

The thesis' research aim is addressed through the following research questions (RQs):

- **RQ1**: How is Regulation (EU) 2023/2405 introducing the EU SAF mandate affecting the resources and strategy management of Icelandair?

- **RQ2:** How do Icelandair's key stakeholders (e.g. fuel and SAF producers, Institutions, other airlines, OEMs…) perceive the upcoming EU SAF mandate, and what strategies and approaches are they adopting to prepare for compliance?

Research Design

This study employs a qualitative, exploratory single case study approach to analyse the impact of the EU SAF mandate on Icelandair and its stakeholders, adopting a constructivist worldview that emphasises diverse stakeholder perceptions within the SAF supply chain. The qualitative approach is deemed suitable due to the new and undefined landscape of the SAF mandate. A tri-fold approach to data collection was employed to ensure the robustness, validity, and reliability of the data. Thus, data collection entangled a stakeholder analysis to identify key players, semi-structured interviews to gather in-depth insights from industry and regulatory perspectives, and document analysis to provide additional context and validate findings through triangulation. The data were inductively and deductively coded using NVivo and systematically analysed to identify transversal themes and concepts, following Creswell and Creswell's (2018) recommended steps for qualitative data analysis.

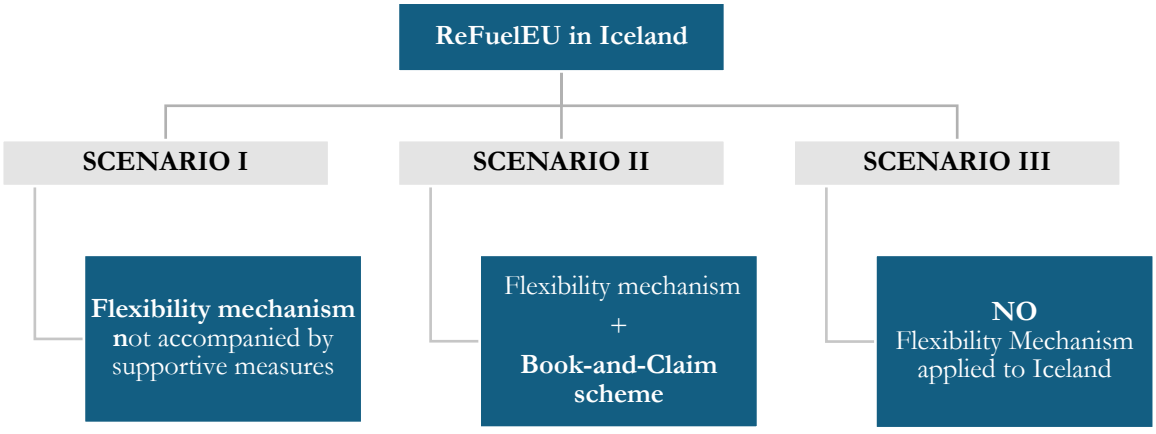
Research Results

RQ1: How is the Regulation (EU) 2023/2405 introducing the EU SAF mandate affecting the resources and strategy management of Icelandair?

The implementation of the EU SAF mandate introduces substantial uncertainties for Icelandair and the Icelandic aviation industry, enhanced by Iceland's unique position as an EEA member located far from mainland Europe. The mandate stipulates that a minimum of 2% SAF must be blended within the total kerosene consumption at Union airports. However, concerns have been raised regarding the flexibility mechanism, which would potentially allow fuel suppliers to meet SAF requirements through a weighted average across the EEA. This mechanism could result in Icelandic airports being excluded from receiving physical SAF supplies, generating uncertainties for Icelandair regarding the potential cost implications, environmental impact, and impact on the competitiveness of the carrier. Based on the interviews and document analysis, three potential scenarios have been identified regarding different manners the mandate could be implemented:

1. The complete adoption of the flexibility mechanism without supportive measures, which may not supply SAF to KEF and may therefore confer a competitive advantage to Icelandair, but which may also hinder the company's environmental goals;
2. The introduction of a book-and-claim scheme, which would ensure equal conditions across the EEA but would raise operational costs for Icelandair, potentially affecting ticket prices and market competitiveness; and
3. The non-application of the flexibility mechanism to Iceland due to fuel suppliers' decisions or legislative interpretations, which could stimulate local SAF production but, like in the previous scenario, increase fuel costs, thus reducing the competitive edge of the focus airline.

These findings highlight the need for proactive measures and strategic stakeholder engagement to navigate the changing regulatory landscape while maintaining competitiveness and advancing sustainability goals. Icelandair's strategy is based on three critical resources: intangible resources, such as building robust relationships with policymakers, and make its uniqueness acknowledge in the EU fora; physical resources, including fleet renewal and efficient route planning; and organisational resources, including risk assessment practices. Additionally, it emerges the importance of a proactive engagement and strategic collaboration for Icelandair to navigate the evolving regulatory landscape and maintain its competitive edge in the transatlantic market, independently on which scenario will unfold.



RQ2: How do Icelandair's key stakeholder perceive the upcoming EU SAF mandate and what strategies and approaches are they adopting to prepare for compliance?

The implementation of the EU SAF mandate has prompted varied responses from stakeholders, including aviation fuel producers, competitors of Icelandair, industry associations, OEMs, governmental agencies of Iceland, and European institutions. Fuel and SAF producers view the mandate positively as it promises a stable market and increased competitiveness, though they express concerns about feedstock constraints and overly ambitious targets. They support gradual production increases and innovative solutions like the book-and-claim scheme. European airlines and industry associations recognise the mandate's necessity for sustainable aviation but stress the need for policy adjustments to maintain competitiveness, suggesting a more refined policy mix to avoid carbon leakage. Aircraft OEMs support the mandate for its role in decarbonisation and promote SAF and hydrogen technologies. The Icelandic government seeks tailored policies to address carbon leakage and competitive disadvantages, advocating for local SAF production. The specialised EU agency views the mandate optimistically, emphasising the need for a harmonised policy landscape and investment in SAF infrastructure. Stakeholders' perspectives are influenced by their positions and interests, with strategic collaboration and proactive engagement crucial to navigating the evolving regulatory landscape and maintaining competitiveness in the aviation markets.

Conclusions and Recommendations

The study suggests that Icelandair should engage with the Icelandic government and the European Commission to clarify the implementation of the flexibility mechanism. Indeed, strong communication with regulatory bodies is essential for navigating risks and maintaining competitiveness. Icelandair should develop a strategy to reduce environmental impact without harming profitability and potentially collaborate with SAF producers to ensure supply and compliance. Investing in fleet modernisation and sustainable technology will enhance sustainability and attract eco-conscious travellers. Policymakers should enhance regulatory clarity, promote local SAF production, and provide supportive measures. Fuel and SAF suppliers should diversify production and logistics, participate in compliance mechanisms, and advocate for gradual production target increases. EEA-based airlines should shape regulations to mitigate competitive imbalances, proactively support global SAF standardisation, and invest in sustainable technologies to maintain competitiveness.

In conclusion, this research fills a gap in the academic literature by providing a case-specific analysis of preparations for the early phases of the EU SAF mandate, offering a concrete assessment of ReFuelEU and its perception within the Icelandic and European aviation industry. Future research should quantitatively assess the financial implications of the mandate for airlines, conduct comprehensive cost-benefit analyses, and perform an ex-ante policy analysis to anticipate outcomes and unintended consequences. Such research will offer further insights into necessary policy adjustments to meet the mandate's goals without disproportionately affecting the competitiveness of EU airlines.

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1 Introduction

Article 2 (2) of the Paris Agreement to the United Nations Framework Convention on Climate Change states the necessity to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C", in order to reduce the risks and impacts of climate change (Paris Agreement, 2015). In 2023, the global mean temperature was 1.48°C warmer than pre-industrial levels, and 0.16°C higher than the previous annual record set in 2016 (Copernicus, 2024). These numbers reveal the paramount challenge faced by the international community to hold to the goal set in 2015. A drastic and rapid turnaround is essential to limit the consequences of global warming driven by the rising greenhouse gas (GHG) and, in particular carbon dioxide (CO_2) concentrations in the atmosphere (Intergovernmental Panel On Climate Change, 2021).

Among the most polluting sector, transport accounts for 15% of GHG emissions globally (IPCC, 2022). It is the third largest contributor, following the energy sector and 'agriculture, forestry, and other land use', usually referred to as AFOLU. From 2010 to 2019, the transport sector faced an annual emissions growth of 2%, meanwhile the other two sectors decreased the yearly growth from 2.3% to 1% (IPCC, 2022). Among the various transport industries, aviation is one of the most rapidly growing with an increase in revenue passenger kilometres from 109 to 8,269 billion km yr^{-1} in the last six decades (Lee et al., 2021). This exponential growth, which occurred mainly after 2000, resulted in an increase in GHG emitted by aviation, reaching 1,034 billion Tonnes of CO_2 yr^{-1} just before the COVID-19 pandemic (Lee et al., 2021).

The growth of the aviation industry has yielded substantial social and economic benefits (Gössling & Humpe, 2020). It has made it possible to increase connectivity, cohesion and reduce inequalities by enabling more remote areas to be reached in drastically shorter times than by any other means of transport (European Parliament, 2023). It is therefore unrealistic to imagine a modernistic world without aviation. However, as Gössling & Humpe (2020) point out, aviation is one of the most energy-intensive forms of consumption. In 2018, only 11.1% of the world's population flew, generating, along with air cargo, 2.4% of total global CO_2 emissions (Gössling & Humpe, 2020).

To cope with the air traffic projected to triple by 2050 (Gössling & Humpe, 2020) and to stay on track in order to meet the goal set by IATA to achieve net zero CO_2 emissions by 2050 (IATA, 2021), the aviation sector must transition from its heavy dependence on fossil fuels to more sustainable alternatives (Lee et al., 2021). Currently, numerous technologies developed by different actors and tested by aircraft manufacturers aim to reduce the environmental impact of aviation. Boeing (2023) and Airbus (2021), the world's leading aircraft manufacturers, have worked for several years on hydrogen and electric-propelled aircraft. Aero turbine manufacturers and various oil companies are researching to produce non-fossil fuels to replace kerosene, the primary fuel used in aviation today (Eni, 2021; Rolls-Royce, 2021). In this changing landscape, sustainable aviation fuels, or SAF, seem representing the primary solution to cutting CO_2 emissions (Bullerdiek et al., 2021; Grimme, 2023; Jiang & Yang, 2021). SAF can seamlessly integrate with traditional fossil fuels, as they are drop-in fuels (Jiang & Yang, 2021). This means there is no need to modify the turbines currently in use or the infrastructure for refuelling aircraft, thus reducing the cost of the transition compared to other technologies and shortening dramatically the timeframe. Even though other technologies are being developed to make aviation more sustainable, such as hydrogen-powered or electric aircraft (Yusaf et al., 2024), these are still at a much earlier state of development and will require

much more substantial structural changes to aircraft and operations for airlines, airports, suppliers, and original equipment manufacturers (OEMs) (Bauen et al., 2020).

Different types of biofuels and synthetic fuels can be labelled as SAF. According to the European Union Aviation Safety Agency (EASA, n.d.-b), SAF should entail a GHG reduction of at least 65% for biofuels and 70% for renewable fuels from non-biological fuels compared to the fossil fuel baseline of 94 g CO_2e MJ^{-1}. This reduction, combined with engine efficiency improvements due to technological advancements, theoretically guarantees that climate change targets will be met (IATA, 2023a).

Policy measures mandating a certain percentage of SAF blended with kerosene are increasingly introduced to foster the expansion of the SAF market and attract more investment. On 18th October 2023, the European Union (EU) adopted Regulation 2023/2405 (hereafter: "the Regulation"), which, among other measures aimed to ensure a level playing field for sustainable aviation, introduces the world's first transnational SAF blending mandate. From 2025, fuel producers will be required to provide a minimum of 2% SAF to aircraft taking off from the European Economic Area (EEA). This quota will gradually increase to ensure the SAF market has adequate time to develop further and thus become a more competitive alternative to kerosene. In 2030, the requirement will increase to 6%; in 2040, 34%; and in 2050 it must reach 70%.

1.1 Problem Definition

Despite the necessity of a policy instrument to foster the adoption of SAF instead of fossil jet fuel, the upcoming EU blending mandate will significantly impact the European aviation industry, airliners, airports, passengers, fuel producers and suppliers. The higher cost of SAF, the need for supply chain reconfiguration and the necessary operational changes represents substantial challenges for the abovementioned stakeholders (see e.g., Bergero et al., 2023; Grimme, 2023; Jiang & Yang, 2021; Kito et al., 2023; Martinez-Valencia et al., 2021; Shehab et al., 2023).

Although SAF are a drop-in technology and require relatively minor changes in airlines' business-as-usual processes compared to other sustainable technologies, the aviation industry will inevitably have to transform to adapt to the new scenario once the EU mandate is implemented. First, the cost of SAF is, on average, much higher than that of fossil fuels. In 2022, the cost of jet fuel was around €1000 t^{-1}, while the cost of SAF was approximately €2300 t^{-1}, nearly 2.5 times higher (IATA, 2023b). However, the cost of SAF varies drastically depending on the types, production techniques and feedstock availability (Transport & Environment, 2023). Economic incentives for the purchase of SAF are not covered by the Regulation, which means that airlines and passengers will have to bear most of the additional costs. In addition, the production and distribution of SAF face significant logistical challenges, which could further impact its already high cost. According to IATA (2023b) global SAF production in 2022 was 0.24Mt, only 0.1% of CAF production, which amounted to 254Mt. The most prominent barriers to the upscaling of SAF production are the challenges of sourcing raw materials and the inherent complexity of reducing the costs of some production procedures. The EU mandate will be effective from January 2025, and the resulting demand increase for SAF will likely further inflate its cost in the short-term, as there is not yet adequate capacity to meet the growing market demand (Grimme, 2023).

The inevitable increase in costs related to fuel procurement could raise issues regarding the competitiveness of airlines based and operating inside the EEA borders that must comply with the EU mandate. An increase in fuel costs will lead to higher operating costs for EU-based

companies, thus tending to be higher than those of some non-EEA competitors, who can then offer lower ticket prices to consumers. This problem may also occur at airports located at the peripherical regions of the EEA. Airlines might prefer to choose airports outside the EU jurisdiction and, therefore, not subject to the mandatory SAF quota as stop-over airports to reach destinations outside the EEA, thus keeping costs lower (Grimme, 2023).

In this setting, numerous researchers have studied and analysed the different types of SAF, their positive impacts on the sustainability of the aviation industry, and potential policy instruments to support their diffusion. Currently, academic and scientific research primarily focused on the technical aspects of SAF (Bauen et al., 2020; Yilmaz & Atmanli, 2017), the positive impact they can have on the sustainability of aviation (Bergero et al., 2023; Brazzola et al., 2022; Gössling & Humpe, 2020; Grimme, 2023; Jing et al., 2022; Kito et al., 2023; Shahriar & Khanal, 2022; Shehab et al., 2023; Voigt et al., 2021); the upscaling of SAF production (Barke et al., 2022; Gegg et al., 2015; Martinez-Valencia et al., 2021; Wei et al., 2019); the role policymakers should have in facilitating SAF development mass production (Bullerdiek et al., 2021; Pavlenko, 2021; Shahriar & Khanal, 2022); and making sustainable fuels competitive with fossil fuels (Grimme, 2023).

Existing literature does not delve into the impact of SAF blending mandates on individual airlines and how different stakeholders involved in the SAF supply chain perceive and try to adapt their operations to comply with upcoming regulations. Precisely for this reason, this thesis primarily focuses on a specific airline: Icelandair, the Icelandic flag carrier, and the challenges it must face to prepare for and comply with the EU SAF blending mandate starting in 2025.

Icelandair is a major European airline that currently operates 51 aircraft and carried more than 4 million passengers in 2023 (Icelandair, 2024). This specific airline presents characteristics that make it unique in transitioning towards a more sustainable aviation. Icelandair, indeed, operates in a very peculiar geographical situation, having its central hub in Iceland, an island in the middle of the Atlantic Ocean. This exceptional location leads to various constraints and advantages when attempting to minimise the environmental impact of aviation. First, replacing aviation with other means of transport will not be feasible, considering that getting to the European mainland by boat would require at least two days of navigation (Visit Iceland, 2023). In addition, due to the country's rugged terrain, domestic air travel is the only way to get from one side of the island to the other in a limited amount of time. Second, the geographical location of the central hub grants a strategic position to operate transatlantic flights using smaller and more efficient aircraft with a stopover in Iceland.

1.2 Aim and Research Questions

The thesis aims to explore the challenges and opportunities for an airline and its stakeholders within a unique geographical and market context following the implementation of the ReFuelEU Aviation Initiative and the EU SAF blending mandate starting in 2025.

The thesis sets out to achieve the research aim by focusing on the economic impact of the higher cost of SAF compared to fossil fuels. The research examines the risk of losing competitiveness in critical markets, how the uncertainties in the regulatory landscape are addressed, the consequences of the current limited production of SAF, and the challenges the intricate SAF supply chain presents to its production and distribution. Furthermore, the thesis analyses Icelandair's process of adapting its operations and strategies to the upcoming ReFuelEU Aviation Initiative.

Additionally, to get a complete overview of the problem at the core of the thesis, it is crucial to outline and analyse how the focus airline's stakeholders along the SAF supply chain perceive the upcoming SAF mandate and the expected challenges and opportunities it entails. This approach sheds light on the transition towards more sustainable fuels within the European aviation industry. Consequently, it allows the focus company to become more aware of the status quo of its stakeholders and have a better overview of what is happening around it when it comes to SAF.

To achieve the aim of the research, the following Research Questions (RQs) are considered:

- **RQ1:** How is Regulation (EU) 2023/2405 introducing the EU SAF mandate affecting the resources and strategy management of Icelandair?

- **RQ2:** How do Icelandair's key stakeholders (e.g. fuel and SAF producers, Institutions, other airlines, OEMs…) perceive the upcoming EU SAF mandate, and what strategies and approaches are they adopting to prepare for compliance?

1.3 Scope and delimitations of the research

The research is centred on a case study of Icelandair and the broader Icelandic aviation sector, with the objective of examining the repercussions of ReFuelEU's implementation from a nuanced and comprehensive perspective. This methodological focus was deliberately chosen to explore both the challenges and opportunities emerging within the sector and to scrutinise the tangible impacts of this important milestone for the sustainability of European aviation. Accordingly, this study does not encompass the entire European aviation industry. Instead, it focuses on the specific implications that the EU SAF mandate holds for a distinct industry segment. As such, while the findings of this research are primarily pertinent to the specific context under investigation, they also offer some degree of transferability to other stakeholders, particularly airline companies within the EEA. Iceland's unique context accentuates specific side-effects and consequences of the Regulation that would still happen, to a certain extent, in other regions of the Union.

The research's focus is deliberately restricted to qualitative considerations that revolve around business and strategic aspects, intentionally omitting the quantitative elements relevant to this topic. This approach was chosen due to the novelty and dynamicity of the regulatory implementation process, which precludes meaningful quantitative analysis. The scope delimitation, therefore, allows for an in-depth exploration of managerial and strategic responses within the evolving regulatory framework while acknowledging the constraints imposed by the dynamic nature of the policy environment.

The Regulation was ratified in October 2023 and is slated for implementation starting January 2025. At the point of thesis submission, it is anticipated that not all facets of the Regulation and the EU SAF mandate have been fully defined or clarified. The European Commission (EC) must provide further clarifications by July 2024, indicating a dynamic regulatory environment that may influence the findings and interpretations presented in the study.

Finally, the scope of empirical data collection is delimited by the number of interviews conducted, which is limited to a selected group of stakeholders. This limitation is attributable to the low responsiveness of contacted individuals and the challenges encountered in securing interviews with distinct stakeholder categories. Consequently, this restriction may impact the comprehensiveness of the results, as they do not reflect the perspectives of all relevant stakeholder groups. A twofold method approach was employed in data collection to mitigate

this issue. Primary data gathered from interviews were supplemented by secondary data acquired through an extensive analysis of relevant documents.

1.4 Audience

The intended audience consists primarily of crucial personnel at Icelandair, peer airlines and competitors, fuel and SAF suppliers, EU policymakers, academics and researchers, and any actor involved in the implementation of the EU SAF mandate.

Indeed, the research aims to help Icelandair better understand what the EU SAF mandate will entail for its operations and how it should adapt its business-as-usual approach. It seeks to help the airline identifying the main barriers that could arise after 2025 and look for drivers to boost the transition towards a larger SAF quota. At the same time, other airlines could compare the findings to their operations and context to better understand the implications of the EU mandate. Furthermore, dialogue and collaboration between different stakeholders are critical in effectively achieving the aim of the Regulation; therefore, exploring the diverse perspectives, priorities, uncertainties, and expectations would help the industry and policymakers to tangibly observe whether the policy instrument approved would be achieving its primary goal without compromising the competitiveness of EEA-based airlines. A comprehensive understanding of these challenges is crucial for airlines like Icelandair to devise more effective compliance strategies.

Finally, the study's results can provide policymakers with valuable insights into the practical implications of these regulations on the aviation industry. The research aims to furnish more clear insight regarding areas where the industry needs additional support or where there are opportunities for collaboration between different stakeholders. It aims to influence lobbying efforts or future policy adjustments. Gaining insights into how Icelandair's fuel suppliers, competitors, peers, and the aviation industry more broadly perceive and prepare for ReFuelEU could provide valuable information on market readiness, development, and challenges in the SAF market. This information is crucial for grasping the current state of the industry and facilitating informed decision-making.

1.5 Disposition

Chapter 1 presents the nature of the problem at the core of the thesis and the specific issue being addressed by the research. Subsequently, research questions are presented, along with an explanation of the purpose and limitations of the study. Finally, the intended audience is listed and described. In *Chapter 2*, "Literature Review", a review of the existing literature on sustainable aviation fuels, relevant policy instruments, and airline industry dynamics is conducted. Consequently, the theoretical framework adopted to analyse the results is described starting from the existing literature on the relevant theories. *Chapter 3,* 'Research Design and Methods', introduces the research design and the methodologies used to collect and analyse data. *Chapter 4,* 'Study Results & Analysis', represents the essence of the thesis. The results of the study are presented into two main sections following the order of the research questions. *Chapter 5*, 'Discussion', has the purpose of interpreting and describing the significance of the results, compared the results to the existing body of literature and discuss the limitation of the study. Finally, *Chapter 6*, 'Conclusions', conclude the study by providing the reader with a clear of the claim of the research, presents the practical implications and recommendations for the audience and recommend future research on the topic.

2 Literature Review

This section has a twofold purpose. Firstly, it reviews and analyses the existing body of literature regarding the concept of sustainable aviation, SAF, the policy instruments promoting their development and deployment, and the main features of the air transport market and airline business models. Secondly, it presents the theoretical framework followed to provide the relevant perspective to address the research problem. The literature review aims to provide the necessary knowledge to critically read the study findings presented in Chapter 4. In parallel, describing and analysing what has already been written by academics and researchers is essential to motivate and justify the approach chosen to study this phenomenon, as defined by the research aim and questions in section 1.2.

2.1 Current knowledge related to the adoption of SAF.

This chapter's structure is based on the six themes emerged in the preliminary literature analysis: (1) sustainable aviation, (2) sustainable aviation fuels, (3) environmental benefits of SAF, (4) policy instruments promoting sustainable aviation, (5) the European SAF market, and (6) aviation stakeholders, business models and airlines market.

2.1.1 Sustainable aviation

Aviation accounts for 2.4% of global carbon dioxide emissions (Gössling & Humpe, 2020). However, recent studies indicate that the CO_2 generated by aviation only accounts for one-third of its actual climate forcing (Brazzola et al., 2022). The remaining two-thirds are referred to as non-CO_2 effects and consist of water vapour (H_2O), nitrogen oxides (NO_x), sulphate aerosols, compounds from incomplete combustion (such as unburned hydrocarbons), soot and contrails (Grewe et al., 2021; Lee et al., 2021). Consequently, if all climate-changing emissions were considered, aviation's actual impact on climate would be around 5% of the anthropogenic forcing (Lee et al., 2010). However, recent research highlights the extremely complex nature of aviation emissions and suggests that the factual impact of the industry could be different than currently calculated (Brazzola et al., 2022; Lee et al., 2021; Skeie et al., 2010).

Apart from the exact share of aviation's effective radiative forcing (ERF), it is essential to reflect on the definition of sustainable aviation. Explicitly state the definition used in this thesis is key, given that each academic, industry expert, or practitioner may have distinct interpretations of sustainable aviation. Generally, 'sustainable aviation' is defined as a net zero-scenario aviation (NASA, 2022). However, the term net zero is ambiguous per se. According to McKinsey & Company (2022), net zero is an ideal state where the amount of GHGs released into the earth's atmosphere is balanced by the amount of GHGs removed. The ambiguity lies in what level of CO_2 emitted into the atmosphere is acceptable. Consequently, several interpretations answer the question: "net zero what?" (Fankhauser et al., 2022, p. 15). Fankhauser et al. (2022) explain that net zero sometimes describes emissions patterns in line with the 1.5°C target (Paris Agreement, 2015), or it can be interpreted as achieving a balance of CO_2-equivalent emissions, calculated through the 100-year global warming potential measurement. In the aviation sector, this ambiguity remains evidently present. As Brazzola et al. (2022) state, the definition and standardisation of the concept of climate-neutral aviation or net-zero aviation needs to be strengthened. Their article proposes three different definitions of sustainable aviation, differing in their level of ambition. The most ambitious and stringent defines aviation as net zero in relation to a world without aviation emissions. The second definition regards aviation as net zero compared to a world on a trajectory to reach the 1.5°C target. The third, less ambitious definition envisions a net-zero aviation industry that aspires to level off its greenhouse gas emissions after 2050 but is expected to grow between now and then. Although Brazzola et al. (2022) provide three definitions of net-zero aviation, only the

most ambitious should be deemed acceptable. However, the prerequisites for achieving this scenario do not seem to occur considering the current state of achievement of global warming targets (Di Sario, 2023).

This thesis defines sustainable aviation as net-zero aviation in line with the 1.5°C target set by the Paris Agreement (Paris Agreement, 2015). According to this definition, aviation's radiative forcing should be limited in line with the Shared Social-economic Pathway SSP1-19 (IPCC, 2022), which tolerates the aviation industry to contribute up to 0.04°C to global warming by 2100 (Brazzola et al., 2022).

2.1.2 Sustainable Aviation Fuels

Article 3 (7) of the Regulation (EU) 2023/2405 defines SAF as "aviation fuels that are either: (a) synthetic aviation fuels, (b) aviation biofuels, or (c) recycled carbon aviation fuels". The EU further defines *synthetic aviation fuels*, E-fuels, or Power-to-Liquid fuels (PtL) as fuels produced using renewable resources, such as solar and wind energy, but excluding biomass (EASA, n.d.-a). *Aviation biofuels* are those produced from feedstocks listed in Annex IX of the EU Renewable Energy Directive 2018/2001 (RED II), e.g.: animal manure and sewage sludge, biomass fraction of wastes and residues from forestry, or straw (EU Parliament & EU Council, 2018). Finally, *recycled carbon aviation fuels* are liquid and gaseous fuels derived from non-renewable origin liquid or solid waste streams, which cannot be repurposed for material recovery, or from waste processing gas and exhaust gas of non-renewable origin generated as an inevitable and accidental by-product of manufacturing processes in industrial installations as described in Directive (EU) 2018/2001 (EU Parliament & EU Council, 2018).

There are currently seven SAF pathways that are certified for commercial use in accordance with the EU's definition of sustainable fuels. All fuels used in civil aviation must meet the standards set by ASTM International to ensure they encounter specific safety, quality, and performance criteria, only then they can be used on commercial flights. For aviation turbine fuels, the relevant ASTM standards include ASTM D1655 for conventional aviation fuel (ASTM, 2023) and ASTM D7566 for aviation fuel containing synthesised hydrocarbons, i.e. SAF (ASTM, 2022). These standards specify the physical, chemical, and performance properties of the fuels to be considered safe and reliable for aircraft engines (SkyNRG, 2023b).

As mentioned by Undavalli et al. (2023), the ASTM D7566 certified SAF pathways currently are:

a. Fischer–Tropsch—Synthetic Paraffinic Kerosene (FT-SPK)
b. Fischer–Tropsch—Synthetic Paraffinic Kerosene with Added Aromatics (FT-SPK/A)
c. Hydroprocessed Esters Fatty Acids—Synthetic Paraffinic Kerosene (HEFA-SPK)
d. Hydroprocessing of Fermented Sugars—Synthetic Iso-Paraffinic Fuels (HFS-SIP)
e. Alcohol-to-Jet Synthetic Paraffinic Kerosene (ATJ-SPK)
f. Catalytic Hydrothermolysis Synthetic Kerosene (CH-SK)
g. High Hydrogen Content Synthetic Paraffinic Kerosene (HC-HEFA-SPK)

The seven ASTM certified pathways, and presented more in details in *Table 2-1,* can generate aviation fuels that fall into one of the three types of SAF described by the EU based on the type of feedstocks, processes used or electricity mix (EASA, n.d.-b). The characteristics of the products derived from each pathway differ in terms of cost, CO_2e emissions, the percentage that can be blended with CAF and energy density, creating a fragmented and complex landscape. Even the same production pathway can result in SAF with varying characteristics in terms of cost and emissions. For instance, Shehab et al. (2023) note that HEFA-SPK, one

of the most widely used and technologically mature SAF today (Bauen et al., 2020), has an emission range varying from 13.9 to 60 gCO_2e MJ^{-1}. Similarly, ATJ-SPK, a SAF produced through the fermentation of sugar cane, wheat, corn, and other biomasses, can generate between 23.8 and 65.7 gCO_2e MJ^{-1}, depending on the feedstock used. In comparison, the average emissions of CAF are 94 gCO_2e MJ^{-1} (Directive (EU) 2018/2001, Annex V). Further, the cost of HEFA-SPK ranges from $1100 to $1550 ton^{-1}, while ATJ-SPK can cost between $2100 and $2900/mt. CAF cost roughly $1095 ton^{-1} in 2022.

Table 2-1 "ASTM certified SAF pathways, cost, emissions and feedstock", Adaption from Shehab et al. (2023) and Undavalli et al. (2023)

SAF Pathway	ASTM approved	Blend	Cost ($ ton 1)	Emissions (gCo_2e MJ^{-1})	Feedstock
FT-SPK	2009	50%	1866-2250	7.7-12.2	Urban solid waste biomass, waste from farming, timber, carbon crops, coal, and natural gas
FT-SPK/A	2015	50-100%	1866-2250	7.7-12.2	Urban solid waste biomass, waste from farming, timber, carbon crops, coal, and natural gas
HEFA-SPK	2011	50%	1100-1550	13.9-60	Fatty acids, fatty acids esters, lipids from plants and animal fats, oils, and greases
HFS-SIP	2014	10%	2100-2900	32.4-32.8	Sugarcane and sugar beet
ATJ-SPK	2016	50%	2100-2900	23.8-65.7	Fermented starches of sugars, field corn, sweet sorghum, cane, sugar beets, tubers, cellulose biomass
CH-SK	2020	50-100%	n/a	n/a	Fatty acids, fatty acids esters, lipids from plants and animal fats, oils, and greases
HC-HEFA-SPK	2020	10%	n/a	n/a	Algae, bio-derived hydrocarbons, fatty acid esters, and free fatty acids
Jet-A1 (CAF)			1094 *(2022)*	94	Crude Oil

2.1.3 Environmental benefits of SAF

SAF produced through the seven pathways outlined previously significantly enhances the sustainability of aviation. Indeed, the most recent academic literature suggests SAF can significantly reduce CO_2 emissions (Grimme, 2023; Shahriar & Khanal, 2022) and decrease non-CO_2 effects (Grimme, 2023): e.g., limiting the formation of contrails (Voigt et al., 2021). Researchers studying this crucial aspect of SAF generally adopt a life-cycle approach to determine the environmental impact of different SAF pathways and compare them to the baseline set by the well-to-wake emissions of conventional fossil fuels (Barke et al., 2022; Grimme, 2023; Seber et al., 2022; Siddiqui & Dincer, 2021; Watson et al., 2024). Quantifying GHG emissions from fuel extraction to combustion permits the comparison of the factual environmental impact of different products undergoing different production processes and supply chains, such as fossil kerosene and SAF.

The consulted academic articles typically demonstrate, as shown in *Table 2-1* above, a reduction in CO_2e emissions over the life cycle of sustainable fuels compared to kerosene. However, researchers disagree on the magnitude of this reduction, which for some is almost imperceptible (Barke et al., 2022; Seber et al., 2022) while for others it is substantial and the upscaling of SAF production should be pursued to limit the environmental impact of aviation (Grimme, 2023; Watson et al., 2024; Yilmaz & Atmanli, 2017). Conversely, Barke et al. (2022)

state that, for now, it is still preferable to continue using conventional kerosene rather than the existing SAF. Even though some of the SAF considered result in effective reductions in CO_2e emissions and human toxic emissions, the study shows that PM emissions, the cost of production and the impact on direct land-use change (DLUC) are greater than those of CAF. In conclusion, Barke et al. (2022) prove that the benefits of SAF are marginal, if not non-existent, and therefore, CAF should be preferred in the current energy mix scenario. The study conducted by Barke et al. (2022), nevertheless, has several limitations, including considering only a limited number of SAF, primarily biobased HEFA. In contrast, studies considering the full array of ASTM certified SAF yield substantially different results (Watson et al., 2024). Watson et al. (2024) critically analyse the existing academic literature on current SAF technologies, their associated costs, emissions generated and market dynamics. The comparative study demonstrates that well-to-wake CO_2e reductions from SAF compared to CAF are substantial, as shown in *Figure 2-1* adopted from Watson et al. (2024). The reduction observed from Watson et al. (2024) ranges from -80% and up to -240% if carbon capture and storage (CCS) technologies are applied (Fernanda Rojas Michaga et al., 2022). Similarly, Yilmaz and Atmanli's study (2017) concludes that using SAF would lead to an average 85% reduction in GHG emissions and a decrease in other pollutants due to low sulphur concentrations. On the other hand, Seber et al. (2022), focusing only on HEFAs, show that a GHG reduction of between 34% and 65% would be possible if emissions from DLUC were not considered. Including DLUC emissions could increase emissions by +46% for biomass based HEFAs. Nevertheless, it is crucial to underscore the substantial uncertainty surrounding the estimation of emissions attributable to DLUC (Shahriar & Khanal, 2022), thereby rendering the validity of numerous studies on this issue open to question.

The direct emissions of non-CO_2 gases during flights represent an aspect seldom considered in studies comparing the sustainability of SAF to fossil kerosene. Voigt et al. (2021) have addressed this gap in the academic literature by demonstrating, through quantitative models, how the utilisation of fuels with low aromatic content, such as various SAF, results in the generation of fewer soot particles and consequently reduces the formation of contrails.

In conclusion, it is clear that even though some production processes of SAF do not lead to a reduction in the aviation's environmental impact mainly due to the impact on DLUC, a vast range of SAF, including some biobased fuels, have a positive effect compared to the fossil fuel baseline (Grimme, 2023).

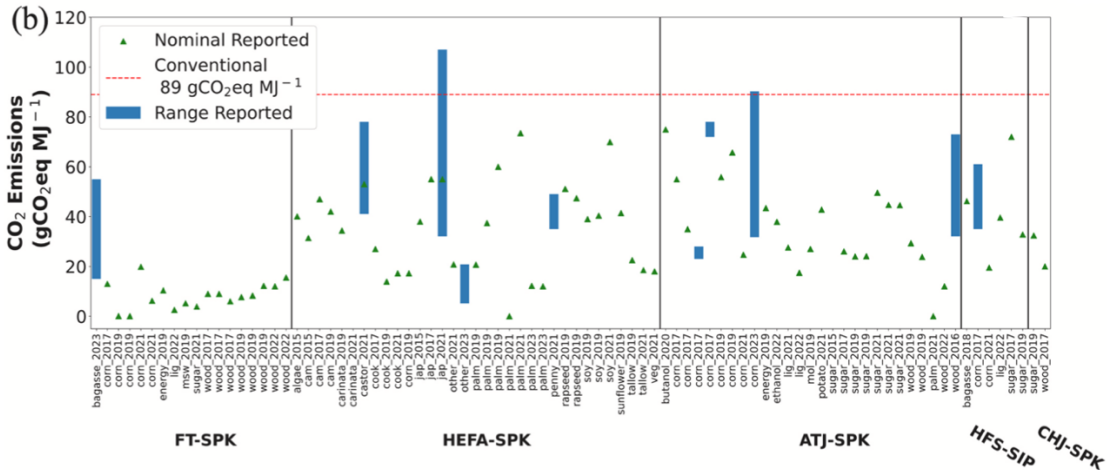

Figure 2-1 "Review of 58 papers CO_2 emissions (b) organised by technology, feedstock, and year of publication" ; adopted from Watson et al. (2024)

2.1.4 Policy instruments fostering sustainable aviation

SAF are currently not cost-competitive in the aviation fuel market and the only way to increase their competitiveness is through policy interventions designed to increase the cost of kerosene or reduce the price of SAF (Bullerdiek et al., 2021). Grimme (2023), and Jiang & Yang (2021) observe in their articles that there are two primary strategies to address this issue. One approach, which is gaining popularity worldwide, is to implement mandatory minimum quotas for SAF to forcibly increase demand and make demand more predictable and stable. This strategy would attract investment in SAF production, leading to reduced costs in the medium term (Bullerdiek et al., 2021). The second is to tax carbon emissions and thus indirectly increase the cost of CAF. Jiang & Yang (2021) compare these two policy instruments to assess their effectiveness and impact on social welfare. Their study concludes that both policies require additional subsidies to reduce the price of SAF, as the instruments alone would not be sufficient. Other researchers contend that implementing a progressively higher mandate, as is the case in the EU, may be sufficient to stimulate the production of SAF, increase demand and autonomously reduce their costs (Grimme, 2023).

Amid various national efforts to promote environmental sustainability in aviation, such as Norway's jet fuel tax and the UK's distance-based air passenger tax (Larsson et al., 2019), the EU is deploying a policy mix to enhance the sustainability of the Union's aviation industry. Since 2012, aviation has been included in the EU Emissions Trading Scheme (EU ETS), which sets an annual cap on the emissions that can be generated by a given sector (European Commission, 2024). As of today, airlines are granted some free allowances and, if they exceed their allocated carbon permits, they must buy them from other actors who have used fewer allowances than they have been allocated (Pavlenko, 2021). The cap on emissions from the sector will be steadily lowered to accelerate the sector's decarbonisation, and starting in 2027, all aviation permits will be auctioned, thus ending free allocations (European Commission, 2022).

Alongside this policy instrument, the EU has ratified the Carbon Offsetting and Reduction Scheme for International Aviation, or CORSIA, agreement. This international scheme, adopted by the UN agency for civil aviation, ICAO, is designed to mitigate any increase in total CO_2 emissions from international civil aviation, using average annual emissions in 2019 as a benchmark (IATA, 2024). To reduce CO_2 emissions, airlines operating between two signatory countries will have to monitor and report their emissions and offset any excess by purchasing carbon credits or using SAF (Deane & Pye, 2018).

These two policy instruments, along with the ReFuelEU Aviation initiative, form the cornerstone of the EU's strategy to enhance the sustainability of air transport. Scholars such as Jiang & Yang (2021), Ziolkowska et al. (2010) and Proost (2024) point out that only a policy mix can deliver the profound transformational changes needed to stimulate and accelerate such a significant shift for a historically fossil fuels-dependent sector. Proost (2024) outlines how each policy instrument aimed at making aviation more sustainable has its barriers or vulnerabilities. For instance, the primary concern with tradable emission permits lies in the fluctuating ambition of EU institutions, which, despite implementing mechanisms like the market stability reserve to manage surplus credits and thus not maintaining an absolute carbon cap for 2020–2030, faces challenges in maintaining the credibility of its carbon cap due to the financial significance of bankable permits in hedging against price volatility. On the other hand, the SAF mandate is expensive, particularly in terms of welfare, and the actual reduction in emissions profoundly depends on the production technologies and type of SAF used (Proost, 2024).

Sustainable fuels mandates are controversial environmental policy instruments (Hertel et al., 2008; Lawrence, 2010; Proost, 2024). In the early 2000s, academics researched and analysed the consequences of implementing policies to promote the use of biofuels for road transport (Balat, 2007; Bomb et al., 2007; Hertel et al., 2008; Lawrence, 2010; Ryan et al., 2006). This body of literature provides a valuable resource for understanding the implications of the EU SAF mandate once enacted. Lawrence (2010) argues that biofuel mandates are not the most efficient or precise instrument for achieving policy goals such as reducing GHG emissions, decreasing fossil fuel consumption, or promoting rural economic development. Biofuel mandates are criticised for failing to follow the principles of good policymaking, which would require developing a specific policy goal and designing an instrument that efficiently achieves that goal. Moreover, Lawrence (2010) highlights how introducing biofuel mandates in the US and EU has resulted in unintended consequences. These include higher food prices due to the diversion of crops for biofuel production, as well as doubts about the actual environmental benefits of biofuels. Proost (2024) is on the same page as Lawrence (2010) regarding the tangible motivations behind adopting a biofuel or sustainable fuel mandate. These policy instruments have been driven more by political motivations and the interests of various stakeholders, particularly airlines in the case of the SAF, rather than by policy efficiency or effectiveness considerations.

The introduction of incentives to purchase SAF is considered to be more attractive to both travellers and airlines rather than a mandate (Wenqi et al., 2022). In the United States (US), the Inflation Reduction Act (IRA) of 2022 introduced credits to encourage the purchase of SAF. In the US, a SAF credit of $1.25 per gallon is given if the fuel shows at least a 50% reduction in lifecycle GHG emissions compared to CAF. For reductions exceeding 50%, an additional $0.01 credit is provided for each extra percentage point (IRS, 2023). This policy instrument allows airlines to purchase SAF without being excessively disadvantaged by its high cost. However, subsidies usually result in a significant loss of revenue for the government (Ziolkowska et al., 2010) and, thus, in a significant expenditure of public funds. On the other hand, implementing a blending mandate target those responsible for excessive GHG emissions. In this case, fuel producers, airlines, and high-frequency travellers. Nevertheless, the resulting increase in ticket fares due to higher operating costs for airlines could make air travel less accessible. Therefore, while the EU SAF mandate can effectively increase biofuel consumption in the EEA, it is less effective in promoting specific SAF, contrary to the US subsidies scheme. Simultaneously, a mandate is preferable to a subsidy because it creates a stable and predictable demand for SAF over time, making investments more secure and less vulnerable to fluctuations in the price of fossil fuels (Ziolkowska et al., 2010) and feedstocks used in SAF production.

Regulation (EU) 2023/2405

Although there is still disagreement among researchers and practitioners about the effectiveness of a mandate to facilitate the upscaling of SAF production and consumption, Regulation (EU) 2023/2405 stands as the EU's flagship policy to address the growing environmental impact of aviation. Indeed, the Regulation is a fundamental policy instrument to ensure that the EU meets the targets set out in the Fit-for-55 package. Fit-for-55 consists of preparatory measures to achieve the objectives of the EU's overarching climate change strategy, the EU Green Deal. Within this political landscape the EU considers SAF as the primary mid-term technology for reducing CO_2 emissions and the overall environmental impact of the aviation industry. As outlined in Regulation (EU) 2023/2405, Recital (7), (European Parliament, 2023) there is a recognition that the transition to electric or hydrogen-powered aircraft will take time. Therefore, in the short and medium-term, promoting SAF development and large-scale deployment is deemed essential for meeting the Paris Agreement

targets. The Regulation (European Parliament, 2023) introduces an incremental mandatory quota of SAF for jet fuel suppliers to be provided to EEA airports (Art. 4(1)) and an obligation to uplift at least 90% of the fuel required from Union airports for aircraft operators (Art. 5(1)). As specified in Annex I, starting in January 2025, the minimum share of SAF will be 2%, increasing to 6% in 2030, of which 1,2% must be synthetic aviation fuels; 20% in 2035, of which a minimum share of 5% of synthetic fuels; and up to 70% of SAF, of which a minimum share of 35% of synthetic aviation fuels in 2050. The progression of the minimum SAF quotas over the years is illustrated in *Figure 2-2* below. Articles 8, 9, and 10 set forth a reporting obligation to airports handling passenger traffic exceeding 800,000 annually or managing more than 100,000 tonnes of cargo and airlines operating at least 500 passenger flights or 52 total freight flights annually. These thresholds are established to mitigate excessive burdens on smaller airports and airlines and additional operational challenges. Despite these concessions, the EU anticipates that the Regulation will encompass at least 95% of the total air traffic within the EEA (Recital 17). Furthermore, the Regulation introduces the possibility for fuel suppliers to enable a flexibility mechanism (Art. 15) that would prevent them from supplying some airports due to operational and logistic challenges. These fuel suppliers would have to provide the required shares of SAF as a weighted average over the total amount of fuel supplied across Union airports. Lastly, the Regulation introduces a voluntary environmental labelling scheme aimed at gauging the environmental performance of flights, as outlined in Article 14. This environmental label intends to enable consumers to make informed decisions at the point of ticket purchase, thereby offering the option to select flights with the most negligible environmental impact.

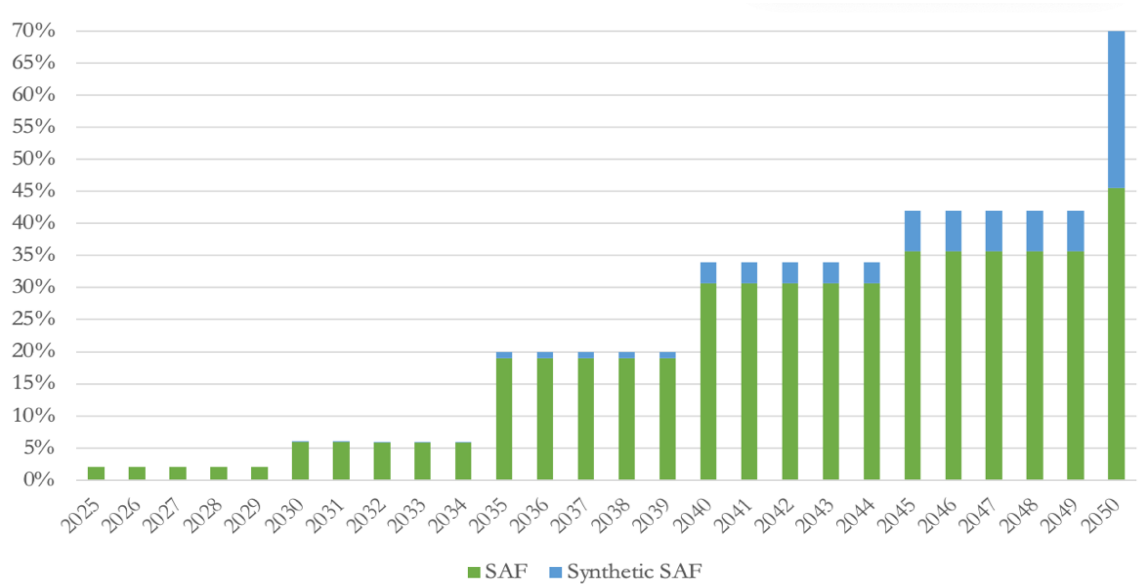

Figure 2-2 "ReFuelEU SAF blending quota 2025-2050", Adapted from Grimme (2023)

Through the Regulation, the EU also aims to harmonise policies for sustainable aviation within the EEA (European Parliament, 2023). In recent years, France, Sweden, and Norway have introduced national SAF mandates, leading to distortions in the competitiveness of airlines operating within the European common market. The adoption of a single European mandate would not only contribute to the achievement of Europe's climate change objectives but would also ensure the competitiveness of the Union's aviation sector, as safeguarded by Articles 101 and 102 of the Consolidated Versions of the Treaty on the Functioning of the EU (European Union, 2012). The only practice foreseen to limit the risk of competitive pressure from non-EEA airlines is the prohibition of *tankering*. Namely, the amount of fuel loaded onto an aircraft before departure from a specific airport within the Union should be proportional to the fuel

required for the operation of flights departing from said airport, according to Recital 28 (European Parliament, 2023). Additionally, Art. 3 (3) states that reporting on the SAF mandate is obligatory for all aircraft departing from airports located in the EEA, regardless of the nationality of the airline operating the flight, in order to avoid harming the competitiveness of European airlines. Finally, the Regulation aims to monitor closely the impact of the mandate on the more remote and border areas of the EEA, acknowledging their heightened vulnerability (European Parliament, 2023).

2.1.5 European SAF market

The global production of SAF was on average 0.005 Mt per year from 2016 to 2018 (Shahriar & Khanal, 2022). In 2022, the European SAF market was valued at $104 million (San Global Research, 2023) for a production of approximately 0.2 Mt (SkyNRG, 2023a). By 2030, the EU SAF market value is projected to exceed $4,000 million (San Global Research, 2023), with a production capacity of about 3.3 Mt. Despite this exponential growth, the SAF production is still significantly below the approximately 4.5 Mt needed to meet the quotas set by the EU SAF mandate (SkyNRG, 2023a). On the one hand, the Regulation promises to create a steady, growing demand, offering investors a high degree of confidence and stability, thereby encouraging investment in this rising sector. Nevertheless, the EU's blending targets present a tangible challenge. Current trends suggest that the mandate will fail to spur the necessary increase in SAF production to meet the 6% quota for the mandate's second phase (2030-2034). Academic studies corroborate this shortfall. Shehab et al. (2023) argue that the amount of feedstock required to produce fuel for the first phase of the EU SAF mandate (2025-2029) would be sufficient, while after 2030, it will be harder to meet the blending quota. If European air traffic remains constant at 2019 levels, the EU expects that the production capacity of various SAF will be sufficient to meet the quota established by the mandate, but if, as predicted by IATA, the demand for flights continues to grow, the production of SAF will be insufficient to meet the demand. Consequently, there would be a risk of failing to meet the targets set by the 'Fit for 55' package.

The transition towards a greener aviation sector faces significant challenges due to the high production costs of SAF and the large-scale investment required to build the refineries needed to meet the future demand for sustainable fuels (SkyNRG, 2023a). According to Martinez-Valencia et al. (2021), the current supply chain and business models for SAF are not cost-competitive with the deeply entrenched, revisited, and refined models of fossil fuels. The researchers believe that the production costs of renewable fuels, particularly second-generation fuels favoured by the EU (EU Parliament & EU Council, 2018), are the most significant barrier to their widespread adoption. Wei et al. (2019) suggests prioritising efforts to reduce the market price of SAF through policy instruments and technological advancement while ensuring their environmental sustainability. Shahriar and Khanal (2022) agree that SAF is not currently competitive. However, they argue that the minimum jet fuel selling price (MJSP), which is the minimum viable selling price of SAF at which the investment breaks even, is expected to decrease significantly as production capacity increases. This consideration suggests that operational costs will be reduced as more SAF is produced, making SAF increasingly competitive compared to CAF. Grimme (2023) highlights that despite the higher cost of SAF the ongoing technological advancements in aircraft and turbines will help to balance out these costs. Additionally, the EU ETS will increase the cost of CAF, making SAF more attractive. Grimme (2023) argues that the rise in operational costs for airlines will be gradual, as implied by the structure of the EU SAF mandate, and therefore, the impact will be less severe than expected.

Some researchers point out that regardless of whether the cost of SAF were to become competitive thanks to policy interventions, the problem would be ensuring the production of SAF needed to meet the demand required by the EU mandate (Bullerdiek et al., 2021; Grimme, 2023). These academics suggest that biomass production for SAF could hinder other industries from achieving their climate targets due to the complicated process of supplying biofuels in the quantities required by other modes of transport. At the same time, Grimme (2023) notes that if power-to-liquid fuels were to be prioritised instead, and the Regulation (EU) 2023/2405 targets were to be met, this would require half of the EU's total electricity generation in 2020; only to supply aircraft taking off from airports in the EEA. However, to date, it appears that biofuels, and particularly HEFA, will be the primary alternative jet fuels during the initial stages of the EU mandate, given their relatively low cost and advanced technological development (Shehab et al., 2023).

2.1.6 Aviation stakeholders, business models and airlines market

Aviation stakeholders and airlines business models

In the aviation industry, four main groups can be distinguished: the aircraft manufacturing industry, airlines, and airports (Wittmer et al., 2011). When it comes to the SAF supply chain, the primary stakeholders, other than those already mentioned, are fuel-producing companies, refineries making the specific SAF blend, fuel distribution companies, policymakers, international organisations, and NGOs (Ahmad & Xu, 2021).

As the research focuses on an airline, it is crucial to have a suitable understanding of the various business models of air carriers. Although every airline offers the same core service, there are differences in their underlying business models, which affect the service level offered and the routes they reach (Wittmer et al., 2011). These differences would translate into different approaches to the ReFuelEU initiative and the impact the EU SAF mandate will have on their operations. Wittmer et al. (2011) categorise airlines into distinct models: *International full-service network carriers* (e.g., American Airlines, Lufthansa) with a business model focused on hub-and-spoke networks for business and premium traffic, which necessitates complex, costly operational structures; *network niche carriers* (e.g., Icelandair, SAS), operating regional routes with some international connections; *regional carriers* (e.g., Widerøe, Air Dolomiti) linking remote areas to major hubs; *low-cost carriers* (e.g., Ryanair, EasyJet), emphasising affordability over

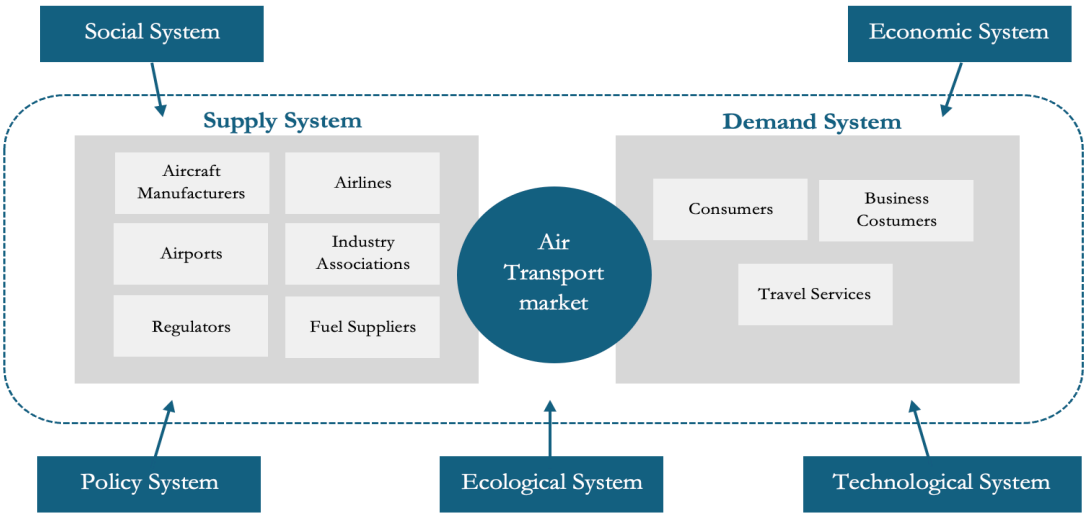

Figure 2-3 "Air Transport System"; adapted from Wittmer et al. (2011)

service quality on short to medium routes; *charter airlines* (e.g., Condor), blending service quality with cost efficiency and tour operator integration; and *air cargo carriers* (e.g., FedEx, Icelandair Cargo), utilising freighters and passenger fleet cargo holds for goods transportation.

A concluding element of critical importance to the study pertains to the characteristics of the aviation market and its integrated system illustrated in *Figure 2-3* above. The aviation industry's distinctiveness arises from the interplay of various systems. Therefore, comprehending the roles and interrelations of all involved actors and stakeholders is essential to fully grasp the intricate dynamics the ReFuelEU initiative seeks to influence. Notably, the aviation market possesses unique attributes that amplify the impact of policy measures such as the EU SAF mandate, which is poised to raise operating costs for airlines and stakeholders.

Airlines market

The aviation industry is commonly defined as a service industry that provides transport services for passengers and freight (Wittmer et al., 2011).

The primary characteristic of the airline industry is substantial deregulation, especially in the US and, to a lesser extent, in the EU, resulting in fierce competition (Wittmer & Bieger, 2021). Airlines face an extraordinarily complex and singular landscape. Indeed, in the supply chain, airlines occupy a position between two categories of stakeholders. On one side are the aircraft manufacturers, with Airbus and Boeing competing for the largest market share, yielding a duopolistic scenario (Vasigh & Azadian, 2022). On the other end are the airports, which have the characteristics of an oligopolistic market, given the limited number of airports and their frequently public ownership (Wittmer et al., 2011). By contrast, the airline industry is typically polypolistic, characterised by a vast number of companies operating in a highly deregulated environment where consumers have a vast range of choices between different providers generally offering very similar services, i.e. to travel from one point to another in a short time (Wittmer et al., 2011).

The cyclicality of the industry development is another unique characteristic of aviation (Wittmer & Bieger, 2021). The high cost of capital and the duopolistic nature of the OEMs result in a time lag of up to ten years between the order of an aircraft and its entry into service. This leads airlines to try to extend the life of their aircraft as much as possible, in some cases up to 30 years, thus lengthening the industry's development cycles. Furthermore, this cyclical pattern makes aviation more vulnerable to overall economic trends, as investments made in profitable times can be recouped in times of recession, either wiping out the value of the investment or damaging the airline's finances.

Thirdly, the airline industry is highly capital-intensive and requires long-term asset investments with low entering and high exit barriers (Smyth & Pearce, 2006; Wittmer & Bieger, 2021). Consequently, marginal costs are of paramount importance to airlines, which will seek to price their tickets at the lowest possible cost, as close as possible to variable costs, thereby enhancing the industry's competitiveness.

A fourth characteristic is the rapid growth of the industry, accompanied by slim profit margins. Over the past few decades, the increasing deregulation of the industry, combined with growing competitiveness, has led to a steep reduction in ticket costs, making air travel more affordable and thus ensuring an exponential increase in air traffic. Despite the increase in passenger numbers, it has not translated into higher profit margins. Airlines struggle to be profitable in a highly competitive marketplace, caught in the sand between duopolistic suppliers and a fierce race to the bottom (Wittmer & Bieger, 2021).

A final trait is a strong sensitivity to external inputs. The primary example is the carriers' vulnerability to fluctuations in the price of fossil jet fuel, which accounts for almost a third of an airline's total costs (Wittmer & Bieger, 2021).

2.2 Discussion on the literature review

After reviewing the literature available, it is evident that although the SAF mandate will only kick in at 2% in January 2025, the economic and technological challenges are paramount. The Regulation's entry into force will be a primary challenge for airlines and other stakeholders along the supply chain. The expected increase in fuel costs (Grimme, 2023), the significant level of uncertainty surrounding the production of SAF, the uncertainty regarding its potentiality to reduce the environmental impact of aviation, and the logistical adjustments needed along the supply chain are only some of the challenges that must be assessed and tackled.

When examining the direct interests of airline companies, their primary concerns revolve around the rise in operational costs and the need to shrink their carbon footprint. However, it is crucial for them to effectively manage and reduce costs. Airlines typically operate on a slim margin of approximately 6% of their total revenue (Maung et al., 2022) in a fiercely competitive and complex market environment. The reduction of CO_2 emissions facilitated by SAF will be of utmost importance, not only for its environmental benefits but also for the prospect of securing discounts on the EU ETS, thereby aiding in the containment of the projected increase in operational expenses. From 2024 to 2030, as per the SAF Allowances systems, 20 million carbon allowances from the Aviation ETS will be allocated to support SAF usage by ETS-eligible aircraft operators (SkyNRG, 2023c). However, this arrangement is currently limited to flights refuelled with physical SAF, which makes the potential adoption of the flexibility mechanism more favourable for fuel producers than for aircraft operators.

Furthermore, compliance with the EU SAF mandate could potentially jeopardise the competitiveness of EEA-based airlines on long-haul routes outside Europe. The diverse policy approaches of different countries (e.g., the US SAF subsidy scheme) could exacerbate fragmentation within the international airline market, thereby impeding the competitiveness of EEA-based airlines due to higher operational costs. This financial burden would likely be passed on to passengers without additional incentives from the EU. In fact, flights with stopovers at EEA peripheral airports and then continuing to the final destination could be significantly cheaper than direct flights departing from the EU and arriving at the same final destination, as they would need to carry much more SAF (Grimme, 2023).

In this policy landscape, Icelandair's location at the border of the EEA, far from SAF production sites, could pose an additional challenge due to logistical and infrastructural barriers to the deployment of SAF to Icelandic airports. However, the uniqueness of Icelandair's context is precisely why it has been selected as an intriguing case study. Although the flexibility mechanism may be implemented for the first phases of ReFuelEU, Iceland will still need to provide SAF at its airports sooner or later. The unique Icelandic context will accentuate the consequences of the EU SAF mandate. Therefore, the case study analysis simplifies identifying challenges other airlines and stakeholders will face throughout the EU from 2025 onwards.

2.3 Theoretical framework

To fill the literature gap regarding the impact of the EU SAF mandate on individual actors within the SAF supply chain, especially airlines, this study utilises a range of strategic management theories. As shown in Figure 2-4 below, both RQs will be primary examined

through the lens of the Resource-Based View (RBV) supported by Stakeholder Theory. Subsequently, RQ1 will be principally addressed through the theoretical framework of RBV, Dynamic Capabilities, along with Stakeholder theory. On the other hand, RQ2 will be mainly explored through RBV, Institutional theory and Legitimacy theory.

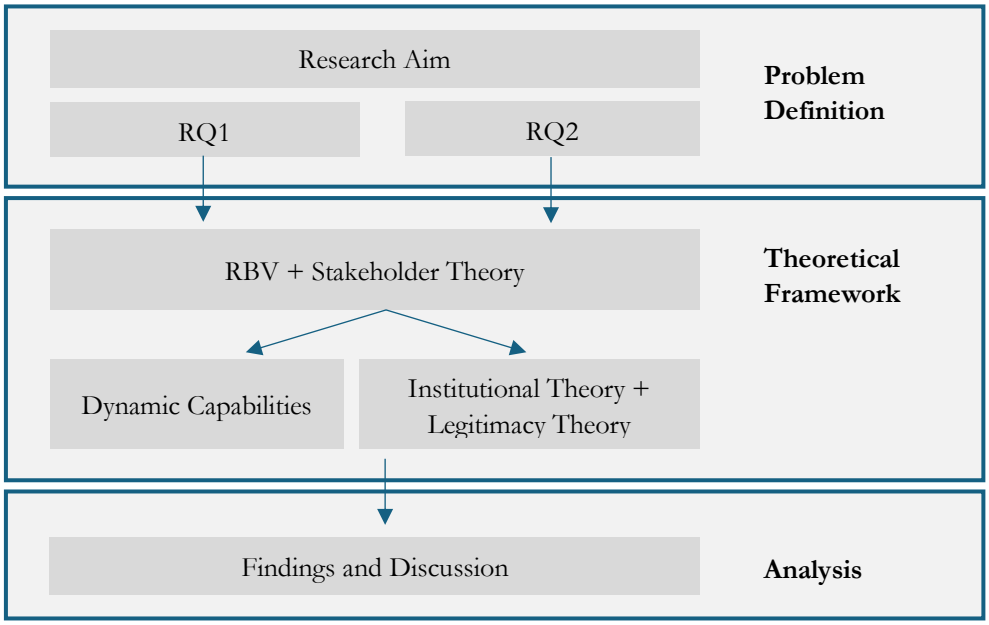

Figure 2-4 "Analytical Framework" (author's own)

The *Resource-based View Theory* was introduced in the 1980s by researchers including Wernerfelt (1984), Barney and Arikan (2005), and Mahoney and Pandian (1992). According to them, the RBV theory emphases the importance of a business organisation's capabilities in achieving and maintaining competitive advantages. Russo and Fouts (1997) build upon the RBV theory and hypothesis and then find evidence that enhanced environmental performance correlates with higher profitability for a company, even considering a higher initial cost. The two academics even highlight that the effectiveness in achieving a competitive advantage is even more pronounced in growing industries, such as aviation.

By applying the RBV to the research questions, a comprehensive analysis can be conducted to determine how Icelandair's internal and external resources and capabilities affect its ability to comply with the EU SAF mandate. This analysis helps identify ways to manage or develop the above-mentioned resources for both competitive advantage and compliance. Using this approach, Icelandair can assess the challenges and opportunities the mandate presents while considering its unique context and the broader stakeholder landscape.

Following the RBV theory for RQ1 leads to identifying Icelandair's distinct resources and capabilities that can be leveraged or further developed to fulfil the EU SAF mandate. Physical resources, such as access to the SAF, intangible resource, like the influence Icelandair can exert, and organisational resources, like the dialogue with policymakers or partnerships with SAF manufacturers or fuel suppliers, are the most salient. Furthermore, by analysing how Icelandair is preparing for the implementation of the Regulation and the way it is allocating its resources, the RBV contributes to an improved understanding of how the airline will be affected by the EU SAF mandate and whether Icelandair can gain further competitive advantage through partnerships with SAF manufacturers, influence on decision-making processes or further innovation regarding the efficiency of its aircraft. RBV also assesses whether complying with

the Regulation will further differentiate Icelandair from its competitors, particularly American-based airlines, and thus help the Icelandair enhance its brand reputation, strengthen customer loyalty, and attract new customers. Finally, concerning RQ1, looking at the data collected through the RBV lens would allow for the identification of any gaps in Icelandair's current resources that need to be addressed to comply with the SAF mandate.

RQ1 is also analysed through the lens of dynamic capabilities. *Dynamic capabilities* refer to the capacity to combine, develop, and rearrange internal and external skills to adapt to quickly evolving business contexts (Teece & Pisano, 2003). In the aviation industry, dynamic capabilities are of paramount importance, particularly in reducing the environmental impact of anthropic activities. Walls & Wittmer (2022) apply the concept of dynamic capabilities to sustainable aviation and argue that companies should not wait for regulatory bodies to approve sustainability policy instruments. This proactive approach can provide more certainty and comfort with the unknowns of a more uncertain future. Walls & Wittmer (2022) suggest that airlines should aim to become agile and flexible organisations to adapt more effectively to a rapidly changing landscape.

RBV and Stakeholder theory are selected as the most suitable theoretical frameworks to address RQ2. RBV identifies the critical resources and capabilities of Icelandair's stakeholders, enabling a reliable comparison across companies and organisations regarding the EU SAF mandate. Stakeholder theory, as outlined by Freeman et al. (2021), complements RBV by emphasising normativity, sustainability, and cooperation. This theory aids companies in making strategic decisions and forecasting, important as the ReFuelEU is set to be implemented in 2025. It also enhances RBV by prioritising sustainability as a competitive advantage and improving stakeholder relationships. Additionally, it introduces the concept of sustainable cooperation, crucial in the tightly knit and dependent relationships within the aviation and SAF supply chains.

Additionally, the legitimacy theory is applied to RQ2. O'Donovan (2002) defines *legitimacy theory* as the postulation that corporations must conduct themselves to align with societal norms of acceptable behaviour to operate effectively. Therefore, to achieve its primary purpose, namely, to generate acceptable returns for its shareholders, a company must comply with societal norms. This phenomenon has been broadly observed over the past decade. Well-established companies are implementing more ambitious sustainable strategies not only to reduce their environmental impact but also to reinforce their societal acceptability and, thus, strengthen their brands (Nylund et al., 2021). The aviation industry is beginning to follow a similar trajectory. The pressure to reduce emissions on airlines and other stakeholders isn't solely institutional; it also encompasses a significant social dimension that demands attention. (Koistinen et al., 2019; Rademaker, 2020).

Finally, institutional theory has been considered mainly for RQ2. According to Oliver (1991), institutional theory traditionally emphasised the extent to which organisations conform to external pressures due to the taken-for-granted nature of institutional norms, myths, and beliefs. However, the researcher extends this view in her paper by suggesting that organisations do not merely passively conform to these pressures. Instead, they can exhibit a spectrum of strategic responses based on various factors, such as the nature of the institutional pressure, the organisation's relationship with institutional constituents, and the perceived benefits of compliance versus resistance. Based on Oliver's (1991) theory, this approach provides a robust framework for understanding the complex dynamics of external pressures affecting stakeholder strategies in response to the EU SAF mandate.

3 Research Design, Materials and Methods

This chapter presents the methodologies used in the thesis. The description of the research design and methods aims to help the reader approach the findings in Chapter 4 and put them into the pertinent perspective. Additionally, it aims to provide clarity and credibility to the research conducted. The chapter presents the research design's characteristics and outlines the various steps undertaken during the study. Consequently, the description of the case study approach is introduced, starting with the relevant theoretical knowledge, and elaborating on the correlation with the specific case the research addresses. The data collection and analysis methods are then described and justified in relation to the research aim and questions. The chapter ends with a discussion of relevant ethical considerations and the role of the researcher throughout the thesis project.

3.1 Research design

As the research aims to analyse the impact the introduction of the EU SAF blending mandate will have on the operations of a specific airline, operating in a definite geographical setting, a *qualitative approach* is adopted, and an *exploratory single case study* design is followed.

A qualitative approach was deemed to be the most suitable for achieving the research objective of the thesis. It allows for the exploration of topics, situations, or contexts that are still under-researched or, as in this case, are very recent developments. Faced with such a new and still very undefined landscape, it is of primary importance to collect data and information directly from the individuals working and operating in or around the focal issue of the research. To understand the reception of the introduction of a radical change for European aviation, it is necessary to explore and identify the concerns, perceptions, predictions, and expectations of practitioners working in companies or organisations involved in the production, procurement, regulation and consumption of SAF.

For the reasons listed above, the study adopts an exploratory approach to understand and analyse an area that is not yet clear, with no predetermined expectations or outcomes. The aim is to enable and possibly stimulate future research on this topic by providing a preliminary understanding of this emerging phenomenon.

The research approach outlined follows the worldview defined as '*constructivism'*. This worldview would advocate for examining different perceptions, insights and experiences of the focus airline, its supply chain of SAF and other critical stakeholders that will be affected in different manners by the implementation of the Regulation. Creswell & Creswell's (2018) 'constructivism' recognises that each stakeholder's perception and response could be distinct and valuable, depending on their experiences and contexts. This perspective allows for a comprehensive and detailed understanding of the challenges and opportunities the SAF mandate will entail. Furthermore, this worldview is considered by the two authors to be particularly suited to exploring complex phenomena in a specific context, as in the case of an airline operating in a highly competitive market while having to comply with an environmental regulation that applies only in one specific region, the EEA.

The research was conducted starting with a literature review that led to the identification of a gap in the existing literature and the problem definition. Subsequently, the research objective, research questions and methodology were developed. During the data collection process, semi-structured interviews were conducted to obtain primary data and document analysis was undertaken to supplement the data obtained from the interviews. Both primary and secondary data were analysed through a coding process, determined based on the theoretical frameworks

selected for the research. Finally, the interpretation of the findings aimed at linking the result of the coding process with the research questions. From there, the final reflections of the study were drawn. The research design is illustrated in *Figure 3-1* that follows.

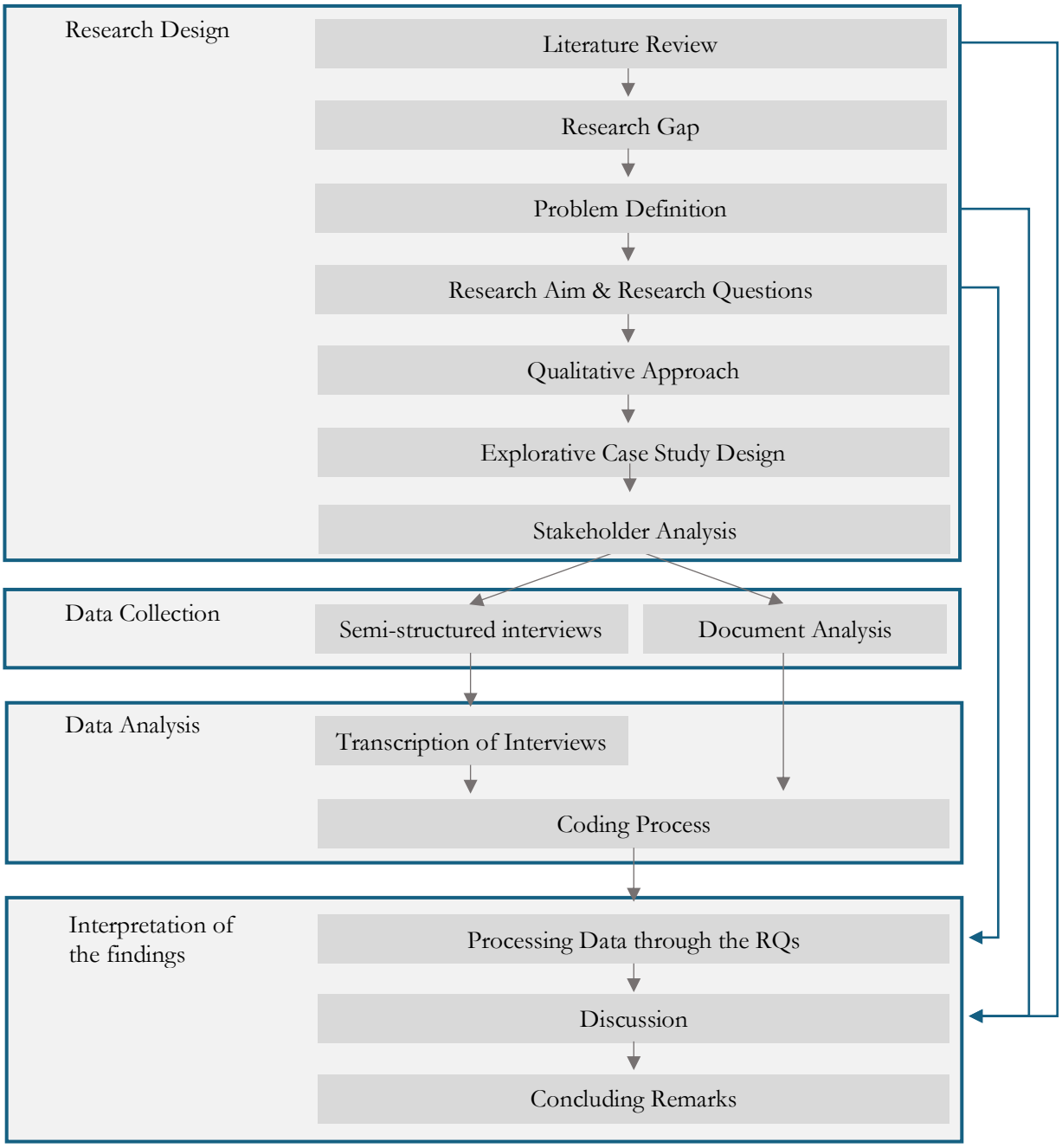

Figure 3-1 "Structure of the research. From research design to findings" , adapted from Ažuolas (2023)

3.1.1 Case Study Approach

The case study approach is one of the most extensively used in qualitative social research (Priya, 2021). It consists in analysing a specific and circumscribed situation and obtaining findings that can be generalised to a larger scale, with possible implications or considerations relevant also for those not directly considered in the study.

According to Yin (2009), a case study is an empirical study of a particular phenomenon or situation in its actual context. To comprehensively study this phenomenon, it is necessary to employ various methods of data collection and focus on a specific context within a defined time frame, as suggested by Creswell & Creswell (2018). This thesis follows an exploratory case study approach, as the research aims to explore a recent phenomenon with many uncertainties and undefined outcomes. This approach is one of three possible types of case studies, the others being explanatory and descriptive (Yin, 2017).

The exploratory case study approach is particularly suited to achieving the research aim due to the vast array of elements to be considered to fully comprehend the challenges and opportunities that the introduction of the EU SAF mandate will pose for the European aviation sector. Focusing on a defined context, such as Iceland, facilitates the identification of fundamental and applied factors and their analysis. While it is substantial to take a holistic perspective of the phenomenon, individual parties will be primary confronted with this impending transition, and the challenges they face are fundamentally of a practical nature. A case study enables researchers to focus on a circumscribed situation and context (Priya, 2021) and identify specifics that other research methods might overlook. Clearly, it is essential that despite the focus on a specific context, the findings can be generalisable. The generalisation of the findings consents the research to have a relevant impact on other contexts and stakeholders not directly involved or addressed in the study (Priya, 2021).

Single case study research presents several limitations. Firstly, case studies are often perceived as deceptively simple, leading to inadequate designs that fail to capture the comprehensive context of the case. It is, therefore, crucial to develop precise RQs, as questions that are too broad or poorly aligned with a case study approach can result in irrelevant findings. Sampling issues arise when convenience dictates sample selection, which can result in superficial analyses. Subjectivity is a significant criticism, as researchers' choices in data collection can introduce bias, compromising the results. Furthermore, establishing validity and reliability is a limitation, as case studies often struggle to ensure that findings are generalisable beyond the specific context. Finally, the subjective nature of case studies limits practical replicability, as other researchers may not be able to replicate the study precisely despite careful documentation due to the high dependency on the context in which the case study was conducted. These limitations underscore the necessity of employing rigorous methodological approaches to enhance the credibility and applicability of case study research (Hunziker & Blankenagel, 2024).

3.2 Methods used to collect data

To address the research aim, data was collected using a tri-fold approach to enhance the robustness, validity, and reliability of the findings. A stakeholder analysis was performed to identify crucial stakeholders to Icelandair and their role in the implementation of the EU SAF mandate. Semi-structured interviews were conducted to gather primary data, while secondary data was obtained through document analysis to complement the information obtained from the interviewees.

3.2.1 Stakeholder analysis

Stakeholder analysis is a collection of methods to gather insights about individuals and organisations. The approach helps to comprehend their actions, motives, interactions, and objectives and evaluate the impact and resources they contribute to decision-making or implementation activities (Varvasovszky & Brugha, 2000). The stakeholder analysis conducted for the purposes of this thesis was not exhaustive nor in-depth; rather, the analysis was

designed to identify the most critical stakeholders related to SAF and Icelandair, and to gain a deeper understanding of their roles and perspectives on the implementation process of ReFuelEU Aviation.

The stakeholder identification process was conducted during the literature review. The thorough examination of academic articles related to the thesis helped identifying the most critical stakeholders to Icelandair and SAF. During this phase of the research process, information was gathered about the stakeholders' relevance to the implementation of the EU SAF mandate and their roles along the SAF supply chain. Used as a leading source, the article by Ahmad & Xu (2021) develops a cognitive mapping of SAF-related stakeholders. The article identifies as critical stakeholders, governmental agencies, and governments, SAF producers, fuel distributors, airlines, and NGOs. These groups were considered the starting point for identifying relevant stakeholders connected directly to the case study of Icelandair. During the preliminary phases of the research, while defining the research aim and conducting initial interviews with practitioners, these general categories were tailored to the context in which Icelandair operates, pinpointing stakeholders surrounding the Icelandic company.

The literature review, followed by interviews with practitioners, facilitated the identification of key stakeholders pertinent to the research. These stakeholders, as depicted in *Figure 3-2*, were then contacted to gather primary data through semi-structured interviews. The only stakeholder group excluded from this process was the customers.

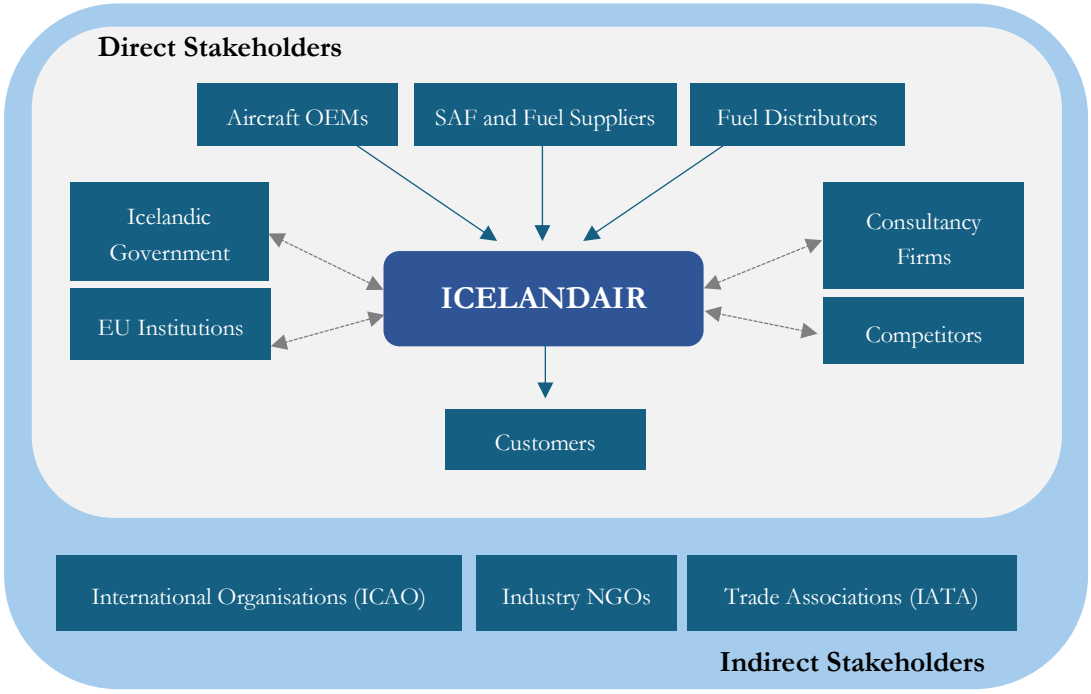

Figure 3-2 "Icelandair's Stakeholders Map" (author's own)

3.2.2 Semi-structured interviews

Qualitative interviews were deemed the most appropriate method for collecting primary data based on the research questions and the nature of the study. This method consists of open questions, few and phrased in such a way as to allow for unrestricted interpretation by the interviewee (Creswell & Creswell, 2018). This approach enables the interviewee to express their ideas and information without undue influence from the interviewer or the questions posed. As mentioned by Ahmad and Xu (2021), semi-structured interviews provide an effective data

collection technique when an emerging phenomenon is at the core of the study. This data collection method, carried with individual respondents, reduce the polarisation that could eventually arise in group judgement approaches.

Seidman (2006) emphasises that the primary manner in which a researcher can investigate and understand a process or phenomenon is through the personal experience of individuals who experience that process or phenomenon first-hand. Furthermore, conducting semi-structured interviews ensures reciprocity between the interviewee and the interviewer. The interviewer can formulate additional questions to obtain more specific information about a given response or to ask for clarification of concepts elaborated by the interviewee (Kallio et al., 2016). This trait enhances the specificity and quality of the information obtained. Despite this degree of flexibility inherent in semi-structured interviews, the backbone of data collection remains the interview guide, which allows similar information to be collected from different actors, making the data gathered more easily comparable (Kallio et al., 2016).

Conducting semi-structured interviews has both advantages and limitations. According to Creswell and Creswell (2018), semi-structured interviews enable the researcher to obtain historical information from participants that may not be available otherwise and ensure that the researcher has control over the nature of the questions. However, the information gathered from interviews may be subject to bias as it is filtered through the interviewer's perspective and presented in a specific context. This context may not accurately reflect the natural setting where the participant typically operates or works. Additionally, the researcher's presence may lead to response distortion, meaning that the information provided may deviate from reality to a greater or lesser extent. Finally, it is essential to note that not all individuals process information orally in the same way. This characteristic can bias how specific sentences are processed and perceived (Creswell & Creswell, 2018).

The selection of participants is crucial as it strongly influences the typology of data collected and, therefore, the study's results. Therefore, in conjunction with the literature review, a careful selection process was undertaken at an early stage. The priorities during this process were to comprehensively include key stakeholders and figures while maintaining a balanced representation of the different stakeholder groups. *Table 3-1* below displays the interviewed actors.

Table 3-1 "List of interviewed stakeholders, role of the interviewee and date"

Resp. no.	Ref. no.	Stakeholder Group	Role/ expertise	Date of the interview
1	**1**	EU Agency	ReFuelEU Aviation Project Manager	18/03/24
2	**2**	SAF producer	Public Affairs Manager Renewable Aviation	20/03/24
3	**2**	SAF producer	Pricing Manager, Renewable Aviation	20/03/24
4	**3**	Focus Company	Senior Treasury & Risk Manager	22/03/24
5	**3**	Focus Company	Sustainability Manager	25/03/24
6	**3**	Focus Company	Sustainable Operations Manager	25/03/24
7	**4**	Consultancy Firm	Project Manager	27/03/24
8	**4**	Consultancy Firm	Unspecified	27/03/24
9	**5**	Icelandic governmental agency	Project Manager	9/04/24
10	**5**	Icelandic governmental agency	Unspecified	9/04/24

The contacted groups were identified by mapping Icelandair's stakeholders involved in or affected by the implementation of the EU SAF mandate. The inclusion interview criteria formulated by Wang et al. (2019) were followed when selecting the potential interviewees within the companies and stakeholder groups identified. The first consideration was the position and responsibilities held within the company. The second factor was the knowledge and experience in the fields of SAF and EU policy instruments. The third and final factor considered was the interviewee's willingness and availability to participate in the interview. This process began by drawing on the article written by Ahmad & Xu (2021). The two researchers developed multi-layer cognitive maps of different stakeholder groups about SAF and its development in their study on stakeholders' perceptions of the SAF. This study has been used as a guideline throughout the literature review to assist in identifying and selecting stakeholders relevant to the implementation of the EU SAF mandate by Icelandair and other relevant players in the Icelandic aviation industry.

3.2.3 Document Analysis

Document analysis is a systematic procedure commonly used in qualitative research to review and evaluate digital and printed documents (Bowen, 2009). Through this analytical method, the researcher must examine and interpret the documents identified to generate robust data that will produce valid research findings (Bowen, 2009). The types of documents that can be included in a document analysis are varied, ranging from corporate sustainability reports, newspaper articles, letters, transcripts of meetings and interviews, press releases, institutional reports, and results of previous surveys (Creswell & Creswell, 2018). This qualitative research method is often combined with other data collection methods, as in the case of this thesis, semi-structured interviews. The theoretical concept of triangulation consists of combining at least two methods within the same research investigating the same phenomenon (Patton, 1999). This process enhances the depth, robustness, and credibility of research results as data can be corroborated or refuted by different sources and methods. Between-method triangulation allows one method to be pitted against the other to maximise the validity of the results (Flick et al., 2004).

When conducting semi-structured interviews, analysing relevant documents can be a helpful supplementary research method (Bowen, 2009). Document analysis can indeed provide additional prompts for questions that could expand the interview guide. Additionally, it could offer supplementary information regarding a similar issue. For instance, the study of different versions of the same documents, such as the sustainability reports of a given company, can yield important data on changes or developments within the company in question, such as the priority given to the environmental sustainability strategy over the years.

Document analysis presents a combination of advantages and limitations. The researchers can access documents at their convenience, allowing for careful analysis at various times. Additionally, documents often contain information the author or client intended to highlight. This provides the researcher with information, as it allows them to understand priorities or shortcomings by focusing only on what is included or omitted and the form in which the data is presented. However, accessing the necessary research documents can be challenging as they may be protected or restricted. In addition, researchers may face challenges locating necessary information, which may be available in digital and physical formats that are difficult to access. It is important to note that the information obtained from consulted documents may be incomplete, inauthentic, or false.

In this thesis, 10 documents were included in the analysis. These are mainly institutional reports, legal texts, position papers, public statements, and sustainability reports of crucial

stakeholders along the supply chain of SAF and its distribution in Iceland. *Table 3-2* below lists the documents analysed, the type of documents they are, and the stakeholder group to which they belong.

Table 3-2 "List of documents reviewed for secondary data analysis"

Ref. No.	Stakeholder Group	Type of Doc.	Title	Publishing date
1	Icelandic Government	Position Paper	Iceland position on ETS Aviation and ReFuelEU Aviation	2022
2	Airline Association	Press Release	Agreement on ReFuelEU is a step forward in letting SAF flow in Europe	2023
3	Airline Association	Public Statement	EU Parliament vote approving SAF allowances in EU ETS is important step for aviation decarbonisation	2023
4	SAF Producer	Blogpost	Disentangling ReFuelEU: How will it shape the SAF market?	2023
5	Trade Association	Public Statement	Statement on Refuel EU Proposals	2023
6	OEM	Public Statement	Contribution on the Net Zero Industry Act	2023
7	Focus Company	Sustainability Report	Icelandair Sustainability Report 2022	2023
8	Focus Company	Sustainability Report	Icelandair Sustainability Report 2023	2024
9	Competitor Airline	Policy Brief	Turning the tide for European aviation	2024
10	Competitor Airline	Position Paper	EU Policy priorities 2024-2029	2024

3.3 Methods used to process information: Data Analysis

Qualitative data analysis consists of making sense of the information collected through interviews and document analysis in the previous stages of research (Wholey et al., 2010). This process requires segmenting, disaggregating and reassembling the collected data in a transversal format (Creswell & Creswell, 2018). These steps are essential for identifying and highlighting the central themes that emerged during data collection. When properly conducted, data analysis creates a solid foundation for processing research findings and reaching conclusions.

This thesis conducts a conceptual content analysis using the NVivo platform. The analysis determines the occurrence of words or concepts in the analysed texts (Carley, 1990). The focus is on extracting explicit concepts (Carley, 1990) to reduce potential researcher bias and remain consistent with the information provided by the interviewees. The NVivo platform was utilised to expedite the timeframe of a manually conducted qualitative data analysis (Creswell & Creswell, 2018) and to enhance the consistency and integrity of the process. Furthermore, using computer software programmes for data analysis enables more efficient collection and retrieval of qualitative data gathered in earlier stages of the research.

The research followed Creswell & Creswell's recommended steps for data analysis. Firstly, the data was organised and prepared for analysis by transcribing the interviews and categorising the documents. Secondly, all the data was reviewed to establish an initial general overview of what had been collected and to reflect on the potential implications of this information.

Thirdly, the coding process began by creating a preliminary set of codes and developing new ones when necessary. This step was conducted as a simultaneous procedure along with the continuation of data collection and the initial write-up of the findings (Creswell & Creswell, 2018). The coding process aimed to describe the central phenomena and identify the main themes that emerged from the interviews and documents. The final step for data analysis was writing a narrative for each of the themes that emerged in preparation for the presentation of the findings and conclusions of the thesis.

3.4 Ethical Considerations and Researcher Reflexivity

The case study of Icelandair and the Icelandic aviation transport industry was identified due to the researcher's previous work experience and this context's unique and favourable characteristics. The researcher conducted a curricular internship at Icelandair's headquarters during the summer of 2023 as part of the 'Environmental Management & Policy in Practice - Internship Course' for the MSc in Environmental Management and Policy, which concluded with the writing of this thesis. This experience provided a comprehensive understanding of the airline organisation, particularly sustainability and procurement strategies. In addition, the Icelandic context, being undersized and relatively circumscribed, facilitated the identification of key parties and the understanding of the dynamics between stakeholders such as government, airlines, partners, and suppliers. These specificities allowed quicker and more effective access to the necessary connections to a range of critical actors to achieve the research objective. The case study of Icelandair facilitated the identification of circumstances or problems that would be less noticeable in a less unique or extreme context.

The topic for the thesis has been discussed and elaborated directly with Icelandair. However, the thesis project operates independently and does not receive funding or support from Icelandair or any other corporate or organisational entities. The researcher's involvement with Icelandair does not extend to employment, nondisclosure agreements, or any kind of formal collaboration. The selection of Icelandair as the focus company for the case study is solely based on the unique geographical position of its main hub and its peculiar business strategy, making it a particularly insightful case within the scope of this research. Nonetheless, considering the strict relationship with Icelandair and their interests in the topic, the researcher is aware that the airline could potentially influence the analysis and conclusions. However, all everything possible has been done to prevent this from happening.

Considering the aviation industry's renowned competitiveness and the sensitiveness of some of the data used, the researcher will be meticulous when managing the data and writing the final thesis. All interviews preserve each interviewee's anonymity, and no sensitive information is disclosed. As for the data that Icelandair provided, only data already available to the public or not sensitive are included in the research. This precaution was taken to prevent all the participants and data providers from suffering any disadvantages or damage from participating in the study.

Furthermore, the researcher contacted the interviewees directly or through contacts within Icelandair. However, the voluntariness of participation was strictly granted. The researcher is aware of the potential sensitivity of some research results; therefore, every measure was taken to avoid the results harming the reputation, dignity, or privacy of the interviewees or the companies they work for. In the Appendix, a copy of the Participant Consent Form is provided.

4 Study Results & Analysis

This chapter presents the research findings for the two RQs. Accordingly, the chapter is divided into two parts. The first section, '4.1 Impact of ReFuelEU on Icelandair and the Icelandic aviation industry', addresses RQ1. The subsequent section, '4.2 Stakeholder Perspectives and Compliance Preparedness for ReFuelEU', presents the results related to RQ2. Both sections are structured based on the theoretical framework presented earlier in section 2.2 'Theoretical Framework'.

The first part of the chapter reviews the impact of the implementation process of Regulation (EU) 2023/2405 on Icelandair and the Icelandic aviation industry. Additionally, it considers the consequences of the EU SAF mandate, which will kick off in January 1, 2025. The following aspects will be presented from the perspective of Icelandair, the company at the centre of the study. The data obtained from interviews with critical stakeholders and analysed documents are reviewed through the lenses of the resource-based view, dynamic capabilities, and legitimacy alignment theories.

The second section of the chapter focuses on the perspective of key stakeholders in the SAF supply chain and how they are approaching the imminent implementation of Regulation (EU) 2023/2405. Unlike the first section, which centres on Icelandair, this part adopts a broader and more holistic approach. It aims to present the findings to understand the challenges and opportunities presented by the EU SAF mandate and to what extent it will benefit or harm various stakeholder categories.

4.1 Impact of the ReFuelEU on Icelandair and the Icelandic aviation industry

4.1.1 Uncertainties regarding ReFuelEU: three scenarios

The EU SAF mandate is set to be implemented in just a few months, starting January 1, 2025. At that time, producers and suppliers of aviation fuels will be required to supply the quantity of sustainable aviation fuels produced from feedstock and other sources of energy among the ones stated by the EU in RED II. The share of SAF must account for at least 2% of the total kerosene consumption at airports within the EU and the EEA. However, primary data collected from semi-structured interviews reveal a significant degree of uncertainty regarding the mandate. Several strategic stakeholders, and the focus company, Icelandair, are still uncertain about the implications, requirements, and concessions of the Regulation (R3,4,5).

In the unique Icelandic context, this uncertainty is even more pronounced, as the country is a member of the EEA but not the EU and is situated thousands of kilometres from mainland Europe, on the most remote border of the common European market. This situation poses numerous logistical challenges and legal ambiguities, which have not yet been clarified by either the Icelandic government or the EC (R3,4,5).

The primary source of uncertainty in Iceland's commercial aviation sector concerns the likelihood of aviation fuel production and distribution companies utilising the flexibility mechanism outlined in Article 15 of the Regulation. This mechanism grants individual distributors and producers the discretion to employ it, yet questions remain about the specific methods for its implementation and the recipients eligible for it. In essence, the flexibility mechanism was crafted to address the logistical and economic hurdles encountered by producers and distributors of SAF and jet fuel. From an infrastructure and logistical standpoint, supplying every airport falling under the Regulation's criteria could prove

challenging. Therefore, to better align with the interests of fuel producers and suppliers and stimulate increased SAF production, the flexibility mechanism permits the possibility of not supplying SAF only to major Union airports. Instead, the Regulation mandates that 2% of SAF be supplied to the European aviation fuel market, irrespective of the airport's location where it is physically distributed. In practical terms, companies producing SAF, such as BP, Shell, or Eni, can choose to distribute sustainable fuels solely to airports closest to their SAF refineries. This approach reduces distribution costs and diminishes the CO_2e emissions associated with transporting SAF by road or sea (R1).

Regarding the specific case of Icelandair, respondents from Icelandair conveyed that there is a concrete possibility that SAF would not be supplied at Keflavík Airport (KEF) due to the flexibility mechanism. Indeed, the flexibility mechanism does not oblige the fuel supplier to import or mix SAF into the Icelandic distribution pipelines. The absence of such an obligation raises substantial uncertainties for Icelandair and other Icelandic airlines, particularly regarding the potential cost implications and environmental impact of either including SAF or continuing without it in the fuel mix at KEF. Furthermore, the respondents (R3) highlighted the yet to be determined position of national government, noting that the adoption of the ReFuelEU regulations into Icelandic law has not yet occurred. The legislative adoption of the Regulation is crucial as it would dictate the conditions under which SAF might eventually be mandated, significantly affecting both logistical considerations and policy compliance.

While the flexibility mechanism's availability is explicitly stated in the Regulation, there is still a lot of uncertainty on the interpretation of regulatory language. In particular, it is still unclear how the mechanism applies to fuel suppliers and distributors. This lack of clarity is a pressing issue that needs to be addressed, as it could significantly impact the implementation of the mandate, not only in Iceland but in many other EEA Member States. A specific point of ambiguity involves whether a single entity can operate across multiple countries under a unified identity or if distinct identification numbers are required for each country to facilitate the movement of fuel to designated 'duty points' (R5). As a result, it is unclear whether the percentage of SAF fed into the system should be at least 2% for each distinct identification number. In this scenario, each company distributing or producing SAF should distribute 2% in each market where it operates with different identification numbers. At the same time, there is the eventuality that these identification numbers will be unified on a European level, making the flexibility mechanism feasible on the whole scale of the EEA aviation fuel market. These different interpretations of Art. 15 of the Regulation would make a substantial difference for Iceland since that would mean whether SAF will be provided to KEF. A respondent (R5) expressed a need for clarity on these issues, indicating a significant gap in understanding how these regulations apply in practical, transnational contexts, which needs to be addressed to better comprehend the scope of the regulatory flexibility.

To address the numerous uncertainties and ambiguities in the text of the Regulation (R3,4,5), the EC is compelled to provide further information regarding the flexibility mechanism by July 1, 2024, after the submission of this thesis. In the meantime, over the coming months, the Commission and various European industry associations are holding workshops and conferences with airlines and other key stakeholders to discuss the most sensitive points of the EU SAF mandate and to clarify the aspects that generate uncertainty (R5).

Based on discussions with the interviewees, three different scenarios have been identified that could unfold from 2025 and during the initial phases of the EU SAF mandate's implementation. These scenarios all revolve around the potential application of the flexibility mechanism in Iceland and, if utilised, how it might be applied. The first scenario is

characterised by the adoption of the flexibility mechanism as outlined in the Regulation, leading to the likely deficiency of physical SAF at Icelandic airports. The second scenario predicts the implementation of the flexibility mechanism within the Icelandic context, supported by the introduction of a book-and-claim scheme and a revision of the relations and interconnections between ReFuelEU, EU ETS, and ICAO CORSIA. The third scenario envisages a situation where the flexibility mechanism is not adopted for Iceland, resulting in aviation fuel companies supplying SAF that is either pre-mixed or blended by fuel distributors directly at Icelandic facilities.

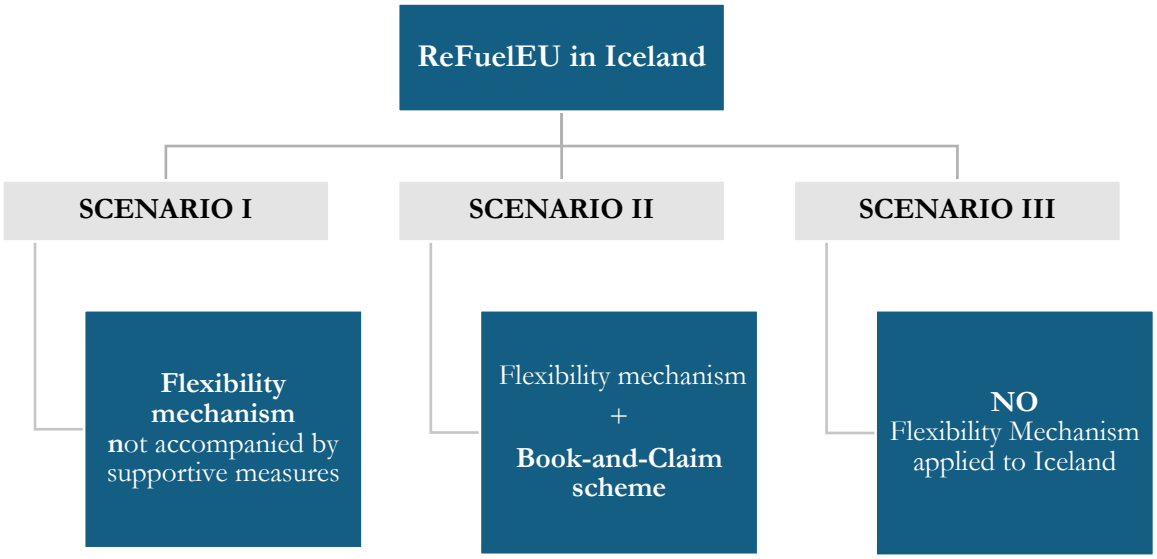

Figure 4-1 "Three scenarios for the implementation of the ReFuelEU in Iceland" (author's own)

Scenario I

The first scenario envisages that the flexibility mechanism, as delineated in Article 15 of Regulation (EU) 2023/2405, will be upheld. This provision allows aviation fuel distributors to meet the minimum required quantities of SAF through a weighted average across all aviation fuel distributed at various EU airports until December 31, 2034. However, this scenario does not include a book-and-claim scheme. Consequently, airlines that do not refuel at airports distributing SAF in its physical form would not be able to claim that they have SAF in their flights, nor would they benefit from incentives under other policy schemes aimed at reducing the environmental impact of aviation, notably the EU ETS Aviation. This arrangement would additionally prevent airlines from reducing their in-flight emissions through SAF, as they would refuel solely with fossil Jet-A1.

In the first scenario, the adoption of the flexibility mechanism is intended in a transnational approach, meaning that the total amount of aviation fuel used at all Union airports would serve as a reference value for the 2% SAF blending, as previously discussed. This scenario is based on the perception of specific stakeholder groups conjuring that the availability of SAF at the principal international Icelandic airport, KEF, does not represent a significant concern for EU policymakers and aviation fuel suppliers as long as the overall fuel mixture complies with ReFuelEU Regulation (R4). This observation extends to a scenario where Icelandair might operate solely between KEF and other airports devoid of physical SAF. In such cases, the absence of sustainable fuel in Icelandair's operations would likely be overlooked, provided that the cumulative fuel composition mix supplied within the EEA meets the stipulated EU mandate. This scenario would indicate a focus on compliance at a broader regulatory level

rather than the specific airports and fuel suppliers. This approach is undoubtedly a priori justifiable, given that the EC's sine qua non-objective is to mitigate the environmental impact of European aviation without compromising the single market's internal competitiveness.

In the event that this scenario occurs, it would be reasonable to conclude that it is a favourable situation for Icelandair and the Icelandic aviation market more generally. Indeed, should SAF not be physically distributed in Iceland, Icelandair's competitive advantage would not only not be affected but could even be strengthened thanks to lower operating costs compared to other airlines that have to cover the same routes but without stopovers (R3). On transatlantic routes, taking Amsterdam Schiphol-New York (AMS-JFK) as an example, Icelandair should only be supplied with SAF on the first short route between Amsterdam and Reykjavik (KEF) as a departing airport subject to the EU SAF mandate. In fact, Amsterdam Schiphol Airport in the Netherlands regularly offers SAF to departing aircraft, so it is very likely that this will continue after January 2025. In the second part of the route, KEF-JFK, if SAF were not distributed to KEF, the aircraft would take off with only fossil kerosene, reducing operating costs. By contrast, a flight operated by another company covering the same route (AMS-JFK) without making any stopovers would not be subject to the same conditions. The second company should purchase physical SAF at the departure airport (AMS) and cover a much longer route at a higher cost. Indeed, Icelandair would only be obligated to conform to the baseline requirements up to Iceland. For instance, if only a mix of 90% conventional fuel and 10% SAF is available at the departure airport, Icelandair would initially incur higher costs. However, they could then negotiate with fuel suppliers to use primarily conventional fuel for the rest of the journey, giving them a fuel pricing advantage. This strategy places Icelandair ahead in fuel management compared to U.S. airlines, which typically fly non-stop from Europe to North America and must use the purchased SAF for the entire route. The stopover in Iceland allows Icelandair to streamline their fuel strategy, unlike European and U.S. airlines that lack this flexibility (R1).

On the other hand, this hypothetical scenario has many disadvantages for Icelandair and other Icelandic airlines. Within the EEA, airlines are required to surrender allowances equal to their emissions, and the allocation of free allowances to airlines granted by the EU ETS is gradually decreasing. The phasing out of free allowances for the aviation sector is expected to happen in 2026. Conversely, in Iceland, the number of free allowances for the Icelandic aviation industry will not be reduced until 2026. The EC recognised the disproportionate economic strain on airlines based in Iceland. Nonetheless, these airlines must also acquire some carbon credits through auctions. The EC has designated 20 million allowances specifically for SAF to be allocated until 2030, thereby enabling airlines to mitigate the financial burden associated with purchasing ETS credits by integrating SAF into their operations. However, this reduction in ETS costs is exclusively linked to the physical delivery of SAF. So, to get this cost difference paid back, there should be SAF physically supplied in Iceland, and if there is flexibility around that system, it's less likely to have physical SAF in KEF; this will be a problem that could compromise this discount scheme (R5). In this specific case, the viability of implementing the flexibility mechanism will depend on the additional cost of EU ETS credits. If these exceed the cost of importing SAF, both pre-mixed and blended in Iceland, and its purchase at the airport by airlines, then the conditions would be met to set aside the flexibility mechanism.

Furthermore, the eventuality for Icelandair to operate multiple flights between airports that do not provide physical SAF could jeopardise the achievement of the environmental objectives set by the company. In its most recent sustainability report, the airline aims to reduce its emissions by 50% by 2030 and become net zero by 2050 (D9). Although Icelandair is rapidly renewing its entire fleet, replacing the old and inefficient Boeing 757-200 and B757-300 with

the state-of-the-art Boeing B737MAX, Airbus A321LR and A321XLR (R3), these replacements alone would not guarantee to achieve the 2050 environmental targets. A crucial part of Icelandair's sustainable strategy is, indeed, the deployment of SAF. In accordance with the guidelines set forth by the IATA, Icelandair anticipates that SAF will account for 65% of the total contribution towards meeting the climate targets for the year 2050. Conversely, the forecasted impact of introducing new technologies, also through fleet renewal, is estimated to be only 13% (D8).

The likelihood of such a scenario becoming a reality is quite remote. For the flexibility mechanism to be effectively implemented, it must be complemented with other support mechanisms, such as a book-and-claim scheme. This arrangement is crucial for the successful implementation of ReFuelEU, ensuring a level playing field within the European common market. Different interviewees emphasised that charging airlines for the fuel mixtures that are actually supplied to the aircraft would result in significant discrepancies (R3,4,5). If, for instance, a SAF-producing company supplies its entire production of SAF only to a limited number of airports in the vicinity of the refineries where SAF is produced, aircraft taking off from these airports will have in their fuel tanks quantities of SAF that could reach 20/30%. Although this results in a significant reduction in CO_2e emissions for that specific flight, which would entitle the aircraft operator to a discount on the EU ETS, the cost of the blended fuel would be considerably higher than that of a flight operating with only 2% SAF (R4). Such discrepancies could have a detrimental impact on the competitiveness of certain commercial routes and potentially on the profitability of the airline concerned (R3,4).

However, it is essential to acknowledge that ReFuelEU has not yet been signed by EEA member states, nor has it been adopted by the Icelandic government. Consequently, despite the low likelihood of the EC advancing this scenario, the national government retains the authority to suspend the EU SAF mandate. This creates a more probable scenario wherein Iceland would, for the time being, not be supplied with SAF (R3,4,5).

Scenario II

In light of the aforementioned considerations, the second scenario presents a situation in which Article 15 is implemented and, as paragraph (2) proposes, the book-and-claim scheme is introduced by the EC. As in the previous scenario, this scheme would permit SAF producer companies to supply sustainable fuel in the most convenient locations. However, a support scheme would be designed to ensure that all flights departing from every airport in the Union are subject to the same operating conditions, regardless of their location or the fuel mix supplied before take-off. This strategy would assist SAF producers and suppliers in mitigating escalating costs while concurrently providing advantages to airlines by enabling them to operate within a less competitive market for purchasing SAF and in a more level playing field within the EEA.

The second scenario would result in the de facto establishment of an optimal, balanced, and unchanged competitive situation in the European airspace. It would entail the implementation of the SAF mandate at any airport, within the limits set by the Regulation, regardless of location and any infrastructural and economic barriers to physically supplying all flights taking off from these airports with SAF. The book-and-claim scheme would guarantee that all aircraft can directly or indirectly operate flights with 2% SAF in their tanks. Subsequently, this scheme should be incorporated into the EU ETS to ensure the validity of SAF certificates in order to reduce the cost of carbon credits under the implementation of the polluter pays principle of the EU ETS.

In this scenario, Icelandair would be subject to the same conditions as all other European airlines on intra-EEA routes. However, it would be at a relative disadvantage on transatlantic routes. Indeed, if the same conditions were met in Iceland, thanks to the implementation of the book-and-claim scheme, out of the four routes needed to connect CPH to JFK and back, as many as three would be covered under the EU mandate. An Icelandair flight would have to refuel with 2% SAF at its departure airport, AMS in the Netherlands, and then, once it lands in Iceland at KEF, it would refuel with 2% blended SAF again and continue to the US. On the return flight, the first leg would not be covered by ReFuelEU but by US legislation for SAF uptakes. In the US, the primary approach is to financially incentivise SAF producers so that the cost is similar to that of fossil kerosene. This is intended to minimise the disadvantages for airlines, including Icelandair. On the second leg of the return trip, from KEF to AMS, Icelandair's flight will have to refuel with 2% SAF again, following the regulatory impositions regarding antitankering practices.

European, or American airlines operating the same route, AMS-JFK and back, without stopovers, will only be required to comply with the regulatory requirements for 50% of the roundtrip, i.e. only for the first leg from AMS to JFK. On the return, however, there will be no constraints with regard to the blended share of SAF in the fuel the aircraft will uptake before taking off.

The potential impact of the SAF mandate on Icelandair's business strategy is significant. Icelandair's primary business is transatlantic routes with a stopover in Iceland, offering passengers the opportunity to spend days in Iceland before continuing their journey across the Atlantic. The rising operating costs due to the higher price of SAF compared to fossil kerosene could undermine this strategy. As costs increase, Icelandair may need to transition to higher ticket costs, potentially affecting its competitiveness (R3)

However, the EC has acknowledged the possible disadvantages for Iceland in complying with EU environmental policy instruments (R3). For instance, the EU has recognised that Icelandair faces a competitive disadvantage under the EU ETS. This disadvantage arises because direct flights from Europe to the US are currently either exempt from ETS compliance or not subjected to its levies, unlike flights that incorporate stops. Flights operated by Icelandair that make a stopover in KEF are subject to taxation for the part of the journey within the EEA jurisdiction. Consequently, this places Icelandair in a less favourable competitive position relative to its European counterparts, who operate non-stop transatlantic flights. However, this recognition has led to the decision that from 2024 to 2026, Icelandair will be permitted to claim free allowances for the emissions credits it loses, which the EU ETS system depreciates. Since this disadvantage has been noticed and corrected, it is plausible that something similar might happen also for the EU SAF mandate.

Scenario III

The third scenario envisages that the flexibility mechanism will not be applied to Iceland. This scenario could occur for two distinct reasons. First, SAF producers and distributors might deliberately choose to supply Icelandic airports with sustainable fuels, even though they are not obligated to do so. Second, the flexibility mechanism might be interpreted by the EC as a more valid mechanism at the national level rather than transnationally, across the EU (R5). Under these circumstances, each state would be required to include 2% SAF in its aviation fuel mix. Consequently, Iceland would need to adapt to this norm, rendering the flexibility mechanism inapplicable within the Icelandic national territory since the majority of flights and aviation fuel consumption in Iceland occurs at a single airport, KEF (R3).

In this scenario, the consequences for Icelandair would be very similar to the ones described in Scenario II. In fact, it would not make a difference for the airline whether the aircraft were physically filled with SAF or if certificates had been acquired ensuring that the flight was operated indirectly through the purchase of the available fuel mix at the given airport, likely containing 2% SAF. There would also be no change in the quantity of Scope 1 emissions released during flights, as the book-and-claim scheme would obviate the need to physically refuel with SAF in order to reduce direct emissions.

This scenario could potentially enhance the establishment of facilities for the production of SAF in Iceland, particularly those fuels produced via Fischer-Tropsch synthesis, which demands substantial energy inputs. Notably, experimental initiatives for the production of electro fuels (e.g., eSAF) are underway (R3,5), leveraging Iceland's abundant renewable resources, including hydroelectric and geothermal energy. Under this framework, Icelandair could emerge as the principal purchaser of eSAF, cultivating a dependable, secure, and transparent supply chain for sustainable fuels. Nevertheless, the feasibility of such developments remains speculative, given the early stage of these projects and the significant energy requirements that a large-scale eSAF production facility might entail. Indeed, the electrical demand for such an operation could surpass Iceland's current production capabilities. Further analysis of this prospect is discussed in subsequent sections of this thesis' results.

On the negative side, in this scenario, the EU SAF mandate would lead to a reduction in Icelandair's competitive advantage on transatlantic routes, increasing operational costs related to the higher cost of the fuel mix supplied at the AMS and KEF airports, using again the AMS-JFK route as an example. This increase could diminish profit margins or necessitate fare adjustments, potentially affecting the airline's market competitiveness against operators flying directly from one side of the Atlantic to the other.

In summary, while Scenario III advances environmental goals of both Iceland and Icelandair, it introduces significant strategic and financial challenges that Icelandair and other Icelandic carriers must navigate to maintain viability and competitiveness in the increasingly regulated EU aviation industry.

Theory-based considerations

The three potential scenarios present inherently different opportunities and challenges for Icelandair and the Icelandic aviation industry. The Icelandic government and Icelandic airlines will have the insidious task of influencing the EC leveraging on the unique characteristics and context. This effort would be essential to ensure that the most favourable scenario for Iceland can materialise across the entire Union or, at least in the country. An analysis of the different scenarios through the lenses of the RBV theory and Dynamic Capabilities theory reveals the constraints that specific scenarios could inflict on the Icelandic aviation sector and the opportunities it might entail. At the same time, it provides a broader encompassing view of the landscape that might arise within the European aviation, following the final decisions of the EC expected by July 2024 and, consequently, the actual implementation of the mandate.

The analysis reveals the importance of proactive action, regardless of the circumstances that may arise. Initiating action in advance and being prepared when implementing the EU SAF mandate or other policy instrument dramatically facilitates the transition to the new regime in which the companies will operate. Furthermore, acting proactively allows companies to reap more significant benefits. For instance, collaborating with other stakeholders and securing safe and reliable SAF supply chains would benefit both producers of sustainable fuels, creating a

sure demand, and airlines, which will be able to secure SAF at lower prices and remain on track with their strategies to enhance sustainability.

A second element that emerges from the analysis based on the theoretical framework is the importance of maintaining good relations with key stakeholders and entering into agreements with strategic stakeholders, regardless of the scenario that will unfold. Whether or not the flexibility mechanism is implemented in Iceland, Icelandair and the entire Icelandic aviation industry must prepare to deploy infrastructure and organisational structures to deploy SAF in its airport system. This technology is not transitional; it is here to stay and is likely to be the main driver of sustainability in aviation (R1,2,4,5).

The two following tables (*Tables 4-1, 4-2*) schematically present the considerations drawn from each scenario in relation to the theoretical frameworks applied to RQ1.

Table 4-1 "Resource Based View analysis of the three scenarios"

Resource Based View Analysis			
	Scenario I Flexibility mechanism not accompanied by supportive measures.	**Scenario II** Flexibility mechanism + Book-and-Claim scheme	**Scenario III** NO Flexibility Mechanism applied to Iceland
Resource Heterogeneity	Without having to refuel with SAF in KEF, Icelandair may be in a position to operate at lower costs than its European competitors, thereby strengthening its competitiveness on transatlantic routes.	Uneven distribution of physical SAF across different airports within the EU.	Resource distribution would be more homogeneous in the absence of the flexibility mechanism. Every fuel producer or distributor airport must supply the same amount of SAF in every Union airport, ensuring a level playing field within the EEA and a more homogeneous distribution of resources.
Resource Immobility	The geographical context and the differentiated implementation of the EU SAF mandate would make it challenging to transfer material resources, such as access to SAF, between airlines. This situation would result in cost savings for some airlines, but at the same time, it would adversely affect their EU ETS performance and their ability to achieve sustainability targets.	Book-and-claim scheme to addresses the immobility of resources by allowing airlines to claim SAF usage. This mechanism serves to enhance the flexibility of resources and to mitigate barriers to accessing the SAF, thus reducing the immobility of resources among EEA-based airlines.	The implementation of the flexibility mechanism at the national level would oblige Icelandair to almost always refuel with the supplied quota of SAF, which would increase operational costs. This ensures the achievement of its sustainability goals and creates added value through more sustainable flights, a resource that would be difficult for other airlines to replicate.
Sustainable Competitive Advantage	If the cost of fuel without mixed SAF were to be lower, Icelandair would enjoy a significant competitive advantage that would be very difficult to replicate in the absence of a book-and-claim scheme.	Uniform book-and-claim SAF distribution in the EU ensures a level playing field for all airlines. However, Icelandair may face cost disadvantages on transatlantic routes due to SAF's higher operating costs compared to fossil kerosene.	The competitive advantage of Icelandair on transatlantic routes may be eroded by higher fuel costs at European and Icelandic airports. Icelandair should consider developing sustainability and green flights as a unique value proposition to enhance its competitiveness despite higher operational costs.

Table 4-2 "Dynamic Capabilities analysis of the three scenarios"

Dynamic Capabilities Analysis			
	Scenario I	**Scenario II**	**Scenario III**
Sense	Regulatory Sensing: To anticipate further regulatory impacts, monitor changes in the Regulation to understand how these might evolve beyond 2034 and how other countries and airlines within the EEA are adapting. Market Sensing: Stay attuned to competitor responses, especially those operating non-stop transatlantic flights who may face higher operational costs due to mandatory SAF usage.	Regulatory Sensing: Icelandair must monitor the implementation of the book-and-claim scheme across EU countries and assess its impact on costs and competition. Market Sensing: Icelandair must monitor competitors' compliance with regulations and the SAF market, including price fluctuations and availability.	Regulatory Sensing: Staying informed about national implementations of the EU SAF mandate and any subsequent regulatory adjustments is critical. It will allow Icelandair to prepare for compliance and leverage any governmental support for transitioning to SAF. Market Sensing: Icelandair needs to closely monitor developments in local SAF production, including the progress of experimental initiatives related to eSAF. Sensing these local dynamics can help the airline anticipate fuel availability and pricing changes.
Seize	Icelandair should seize the opportunity presented by the absence of SAF at its hub to negotiate contracts with fuel suppliers aiming for lower costs compared to the SAF blend distributed throughout the rest of Europe. This would strengthen the company's competitive advantage.	The Book-and-Claim scheme enables Icelandair to claim the use of SAF without necessarily refuelling with it physically. The airline must manage these claims effectively to ensure compliance and to optimise the cost benefits related to carbon credits under the EU ETS.	Icelandair must manage the usage of SAF effectively to ensure compliance with different policy instruments and to optimise the cost benefits related to additional allowances under the EU ETS. The company should pursue agreements with SAF producers in Iceland and abroad to guarantee a reliable supply of blended fuel at competitive prices, thereby mitigating the impact on its competitiveness.
Transform	The company should adapt its sustainability strategy to focus on alternative sustainable technologies to SAF during the period in which the flexibility mechanism is viable. This could include investing more in optimising flight routes and enhancing capabilities in tracking and reporting emissions to ensure compliance with the EU ETS.	Icelandair may need to modify its refuelling strategy and route planning to reduce the costs associated with higher-priced SAF. By leveraging the enhanced sustainability of its operations through the use of SAF, the company can strengthen its brand reputation vis-à-vis non-EEA airlines and attract more environmentally conscious consumers. Continual modernisation of the fleet to enhance fuel efficiency. This transformation will not only comply with regulatory demands	Icelandair may need to modify its refuelling strategy and route planning to reduce the costs associated with higher-priced SAF. Adopt a more proactive approach in securing new fuel contracts to acquire specific qualities of SAF, which will result in a more significant reduction of its GHG emissions. By leveraging the enhanced sustainability of its operations through the use of SAF, the company can strengthen its brand reputation vis-à-vis non-EEA airlines and attract more environmentally conscious consumers.

		but also improve operational efficiency in the long run.	Continual modernisation of the fleet to enhance fuel efficiency. This transformation will not only comply with regulatory demands but also improve operational efficiency in the long run.

4.1.2 Role and Resources of Icelandair

As shown schematically in the two tables above and presented in the previous section, the consequences for Icelandair and the Icelandic aviation industry will be profoundly different depending on which of the three scenarios materialises. The potential outcomes for Icelandic airlines range from the possibility of gaining competitive advantage in the European market due to the differentiated implementation of the Regulation (*Scenario I*) to the eventuality of ReFuelEU becoming a hindrance to maintaining the competitive advantage that has been built up over the years thanks to Icelandair's unique market and operational strategy (*Scenario II, III*).

From the standpoint of the airline and other stakeholders affected by Regulation, it is evident that having a clear, foresighted vision of the scenario that will ensue following such a significant change for the industry would be of paramount importance. In this way, companies could better prepare and make the necessary changes to their strategy, make the necessary collaborations and investments. However, it did not occur in this circumstance due to the complexity of the change required to ensure an effective reduction in emissions in an aviation industry that is heavily dependent on fossil energy sources. Moreover, the peculiarities of the sector, among all the pronounced competitiveness not only within the European common market but also with external actors, makes the introduction of an SAF mandate even more delicate. These circumstances have led to the situation in which, less than nine months before the entry into force of the critical Articles 4, 5, 6, 8 and 10 of the Regulation, several uncertainties still remain.

This line of argument may be generalised across a broader spectrum of airlines and other critical stakeholders throughout Europe. If many suppliers and distributors of sustainable fuels adopt the flexibility mechanism, numerous airports, mainly not major international hubs, may not receive physical deliveries of SAF. Consequently, this approach introduces significant uncertainty and logistical challenges for many airlines, complicating their ability to navigate the impending regulatory and operational landscapes.

In the specific context of Icelandair, it is evident that certain scenarios or developments would be advantageous for the airline. In the following paragraphs, Icelandair's characteristics, resources and capabilities will be analysed and compared to the various scenarios presented above in order to examine the direction in which the airline is moving and to understand the changes it is pursuing to its strategy and operations given the implementation of the EU SAF mandate.

Intangible Resources

Icelandair's strategy for deploying sustainable fuels is currently largely determined by the trajectory set by political frameworks in Iceland and in Europe. The airline is striving to meet the requirements imposed by the EU, the Icelandic government, ICAO, and IATA, reacting reflexively to developments around it. This approach is primarily induced by Icelandair's small size and its consequently marginal influence on the European and global aviation industry (R3). In an inherently global industry, carriers with larger fleets, more passengers, higher revenues,

and greater political influence set the direction for the global industry, while smaller players often find themselves compelled to follow in their footsteps. Icelandair occupies the latter role, as with approximately 4.3 million passengers in 2023 and 51 aircraft in its fleet (D9), it represents a minor player in the global aviation industry compared to industry leaders such as Lufthansa, American Airlines, Air China, and KLM-Air France. Indeed, observing how these major air carriers are operating regarding their SAF strategy reveals approaches that are far more proactive and sometimes even anticipatory of the direction policy is taking (D10, 11).

Nevertheless, Icelandair occupies a unique role even when it comes to the influence it exerts. It is, indeed, a medium-sized company within the European and global landscape, yet it is undoubtedly one of the major companies in Iceland, employing more than 3,600 individuals (D8) in a nation of just over 380,000 inhabitants. This distinctive feature renders the case of Icelandair particularly intriguing, as it can be analysed both as an influential actor at the national level and as a follower at the European and global level.

A great example of the influence Icelandair can exert on regulators, are the concessions given to Icelandic companies regarding the EU ETS Aviation. In fact, along with other Icelandic airlines and the Icelandic government, Icelandair has effectively managed to highlight its competitive challenges at the EU level. Icelandic airlines face a significant competitive disadvantage under the EU ETS. In particular, direct flights from Europe to the US are not subject to the same ETS requirements as flights with a stopover, such as those operated by Icelandair via KEF. This regulatory framework places Icelandair at a competitive disadvantage compared to its European counterparts, as flights transiting through Iceland are subject to partial taxation under the ETS. Icelandair has successfully lobbied to have this disadvantage recognised in the regulatory framework. The concessions granted were a crucial step in levelling the playing field for Icelandair with its European and American competitors (R3).

The example demonstrates the influence that Icelandair can exert on the national government and, to certain extent, on the EU. Clearly, the EU is compelled to acknowledge the disadvantaged position within the common market that has been created by policies that fail to consider the consequences on actors operating under unique conditions. A similar situation is likely to arise with the EU SAF mandate.

However, this intangible resource of Icelandair, generated by its uniqueness and the geographic context in which it operates, proves to be a valuable asset primarily in terms of responses to already implemented political instruments. It could be described as a capacity for reactive influence. What Icelandair lacks, owing to its smaller scale within the European aviation landscape, is the capacity for proactive influence. Icelandair does not possess the political clout at the European level to influence the drafting of new environmental policies for aviation or to advocate for the approval of a political instrument that would benefit its commercial or sustainability strategy. It is at least implausible doing so if acting independently. As a consequence, Icelandair's sustainability strategy is fundamentally grounded in the regulatory environment. It is evident that the approval of ReFuelEU has provided a foundational framework for the airline's strategic development of its sustainability strategy. This approach of the airline demonstrates an emphasis on the operational framework that is significantly influenced and contingent on the prevailing political context. As a consequence, the airline is required to adopt a reactive stance in response to external stimuli.

Another crucial aspect for Icelandair is its relationship with the Icelandic government and relevant governmental agencies. A close and collaborative relationship is essential for monitoring exemptions granted to Iceland within the framework of the EU ETS, as well as for

monitoring and responding to upcoming developments related to ReFuelEU (R3). Strong relationships would enable Icelandair to garner institutional support in case the European Commission takes measures that could be disadvantageous for the national airline and the Icelandic aviation industry. Furthermore, as the government is responsible for implementing European regulations into its national law, an open and ongoing dialogue with Icelandair would be beneficial and constructive for both parties.

Physical Resources

The physical resources required by Icelandair to implement the EU SAF mandate are relatively limited. The mandate applies to SAF producers and suppliers and not to airlines. The latter will only have to comply with the new Regulation relating to the prohibition of anti-tanking measures and the obligation to document and report to the EC the quantities of fuel uplifted from EU airports and the quantities and characteristics of SAF carried on board.

This legislative context further justify the reactive approach Icelandair is undertaking. However, this line does not necessarily adversely impact the quality of the airline's sustainable strategy. In fact, within the policy framework defined mainly by ReFuelEU, EU ETS and CORSIA, Icelandair is attempting to define its own strategy and potentially exceed the requirements imposed or the guidelines drawn up (R3). For instance, even though the Regulation does not impose specific mandates on Icelandair, different departments within the company are actively considering and evaluating the implications it will entail for the airline's operations. As the sustainability strategy of the airline evolves, there is an increasing focus on the requirements and opportunities presented by SAF. Specifically, the airline is evaluating the potential benefits of utilising SAF to be compliant with the Regulation but also on a voluntary basis (R3). This strategy allows for the exploration of additional opportunities beyond mere compliance and therefore strengthening the environmental commitment of the airline (R3).

Furthermore, given the considerable uncertainty surrounding ReFuelEU and the actual quantities of SAF that will be available, Icelandair's strategies are still in the process of being outlined and evaluated. As of today, Icelandair is already using SAF, as biofuels are already being distributed at several airports serviced by the carrier. Moreover, the airline has already established concrete objectives within its climate strategy, encompassing emissions reduction targets through the deployment of SAF. However, specifying the exact contribution or percentage of SAF as part of these goals remains uncertain since the precise quantity of SAF in the airline's environmental roadmap is currently being finalised and cannot be definitively quantified at this stage (R3).

Icelandair could follow Lufthansa and KLM-Air France by establishing a secure SAF supply chain to reduce its environmental impact. This would allow the airline to maintain SAF supplies regardless of the EU's upcoming clarifications in July 2024, supporting its sustainability agenda, improving its commercial image, obtaining EU ETS exemptions, and meeting CORSIA targets. In this regard, Icelandair recently signed a Memorandum of understanding (MOU) with Iðunn H2, a potential Icelandic SAF producer (R3). Iðunn H2 is a hydrogen development company establishing a commercial-scale SAF production facility in Iceland and aims to enter the market in 2027. Icelandair firmly believes in such partnerships and collaborations since agreements like this are crucial for SAF producers and the upscaling of their productions. Additionally, Icelandair claims that developing a definitive SAF strategy, including volumes and costs, will facilitate deeper negotiations and potential agreements or offtakes with producers. Nevertheless, it is premature to confirm any specific plans for concrete offtakes at this stage, given the numerous and significant uncertainties surrounding the implementation of the EU mandate in Iceland and at the European level (R3). The prospect of such

collaborations should also be explored with SAF producers outside of Iceland. Although Iceland possesses the potential to produce SAF from renewable sources, such as geothermal and hydroelectric power, the current energy production capacity would not support large-scale SAF production. Therefore, regardless of the scenario, it would be beneficial for the airline to sign MOUs with established SAF producers to ensure a reliable supply. Agreements and collaborations would be advantageous even if the flexibility mechanism is implemented without supportive measures. This approach would be crucial for continuing to work towards the airline's own goals of reducing its environmental impact and safeguarding its reputation in an increasingly climate-aware context, conscious of the aviation industry's significant contribution to anthropogenic greenhouse gas emissions.

As it awaits clarity on the EU mandate, Icelandair is focusing on aspects within its direct control, particularly fleet renewal, which is a major part of its sustainability agenda and, probably, the most significant contribution the airline can autonomously manage to reduce its environmental impact (R3). This strategy outlines the sustainability framework being currently addressed by Icelandair, which centres on emission reduction as a top priority, but within the direct scope and control-range of the company. In four to ten years, the company will manage to upgrade its fleet to more sustainable aircraft and potentially include the exploration of electric airplanes for domestic routes. However, the adoption of these new technologies remains exploratory, as the airline assesses all available options for achieving its net-zero target. The financial viability and practical feasibility of these innovations are yet to be determined due to their early development stage (R3).

Organisational Resources

Despite the organisational resources required to implement ReFuelEU and the use of SAF in Icelandair's operations, the uncertainty surrounding the Regulation significantly hinders their identification and deployment. The company has very limited knowledge of the potential risks associated with the EU SAF mandate. As a result, Icelandair lacks the necessary information and data to mitigate the risks that could arise from it. This situation hampers the ability to tackle the implementation of the Regulation practically and concretely.

It is only when the conditions under which the EU SAF mandate will be implemented are clarified that Icelandair will be able to determine how to define and eventually strengthen its organisational resources. Depending on the realisation of one scenario or another, the airline may need to consider revising its contracts with fuel suppliers. Typically, these contracts are renewed every one to two years, so only at a later stage will Icelandair truly know if it will have access to physical SAF at its hub in Keflavík (R3). Should its suppliers be unwilling to provide SAF in Iceland and Icelandair deems it necessary, the airline will be required to take steps to ensure its availability through a reorganisation of its supply chains.

Icelandair is taking a proactive approach to evaluating the financial implications of transitioning from fossil fuels to SAF. This shift is expected to significantly influence the company's cost structure. The airline is actively assessing how to balance the use of SAF with the associated financial implications, aiming to determine the optimal level of SAF utilisation that maximises environmental benefits while minimising cost exposure. Furthermore, Icelandair is exploring potential avenues to offset these costs, such as accessing initiatives, incentive schemes, and SAF allowances, which could help manage the financial burden of transitioning to SAF (R3).

Theory-based considerations

The strategic utilisation of intangible, physical and organisational resources by Icelandair, when analysed through the lenses of RBV and Dynamic Capabilities theories, highlights a complex interplay between influence at a national level and European and global market constraints. Icelandair's intangible assets, such as its ability to secure regulatory concessions like those from the EU ETS, underscore its significance within Iceland and its adeptness at leveraging its unique geographic and political context. This ability allows Icelandair to enact a form of reactive influence, strategically navigating the existing political frameworks to mitigate competitive disadvantages. However, the broader global aviation market dynamics illustrate Icelandair's limited proactive capabilities on a larger scale. Its efforts are shaped mainly by industry leaders, indicating a gap in its strategic capabilities in influencing the drafting and anticipation of new policies. This scenario reflects a need for Icelandair to enhance its dynamic capabilities, moving beyond mere adaptation and towards actively influencing regulatory environments within the limits posed by its relatively small size.

Furthermore, Icelandair is actively pursuing measures to bolster the sustainability of its operations, with a particular focus on initiatives that rely solely on the company's capabilities. Strengthening physical resources such as a more modern and sustainable fleet and improving route management to maximise efficiency and reduce environmental impact are just a few examples of the company's ongoing efforts. However, in a globally oriented industry, intangible resources such as agreements with critical stakeholders and organisational resources are crucial to get as close as possible to reaching the concept of sustainable aviation discussed in the previous section of this thesis.

From a strategic standpoint, Icelandair's current approach reveals a reliance on regulatory frameworks for shaping its sustainability strategies, such as those around SAF. While this reactive stance aligns with the firm's current resource base, the evolving nature of international aviation regulations and sustainability norms presents a crucial opportunity for Icelandair to adopt a more proactive approach to shaping these regulations and norms. Icelandair must transition towards a more proactive engagement in policy shaping and explore broader collaborative efforts to maintain and strengthen its competitive edge. This approach could significantly amplify its influence and strategic positioning both in Europe and globally. This transition would better align Icelandair's strategic initiatives with the dual thrust of RBV and Dynamic Capabilities, focusing not just on leveraging current strengths but also on developing capabilities that foresee and shape future regulatory landscapes and market opportunities.

4.2 Stakeholder Perspectives and Compliance Preparedness for ReFuelEU

This section addresses RQ2 by first presenting the different stakeholder groups considered in the research, their respective perceptions of the EU SAF mandate and the trajectory they are pursuing in anticipation of the 2% SAF blending quota. Secondly, the section delves into a theory-driven analysis of the information on the different stakeholder groups. This includes a comprehensive cross-comparison of the companies and organisations involved in the implementation of the Regulation, aiming to identify the rapports, dynamics, and influence among stakeholder groups.

4.2.1 An overview of Icelandair's key stakeholders and their current stance

This section begins by presenting the perspective of those stakeholders directly affected by the EU SAF mandate, namely aviation fuel producers. It then describes the approach of

Icelandair's competitors, as well as the position and perspective of industry associations and aircraft OEMs. It concludes with the parties responsible for implementing the Regulation: Icelandic governmental agencies and European institutions. By examining the viewpoints of a range of stakeholders, this section aims to provide a comprehensive understanding of the SAF mandate and its impact on the European aviation industry as a whole, while always having the Icelandic context as the primary focus.

Fuel and SAF producers

The two fuel and SAF producers considered in the research perceive the EU SAF mandate favourably, highlighting its positive impact on the European aviation industry and its essential contribution towards sustainable flight practices (R2, D4). They particularly commend ReFuelEU for its ambition to equalise conditions across the aviation and fuel markets, thus preventing excessive fragmentation and potential competitive disadvantages within the EEA. The mandate is praised for its role as a policy instrument, enhancing demand predictability compared to previous incentive-based models, thus offering a stable market and boosting competitiveness. The producers also appreciate the EU's strict compliance mechanisms, noting the positive impact of penalties and mandatory SAF supply if initial quotas are not met, ensuring sustained demand and investment in SAF production (R2, D4).

Both producers advocate for innovative solutions like the proposed book-and-claim scheme, which allows for more flexible compliance and efficient management of SAF allocations, addressing financial and logistical challenges. This aspect is crucial as the uniform SAF supply across all EU airports, despite 50% of aviation fuels is supplied to just ten major airports, adds high costs primarily due to logistical inefficiencies. Addressing this barrier through focused supply could contain costs, making SAF more competitive against fossil fuels (R2, D4).

However, concerns about potential limitations on specific feedstocks for biobased SAF production under "Annex IX" of RED II are raised, suggesting it could hinder the development of a robust SAF supply chain. They argue for a more gradual increase in production targets to align better with incremental production capacities and the substantial investments required for new SAF refineries. Furthermore, the producers are wary of the EC's perceived over-responsiveness to critical NGOs, fearing it could negatively impact policymaking regarding emerging green technologies (R2).

The increasing demand for SAF presents significant challenges, especially with the second phase of the mandate (2030-2035), due to still immature eSAF technologies and intense competition for feedstocks across multiple sectors, complicating the ability to meet stringent future quotas (R2). To counter these challenges, SAF producers recommend introducing a sub-target for advanced bio-based SAF by 2030 to ensure investment signals align with production needs (R2, D4). Extending the SAF allowances program to 2040 would also enhance investment certainty, and allowing member states more flexibility in setting ambitious SAF targets could facilitate progress towards net-zero emissions in aviation while maintaining competitive equality. Additionally, SAF producers have raised concerns regarding the EU SAF mandate's targets. They argue that while the 2025 target is achievable, the 2030 target appears overly ambitious (R2, D4). The challenges stem from working with limited feedstocks and the requirement to significantly ramp up production in large increments, which could pose considerable difficulties. Both producers suggest revising the stepped approach of the mandate to a more gradual increase, better aligning with the incremental growth in production capacities and the highly onerous investments needed to build new SAF refineries.

Although the aviation industry is exploring potentially transformative technologies like electric and hydrogen-powered aircraft, according to fuel producing companies, SAF remains the leading technology due to its compatibility with existing infrastructures and the long operational lifespan of modern aircraft. Thus, while 100% SAF usage remains a future goal, significant advancements are required to make it economically viable. Recognising the foundational role of ReFuelEU, SAF producers call for ongoing adjustments to refine investment certainty, regulatory balance, and logistical efficiencies to successfully implement the SAF mandate.

Industry Associations and Competing Airlines

European airlines and industry associations share a similar perception of ReFuelEU and the proposed changes to the SAF mandate. Their shared priority is to ensure the competitiveness of the airline market, both within the European common market and for European carriers operating on routes outside the EEA. All airlines and associations included in the analysis concur that the EU is progressing in the right direction regarding the transition towards more sustainable flight technologies and operations. However, they also recognise considerable potential for improvement in ensuring commercial competitiveness (D9, D10).

Lufthansa Group (D9) claims that the European aviation industry faces significant challenges due to escalating costs driven by EU policy instruments and the competitive advantages held by carriers outside the EU. The airline states that the EU policy landscape leads to a distortion in the level playing field. In particular, Lufthansa underlines how the EU ETS and ReFuelEU, as currently structured, undermine the competitiveness of EU airlines operating globally. The German carrier claims that the SAF blending mandate disproportionately escalates costs for flights transiting through EU hubs due to the mandatory use of pricier SAF for both long and short-haul flights originating within the EU. Thus, the airline urges the European Commission to address these disparities during the review process of the ReFuelEU to ensure equitable treatment of EU and non-EU carriers.

Air France-KLM (D10) claims that strategies to mitigate the cost disparity of SAF between Europe and other regions are needed, starting with SAF allowances in 2024 and potentially extending to further financial incentives to boost SAF uptake. These measures are crucial as SAF standards in Europe are more stringent than those in regions where SAF is subsidised. Furthermore, the airline considers the availability of SAF in Europe limited and significantly more expensive than conventional kerosene. To address this, Air France-KLM proposes that the EU support SAF technology development under the Net-Zero Industry Act (NZIA) and consider introducing a tradability mechanism like the Book-and-Claim scheme to efficiently manage SAF supply.

The book-and-claim scheme is praised by all airlines and industry associations considered (D9, D10, D2, D5). IATA (D5) claims that although SAF mandates indicate expectations for the market and producers, they may lead to significant cost increases and potentially disproportionately benefit fuel suppliers without a comprehensive policy framework that promotes cost-effective production and flexible supply regulations. Establishing a book-and-claim scheme is essential to facilitate a flexible SAF market throughout the EU. On the same page, A4E (D2) suggests that EU policymakers should advance the development of a leading SAF industry. The EU must approach SAF production with the same framework for other sustainable technologies like wind turbines and solar panels. This approach will support the aviation sector's energy transition while ensuring that air travel remains economically accessible to passengers.

To address the EU mandate's challenges, industry stakeholders recommend essential policy adjustments to ensure competitiveness for EU-based carriers. Proposals include implementing a European Climate Fee on airline tickets, which would fund SAF purchases and help maintain a competitive balance with non-European airlines while reducing carbon leakage. Policies to narrow the cost disparity between conventional kerosene and SAF are also advocated to support increased SAF production. Extending the Carbon Border Adjustment Mechanism (CBAM) to air transportation could harmonise EU emissions reduction efforts with global standards. Following the US example, utilising ETS aviation allowance revenues to subsidise SAF costs and invest in low- and zero-carbon fuel technologies is crucial. These strategies collectively aim to reduce reliance on imported SAF, mitigate environmental impacts, and bolster the sustainability of the European aviation industry.

Furthermore, the two airlines are not just passively adapting to the relevant EU policy framework but are independently spearheading more ambitious sustainability strategies. Lufthansa (D9) is making significant investments in technological advancements, committing to renewing all its fleet with more sustainable aircraft by 2030. Additionally, the German carrier is developing forefront technologies to optimise the aircraft's airflow, decreasing fuel consumption. The Air France-KLM Group (D10) is committed to surpassing the ReFuelEU target by incorporating at least 10% SAF by 2030, exceeding the required 6%. In 2023, the Group nearly doubled its SAF usage from the previous year, solidifying its position as the world's largest SAF consumer. These proactive measures, including operational enhancements and advanced AI-supported eco-piloting techniques, aim to further reduce fuel consumption.

Aircraft original equipment manufacturers

As one of the world's leading aircraft manufacturer, Airbus perceives the upcoming EU SAF mandate as a crucial step towards achieving significant decarbonisation but recognises the need for strategic adjustments to ensure effectiveness and competitiveness (D6).

Airbus advocates recognising SAF as a strategic net zero technology within the NZIA. Under the EU Green Deal umbrella, the NZIA initiative aims to support the production, deployment and supply of net-zero technologies like SAF. The OEM deems this classification necessary to unlock substantial private investments by providing investors with the certainty and visibility needed due to the upcoming EU mandate. The lack of such recognition could hinder the scaling up of SAF production, potentially leading to a new energy dependency in Europe, especially as other regions like the US accelerate their SAF production supported by incentive-based policies. Airbus also supports including liquid hydrogen technologies as net zero technologies, highlighting the essential role of hydrogen in both SAF production and future hydrogen-powered aircraft (D6).

Airbus is proactively preparing for the EU SAF mandate even though it will not be directly affected by it. The OEM advocates for legislative amendments that enhance the scalability of SAF and associated technologies, which is critical for the aviation industry's progression toward net-zero emissions. This strategy consists of endorsing the strategic recognition of crucial technologies in EU legislation and establishing a supportive framework for innovation and investment in sustainable aviation technologies. Additionally, Airbus is engaging in partnerships and forming industry alliances to advance the development of more efficient aircraft. The company reports that its latest generation of aircraft achieves a 20 to 40% reduction in emissions, which is essential to offset the higher costs associated with adopting more expensive SAF, thus alleviating the financial burden on airlines (D6).

Icelandic Institutions

The Icelandic government has numerous concerns and uncertainties regarding EU policies on sustainable aviation despite its commitment to achieving the targets set by the 2015 Paris Agreement and its collaboration with the EU to fight climate change and achieve carbon neutrality by 2040. As previously stated, the role of aviation in Iceland is of particular strategic importance due to the country's geographic location and considering that it contributes to approximately 14% of Iceland's GDP. Consequently, an excessive impact on the Icelandic aviation industry could significantly impact the entire national economic structure. Exactly for this reason, Iceland has grave concerns regarding the proposals on the EU ETS and ReFuelEU aviation (D1). The Icelandic government claims that there is the risk that these policy instruments will have an overly disproportionate effect on the country. According to a study commissioned by the office of the Prime Minister (D1), Iceland will be the most negatively hit by these proposals compared to any other EEA State. The cost per flight of implementing the various policy instruments introduced by the EU would be considerably higher for Icelandic airlines compared to those in other EEA countries, as illustrated in the *Figure 4-2* below (D1).

The Icelandic government claims that in particular the EU SAF mandate is likely to place Icelandic airlines and KEF at a significant competitive disadvantage, threatening strategic transatlantic routes. Additionally, according to Icelandic institutions, the risk of carbon leakage is substantial, as travellers may opt for cheaper flights from carriers outside these regulatory frameworks, undermining the environmental goals of the proposals.

Different stakeholders (R4,5) express mixed perceptions regarding the EU SAF mandate, particularly focusing on the eventuality of the flexibility mechanisms and overall compliance implications. Concerns are raised about the potential for fuel suppliers to opt for flexibility mechanisms that might lead to a lack of physical SAF in Icelandic airports, generating a high degree of uncertainty.

External stakeholders to the Icelandic government (R4) emphasise the fact that, in Iceland, fuel suppliers can offset the cost difference between SAF and conventional fossil fuel through the ETS, provided SAF is physically delivered within the country. This requirement could create challenges considered that the regulatory flexibility would reduce the possibility of having physical SAF in Iceland.

Some stakeholders view the EU SAF mandate as an opportunity to begin production of SAF, particularly eSAF, in Iceland (R4,5). However, there are significant challenges, including the

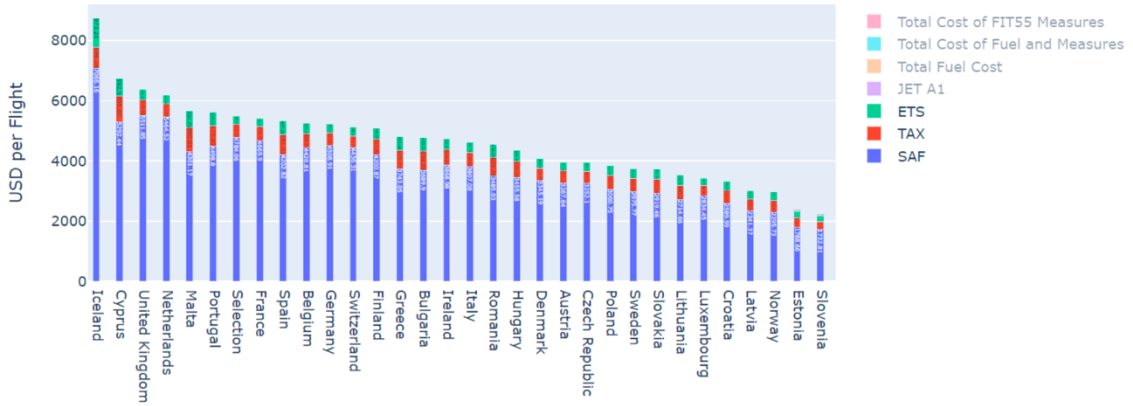

Figure 4-2 "Estimated Average Cost pr. Flight in 2050" , adopted from the office of the Prime Minister of Iceland, (2022).

island's reduced energy production capacity and the potential need to import CO_2 to produce SAF. The costs of establishing a SAF industry in Iceland would be considerable, suggesting that the most economically feasible solution may be to sign agreements with European or US SAF producers and import the already blended fuel, minimising costs and not requiring new infrastructure. However, Iceland could, in the near future, play a strategic role in hydrogen production and the operation of the first transatlantic flights fuelled by this technology. Indeed, some stakeholders (R4) have pointed out that if Iceland were to invest resources and money in sustainable fuels, hydrogen would be the most likely. It is anticipated that early models of hydrogen-powered planes will have a range below 2,000 miles, requiring a stopover to cross the Atlantic. Consequently, KEF would become the ideal location for transatlantic stopovers.

EU Institutions

The specialised EU Agency is currently having a twofold priority (R1). First, it assesses how various obligated entities, particularly fuel suppliers and distributors, comply with the mandate, as stated in Article 5 of the Regulation. This assessment aims to determine the status of various stakeholders in preparing for compliance with ReFuelEU. Secondly, the agency is collecting detailed data that will be shared with relevant institutions, as outlined in Article 13, to help the EU understand the progress of SAF adoption. The data will clarify the speed and extent of SAF implementation and related infrastructure development across the EEA. Thus, an annual report will be drafted to evaluate compliance and provide insights into SAF market growth. Indeed, understanding market trends and developments is crucial for regulators to refine their strategies and make adjustments and corrections if needed.

The EU agency interviewed (R1) views the upcoming EU SAF mandate with cautious optimism. They recognise the mandate's potential to promote sustainable fuel usage within the aviation sector while also acknowledging its geographical limitations and competitive implications. One concern is that airlines may opt for nearby non-EU hubs, like Istanbul, to avoid strict regulations or high compliance costs. They recognise that the transnational dimension of aviation could lead to market distortions, where non-EU carriers gain a competitive edge. The agency suggests that the Regulation needs to align with incentives that bolster the production of SAF and prevent fuel suppliers from simply paying fines instead of adopting SAF.

On the other hand, the respondent (R1) underscores the critical element of the Regulation, which is to establish a harmonised policy landscape across EU member states. This is one of the primary aims of the EU, intending to prevent the proliferation of a regulatory patchwork, where each Member State has different mandates, potentially causing market imbalances. A harmonised market is essential to maintain a level playing field. Additionally, the EU agency stresses the importance of long-term incentives and policies that reassure fuel producers about consistent demand for SAF, encouraging them to invest in its production.

According to the interviewee (R1), European airlines have expressed significant interest in gaining access to SAF. However, when approached, fuel producers often hesitate to invest substantial sums, up to 2 billion euros, into constructing new refineries due to uncertainty around long-term demand for these products. It is therefore reiterated that the objective of ReFuelEU is to guarantee a reliable and predictable demand for SAF, thereby encouraging investment in increased SAF production and the construction of new refineries or the conversion of fossil fuel refineries to renewable fuels.

The EU views SAF as a long-term solution due to the extended lifespan of aircraft and jet engines, which will continue to operate for 20 to 30 years (R1). The prolonged design, testing,

and approval processes for new aircraft further delay the adoption of alternative technologies such as electric or hydrogen-powered planes, which are expected to enter the market around 2030 or 2040. Given the urgent climate challenge, SAF is considered an immediate, cost-effective solution compatible with existing aircraft, unlike the more expensive hydrogen or electric alternatives.

Furthermore, the respondent (R1) claims that, ideally, fuel producers will recognise the SAF mandate as an opportunity to diversify their portfolios. However, it is essential to remain realistic, given that sustainable fuels and renewable energy still constitute a relatively small portion of oil and energy companies' overall business operations. A substantial majority of the revenue of these companies is derived from conventional fuels and refineries producing fossil fuels. Therefore, these regulatory frameworks must adequately address this aspect to ensure effective and equitable implementation of more sustainable energy sources.

4.2.2 Theoretical Considerations on Stakeholder Perspectives

The theoretical framework drafted to analyse and contextualise RQ2 within the academic literature will be employed to analyse and compare the stakeholders' positions, perceptions, and actions. This analysis will seek to identify similarities, differences, and divergences between the various stakeholders comprising the complex implementation system of ReFuelEU.

RBV Analysis

Analysing the different stakeholder's perspectives through the lens of RBV theory offers a sound understanding of how these players in the aviation industry employ their resources to address the challenges posed by the EU SAF mandate. SAF producers recognise the mandate's high potential to improve their competitive positioning and resource capabilities. They aim to further streamline the production and distribution of SAF by lobbying for policy instruments, such as the book-and-claim scheme, to align their operations with demand predictability and market expansion thanks to a homogeneity of resources within the common market. This alignment is consistent with the RBV, as producers strive to manage their resources efficiently to gain a sustainable competitive advantage.

Airlines such as Lufthansa and Air France-KLM follow the RBV framework by optimising internal resources through technological advancements, strategic partnerships, and operational efficiency measures. These airlines leverage specific valuable resources to adapt and thrive under new regulations. They are investing in more sustainable aircraft technologies and beyond compliance SAF usage. This approach is essential to establishing a competitive edge. In fact, these valuable resources enable them to meet regulatory requirements while appealing to increasingly environmentally conscious consumers. Furthermore, accessing and deploying SAF at a competitive cost is a rare capability that can differentiate airlines within the market. Air France-KLM's status as the world's largest SAF consumer indicates a unique positioning that can be difficult for competitors to replicate quickly. The proposed book-and-claim scheme for managing SAF supplies also represents a strategic move to maintain a rare competitive advantage by ensuring more efficient SAF logistics for fuel suppliers and lower costs for airlines.

The analysis of the case of Airbus reveals that the company's inimitable resources are particularly evident and well-preserved. Airbus is at the vanguard of its field regarding the efficiency of current generations of aircraft and research and study on hydrogen-powered aircraft. Consequently, the company is likely attempting to influence political decisions that align with this objective. Indeed, Airbus is leveraging its resources and influence to advocate

for strategically recognising SAF and hydrogen technologies in EU policies. This approach aims to foster investments in sustainable aircraft manufacturing, providing Airbus with a framework that aligns with emerging trends, and secure its competitive positioning, producing ever more efficient aircraft without investing massively in utterly different technology.

Icelandic institutions are emphasising the unique value and strategic positioning of KEF as a critical transatlantic travel hub. They seek regulatory flexibility to retain the airport's resource-based advantage, which aligns with RBV principles. This approach would safeguard Iceland's strategic aviation resources while addressing the EU SAF mandate and enhancing the sustainability of the Icelandic aviation industry. The Icelandic government aims to ensure the heterogeneity of resources across the EEA since they claim that different regions and contexts should be treated differently; otherwise, the consequences would be more severe due to geographical constraints. This stance would indeed guarantee the competitive advantage Icelandic carriers are benefiting from.

Conversely, the EU institutions are working to promote an efficient and effective adoption of the mandate across the EEA. They are currently focusing on optimising their policy resources to create a consistent and predictable regulatory landscape, trying to grant a level playing field. This will give airlines and fuel producers the certainty they need to invest in SAF infrastructure and technologies. The core aim of the EU is to grant a more homogenous distribution of resources across the common market to make it more competitive, thus making it cheaper for consumers and, at the same time, more sustainable.

Legitimacy Theory Analysis

Legitimacy Theory is an essential framework to assess how the stakeholders analysed address the EU SAF mandate. When it comes to environmental policies, many companies and organisations are often driven by the necessity to maintain public approval, align with societal norms and expectations, and safeguard their competitive positions. When it comes to ReFuelEU, there are no differences. All stakeholders involved are willing to pursue more sustainable strategies to legitimate their operations and possibly attract more consumers.

On one end, SAF and fuel producers have enormous pressures on their shoulders in a society increasingly reliant on renewable energy sources. SAF producers must keep up with the increasing demand for sustainable fuels and urgently need to lower operational costs to become more competitive with fossil fuels since, in such a deregulated market as aviation, the ticket fare should not increase excessively. Fossil fuel producers must start transitioning towards more sustainable fuels to legitimise their role in a more sustainable society. They strive to expand their portfolios toward sustainable fuels to meet societal expectations and align with emerging environmental norms. Consequently, public perception and compliance with policy instruments enhancing sustainability are vital to maintaining legitimacy. This proactive approach ensures that even fuel producers are seen as compliant industry leaders, bolsters their reputation in an ever more sustainability-aligned and rapidly changing market.

Similarly, airlines attempt to secure legitimacy through proactive and reactive sustainability efforts that extend beyond simple compliance. Market leader airlines aim to exceed the EU SAF mandate and adopt advanced efficiency measures to showcase their commitment to environmental stewardship, thus granting a more robust public image in an industry that is one of the most unsustainable forms of consumption. On the other hand, airlines advocate for policy changes to ensure SAF mandates do not impair their global competitiveness. This approach demonstrates the willingness of the airlines to align with societal expectations while safeguarding their competitiveness and business strategies.

To showcase the stance of aircraft OEMs, Airbus exemplifies how a corporate strategy can align with societal expectations for decarbonisation by innovating aircraft designs that significantly reduce emissions. The company advocates for policies that sustain sustainability while promoting its business model as the only way to make aviation less environmentally harmful.

The Icelandic institutions aim to legitimise their position by stressing the ReFuelEU's disproportionate effects on the country's economy and competitiveness. They advocate for tailored policies that reflect Iceland's unique aviation landscape. By highlighting these economic vulnerabilities and advocating for regulations that consider their specific challenges, the Icelandic government aims to establish legitimacy as a responsible protector of Iceland's aviation industry while aligning with EU environmental goals.

Together, these stakeholders demonstrate varying strategies under Legitimacy Theory to ensure they maintain public approval while meeting the EU SAF mandate's environmental and regulatory demands. They tailor their approaches to reflect their unique positions and interests, seeking compliance, proactive policy advocacy, and strategic innovation to build legitimacy in an increasingly sustainability-focused aviation landscape.

Institutional Theory Considerations

Fuel and SAF producers, industry associations and airlines, aircraft OEMs, and Icelandic institutions are all shaped by institutional pressures in their approach to the EU SAF mandate.

Fuel and SAF producers strategically align with regulatory demands, perceiving strict quotas and penalties as institutional incentives while advocating for policy adjustments that foster investment certainty and efficient feedstock management. These stakeholders generally comply with EU requirements, supporting innovative compliance solutions like the book-and-claim scheme as a compromise strategy. They recognise institutional mandates but push for mechanisms that offer flexibility, balancing compliance needs against logistical and financial challenges, thus pragmatically adapting to institutional pressures. Additionally, concerns about the limits on biobased SAF production and overly ambitious 2030 targets suggest a form of avoidance, as SAF producers raise these issues to sidestep potential negative impacts of stringent regulations on their operations and long-term planning. Proposals to introduce a sub-target for advanced biobased SAF by 2030 and to expand SAF allowances under the ETS framework represent a manipulation strategy, aiming to influence the regulatory landscape to align with their operational realities and strategic interests, thereby ensuring that the Regulation continues to support sustained investment in SAF technologies.

Industry associations and airlines perceive ReFuelEU as a necessary regulatory framework to drive a more sustainable aviation. Leader airlines' efforts to exceed the EU mandate, like Air France – KLM's SAF target, even demonstrate proactive alignment with broader sustainability norms. Exceeding the mandated requirements reflects an acquiescence strategy, where organisations fully embrace institutional norms to enhance their legitimacy and market position as sustainability leaders. However, the adoption of a compromise strategy also emerges to some extent. The airlines analysed propose solutions that meet regulatory requirements and, at the same time, address their operational concerns, such as advocating for the introduction of a traceability mechanism like the book-and-claim scheme or introducing more stringent measures to avoid favour extra-EEA carriers. This complementary measure to the EU mandate would mitigate some logistical challenges, costs, and risk of losing competitiveness. This approach seeks to balance compliance to the Regulation with operational efficiency and competitiveness.

The aircraft OEM demonstrates acquiescence by recognising ReFuelEU as a crucial step toward significant decarbonisation, even if not directly affected by it. Airbus is generally acceptant and supports the mandate's objectives. By aligning with these institutional norms, Airbus not only sticks to the Regulation but also aligns its corporate strategy with the broader environmental agenda pursued by the EU. At the same time, Airbus' concerns about the lack of recognition for SAF as a strategic net-zero technology hint at a mild form of defiance. Airbus is wary of the consequences that might arise from insufficient legislative support, which could place the European aviation sector at a disadvantage compared to regions like the US, where incentive-based policies boost SAF production. This concern challenges the adequacy and effectiveness of current EU policies in supporting the aviation industry's transition to sustainability. Finally, manipulation is clearly displayed in Airbus' efforts to shape the regulatory environment to support its business and technological advancements. Advocating to include liquid hydrogen technologies and SAF as net zero technologies under the EU Green Deal demonstrates Airbus' intent to influence policy decisions. This strategic manoeuvring aims to ensure that legislative frameworks are favourable and conducive to Airbus' long-term business interests and technological innovations.

The Icelandic government's commitment to achieving the targets set by the 2015 Paris Agreement and its collaborative stance with the EU in fighting climate change represents an acquiescence strategy. By aligning with international climate goals and EU policies, Iceland is showing compliance with the prevailing norms and regulations despite the potential economic impacts these might have on its aviation sector. While aligning their policies with broader EU goals, the Icelandic institutions advocate for exceptions to address Iceland's unique geographical challenges. The concerns expressed about carbon leakage and the fear of losing the competitive advantage on transatlantic routes illustrate an avoidance strategy for some aspects of ReFuelEU and EU ETS. Icelandic institutions are worried about the economic repercussions of these policies. They are seeking ways to mitigate these risks, which might include striving for flexibility in how these policy instruments are implemented to maintain competitiveness. At the same time, a strategic response with a certain extent of manipulation is perceived in how Iceland explores strategic roles in alternative fuel markets, such as hydrogen production, which could position it advantageously in future aviation fuel supply chains.

The analysis reveals a scenario characterised by fragmentation, with different and sometimes conflicting priorities and interests. Nevertheless, all parties concur on the necessity to avoid undermining the competitiveness of the EU commercial aviation sector in pursuit of the EC's climate agenda. All parties considered in the analysis have a priority to maintain their current status and, if possible, improve it. Consequently, there are companies and organisations, typically the most influential due to their strategic nature, who are able to exert pressure to implement the desired changes to the industry's sustainable transition policy approach. Conversely, other stakeholders attempt to capitalise on the prevailing shift in direction and position themselves as leaders in the foreseeable future, even if this entails compromising their own financial resources and strategic plans in the short term. Finally, institutional stakeholders naturally prioritise the competitiveness of their area of competence. The EU and Iceland, therefore, diverge in their priorities and positions. The EU aims to create a level playing field within the EEA, while the Icelandic government focuses on promoting national interests and maximizing its presence in the EEA without harming its economy or companies like Icelandair.

5 Discussion

This section presents the findings of the research on the impact and perceptions of Icelandair and its stakeholders on ReFuelEU, compared to the existing body of academic literature and demonstrate how the research has advanced the understanding of the research problem. Furthermore, the chapter aims to introduce the limitations of the study and RQs' legitimacy.

5.1 Comparative analysis of findings from literature

The study results indicate a general perception of uncertainty regarding the implementation of the EU SAF mandate. This reservation is due to the lack of clarity in the text of the Regulation and the current lack of complementary policy instruments to support the mandate. These shortcomings would risk undermining the competitiveness of the European aviation industry, both within the internal market and against third country carriers. The need for clarity and certainty about the future, which emerged as a dominant theme in both the interviews conducted and the documents analysed, is partially addressed in the academic literature. Ziolkowska et al. (2010) acknowledge the importance for parties to have certainty about the future demand, cost and availability of SAF and, therefore, suggest that a mandate is the most preferable policy instrument as its main feature is to create a steady demand for SAF. However, the fundamental importance of clarity on the part of regulators and the challenges of adapting to a profound policy change such as that driven by ReFuelEU are not sufficiently addressed in the academic literature on SAF and sustainable aviation. At the same time, the study's findings support the assertions of Proost (2024) and Lawrence (2010). Indeed, the two researchers find that mandates are primarily driven by the interests of the various stakeholders, airlines and SAF manufacturers, rather than by considerations of the effectiveness of the instrument. The study results show that most of the stakeholders interviewed are satisfied with the mandate, among other forms of policy intervention, mainly because it will have only a marginal impact on their competitiveness, at least for the time being.

Moreover, the study highlights a gap in the academic literature, which primarily focuses on the upscaling of SAF production and its environmental benefits. There is a lack of research on the practical challenges that airlines, SAF distributors, manufacturers, and national governments would face in implementing the SAF mandate effectively. The study's results indicate that the current SAF production capacity in the EU is sufficient to meet the 2% target for the first phase of the mandate, contradicting some academic articles (Bullerdiek et al., 2021; Grimme, 2023). However, the interviewees and the literature review agree that achieving the subsequent stages of the mandate will be more challenging without increased investment in the future.

Another area of consensus among the practitioners and academic literature is the need for a balanced policy mix to promote aviation industry sustainability without compromising competitiveness. All parties agree with the findings of Jiang & Yang (2021), Ziolkowska et al. (2010), and Proost (2024). Each policy instrument has its limitations and benefits. Therefore, to achieve the dual priorities of the aviation industry, namely profitability and sustainability, a combination of different policy instruments is crucial. This mix could include the SAF mandate, a book and claim mechanism, the EU ETS, CBAM, and fossil fuel taxes.

Icelandair is indubitably undergoing a transformation to comply with the EU SAF mandate. However, in consideration of the aforementioned uncertainties about its implementation, the company predominantly focuses on preparedness for possible scenarios. More tangible actions will be pursued only when the EC clarifies whether the book-and-claim scheme will be granted, whether the flexibility mechanism will be enforced at the Union level or a national level, and even whether the Icelandic government decides to ratify and adopt ReFuelEU or not. These

elements are relatively detached from the academic literature, as they are specific to this situation and the timeframe in which this thesis was written. Nevertheless, the theories considered in the analysis suggest that Icelandair should adopt different approaches to ensure its readiness before 1st January 2025, regardless of the scenario that unfolds. As Teece & Pisano (2003) and Walls & Wittmer (2022) describe in their papers, the capability to adapt to different scenarios is indispensable, especially in a dynamic and competitive industry such as aviation.

Finally, the theoretical framework used to analyse the data collected during the research provides further insight into the motivations behind certain decisions and positions taken by Icelandair and the various stakeholders about ReFuelEU. The primary impetus for sustainable change in the aviation industry remains the need to maintain or increase its competitive advantage. Sustainable innovation is positively embraced only when it provides some sort of economic or competitive advantage.

5.2 Critical reflections on research limitations

The results of this study are heavily influenced by the methodological choices and theoretical framework used. As a result, their reliability and validity are limited.

The first limitation is the choice of Icelandair and the Icelandic aviation industry for the case study, influenced by the researcher's internship with Icelandair in 2023. This prior experience biased the selection, despite potentially more suitable cases for this research. However, direct knowledge of the context was invaluable, enabling direct contact with individuals within the focus company. Without direct contact, accessing a highly competitive sector dominated by large companies would have been more challenging and time-consuming.

Using semi-structured interviews as the primary data collection method introduces biases from both interviewees and interviewers. Interviewees might alter their answers to appear socially acceptable, resulting in data that do not accurately reflect their true opinions or behaviours. Their memories and perceptions can also influence responses, adding subjectivity. Interviewer bias can stem from question wording and response interpretation, with the flexible nature of semi-structured interviews allowing for inconsistent questioning and follow-up, complicating systematic analysis and risking biased conclusions. Additionally, the study's credibility is undermined by the limited number of interviewees, often only one per stakeholder group, which fails to provide a comprehensive overview of the aviation industry's perception of ReFuelEU. To address this, secondary data analysis through document analysis was conducted, but this is constrained by the limited publicly available information from companies and organizations.

Third, the methodological framework adopted, which has a strong business/management orientation, may have led the research to focus mainly on what the company and its various stakeholders are currently doing, excluding important political or social aspects.

Finally, the RQs were considered valid and provided insights that have not been extensively discussed in the extant academic literature. Their purpose was to ensure sufficient detail in the case study while allowing for the generalisability of the findings. RQ1 ensured generalisability since all European and non-EU airlines flying into the EEA will have to deal with the EU mandate to some extent and will be affected by it to varying degrees. RQ2 takes a more general and holistic approach, aiming to map out the different approaches taken by the stakeholders in preparation for the implementation of the Regulation and their perceptions of ReFuelEU. RQ2 inherently produces more generalisable findings.

6 Conclusions

The upcoming EU SAF mandate is poised to significantly impact the EEA aviation industry, including airlines, airports, passengers, and fuel producers. The higher cost of SAF, supply chain reconfigurations, and required operational changes present substantial challenges to the parties involved. Despite the benefits of SAF as a drop-in technology requiring relatively minor operational changes, its integration necessitates significant transformations. The mandate will increase the operational costs for stakeholders due to SAF's higher price and logistical complexities in production and distribution. These challenges are compounded by the absence of economic incentives within the mandate, placing the financial burden predominantly on airlines and passengers. The blended fuel cost increase may impair EEA-based airlines' competitiveness compared to non-EEA competitors, who can maintain lower ticket prices on certain routes. This thesis addressed the gap in the existing academic literature by examining Icelandair and its unique geographical and operational challenges in aligning with the EU SAF mandate. Icelandair's distinctive business strategy, Iceland's reliance on air travel and its geographical context, defined by its location at the border of the EEA, highlight the unique constraints and opportunities the carrier and the national aviation industry face in complying with ReFuelEU and consequently reducing aviation's environmental impact.

The research addressed two research questions to explore the adaptation strategies and perceptions of Icelandair and its stakeholders surrounding the EU SAF mandate:

- **RQ1:** How is Regulation (EU) 2023/2405 introducing the EU SAF mandate affecting the resources and strategy management of Icelandair?

- **RQ2:** How do Icelandair's key stakeholder (e.g. fuel and SAF producing companies, Institutions, other airlines, OEMs…) perceive the upcoming EU SAF mandate and what strategies and approaches are they adopting to prepare for compliance?

The RQs favoured a comprehensive analysis of the operational and strategic challenges posed by the mandate, shedding light on the broader implications for the Icelandic and European aviation industry's shift towards sustainability.

RQ1 concluded that the considerable uncertainty surrounding the Regulation's critical aspects renders it highly complex for Icelandair to prepare for implementation in advance. The potential for a multitude of scenarios to unfold, each with profoundly divergent implications for the focus company and the market in which it operates, also renders it inadvisable to make ex-ante considerations about how the mandate will impact the airline's operations. Consequently, based on the information provided by the interviewees, three potential scenarios were identified, offering a general overview of the potential future challenges that Icelandair may face. Furthermore, the analysis of these scenarios through the lens of the theoretical framework enables the prediction of the potential opportunities and challenges that Icelandair may encounter in each scenario, with the need to maintain the company's competitiveness as the main parameter. The objective of this study is not to prescribe a specific course of action for the focus airline. Instead, it is to present a variety of possible scenarios that can guide decision-making and help apply the findings to similar situations. As many EEA airlines are likely to face similar challenges, the study's findings can support their strategic planning.

RQ2 also concludes by outlining a general sense of uncertainty regarding the imminent implementation of the EU SAF mandate. The response and strategy to adapt to ReFuelEU varies considerably depending on the stakeholder group and the size and influence of the

organisation or company in question. Nevertheless, there is a widespread consensus that such a policy instrument is necessary and that the mandate represents one of the most effective ways to address the challenge of reducing GHG emissions from aviation. Finally, almost all stakeholders emphasise the necessity for a more robust policy mix, as the sustainable transition of the EU aviation industry would otherwise be accompanied by a significant loss of competitiveness, primarily for airlines.

6.1 Practical implications and recommendations

Icelandair

The findings of the study indicate that Icelandair should pursue a proactive engagement with both the Icelandic government and the EC. This engagement should seek to clarify the application of the flexibility mechanism and, where possible, influence its alignment with the airline's operational context. It is important to establish robust communication channels with regulatory bodies in order to navigate the regulatory landscape effectively. Only through an open and structured dialogue could Icelandair identify its distinctive position and the potential risks associated with the implementation of ReFuelEU, which may not fully consider the unique characteristics of the Icelandic aviation industry. Such an outcome could have a detrimental impact on the company's competitiveness and profitability. In light of the potential scenarios, Icelandair must define its strategy for the pre-implementation stage of the mandate. This approach would be essential to ensure that, from 1 January 2025, the company has the opportunity to further reduce its environmental impact, without unduly burdening its economic profits.

Secondly, Icelandair could consider forming strategic alliances with SAF producers to establish a dedicated supply chain, thereby mitigating the risks associated with the potential lack of physical SAF supply at KEF. This approach would ensure compliance with future policies and align Icelandair's sustainability objectives. Indeed, a proactive approach is the main strategy employed by industry leaders. Icelandair should adopt a proactive strategy within the Icelandic context, given the criticality of the issue and the crucial role it plays in the country's economy.

Finally, given the pivotal role of sustainability in future aviation markets, Icelandair should persist in investing in fleet modernisation and other technological innovations that reduce reliance on traditional fossil fuels. By enhancing its sustainability profile, Icelandair can adhere to upcoming regulations and attract a growing segment of eco-conscious travellers, thus securing its market position in a changing industry landscape. These strategies collectively ensure that Icelandair remains resilient, competitive, and compliant despite evolving environmental regulations.

Policymakers

Policymakers implementing the EU SAF mandate should focus on enhancing regulatory clarity, promoting local SAF production, and offering supportive measures, like free allowances within the EU ETS, to mitigate aviation's environmental impact effectively. Clear, detailed guidelines are crucial for applying the flexibility mechanism uniformly across the EEA, defining fuel suppliers' obligations, and ensuring coherent integration with existing policies like the EU ETS and ICAO CORSIA. Additionally, investing in local SAF production, especially in isolated regions like Iceland, can alleviate logistical challenges and spur economic development. Policymakers must also tailor SAF blending requirements to regional needs, offering a flexible, adaptive policy framework. Continuous monitoring and data-driven adjustments are essential to assess environmental and economic impacts and ensure the

policy's effectiveness as the aviation industry progresses towards sustainability. This approach will help maintain the sector's competitiveness while achieving environmental objectives, particularly in regions facing unique challenges.

Other Stakeholders

Fuel and SAF suppliers are encouraged to diversify their production capabilities and enhance their logistical strategies to efficiently manage the distribution of SAF across Europe. Achieving this necessitates active participation in the development and implementation of flexible compliance mechanisms, such as the book-and-claim scheme, which can mitigate logistical challenges and reduce distribution costs. It is recommended that suppliers advocate for gradual increases in production targets that align with technological advancements and available feedstocks, thus facilitating a stable transition without imposing unrealistic expectations on the industry. Furthermore, investment in the development of advanced bio-based SAF technologies and the expansion of the SAF allowances programme represent essential strategies for the consolidation of market position, the enhancement of investor confidence and the commitment to long-term production targets. It is of the utmost importance to address feedstock availability limitations and advocate for nuanced policy adjustments to avoid stifling innovation and ensure sustainable growth in the SAF sector.

Airlines based in the EEA should proactively shape SAF regulations to mitigate competitive imbalances with non-EU carriers. To enhance the sustainability of their operations and reduce SAF cost disparities, airlines need to champion policies that include financial incentives and promote the global standardisation of SAF criteria. Beyond mere compliance, airlines should also invest in sustainable technologies and strategic initiatives. These include renewing fleets, forging stable supply partnerships with SAF producers, and adopting advanced techniques to cut fuel usage. Market-leader carriers like Lufthansa and Air France-KLM have integrated sustainability into their business strategies effectively, aiming at exceeding the requirements of the EU mandate. A unified push for a book-and-claim scheme, interconnected policy frameworks, and a strong SAF market will help airlines manage a balanced and economically viable shift to SAF, ensuring they meet EU environmental goals while maintaining global competitiveness.

6.2 Recommendations for future research

This study offers a case-specific analysis of the preparation for the implementation of the early phases of the EU SAF mandate in 2025, filling a gap in the extant body of academic literature. The research provides a previously lacking perspective, allowing for a more concrete and realistic assessment of the status quo of ReFuelEU and the perception of this policy instrument within Icelandic and European industry.

Future research should focus on quantitatively assessing the financial implications of the EU SAF mandate for airlines to better understand the economic impacts on different types of carriers operating within and outside the EU. Comprehensive cost-benefit analyses should be carried out, considering the inherent variability in SAF prices, fuel consumption rates, and the potential financial benefits of complying with or exceeding the mandate. An ex-ante policy analysis of the ReFuelEU is essential to anticipate the outcomes of this regulation before its full implementation. This research should evaluate the potential effectiveness and unintended consequences of the mandate, examining how it could shape the aviation industry's transition to sustainable fuels. By assessing these aspects, researchers will be able to provide valuable insights into the necessity of policy adjustments to ensure that the mandate's goals are met without disproportionately affecting the competitiveness of EU airlines.

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Appendix

Participant Consent Form

LUND UNIVERSITY

iiiee
THE INTERNATIONAL INSTITUTE FOR INDUSTRIAL ENVIRONMENTAL ECONOMICS

MSc THESIS PROJECT on the Impact of the EU SAF Mandate

PARTICIPANT CONSENT FORM

This form is to ensure that you have been given information about the thesis project on the impact of the EU SAF mandate on Icelandair and its stakeholders (see **Information Sheet** on pages 2 and 3) and to give you an opportunity to confirm that you are willing to take part in this research. For all activities below, please indicate which applies to you (*checked box indicates consent*):

☐	I have been **familiarised** with the thesis project about the impact of the EU SAF mandate on Icelandair, I have had the possibility to ask questions and I have received satisfactory answers to my questions before being interviewed
☐	As a research participant, I am aware of my **right to withdraw participation** at any time
☐	I give my consent that the interview can be **recorded in writing** and analysed
☐	I give my consent that the interview can be **audio-**recorded, transcribed, and analysed
☐	I understand that the results of the research will be presented so that **no information can be traced to me personally or my company/organisation.** I have been informed that **pseudonymity of participants will be ensured**
☐	I give my consent that a record of my interview can be **safely stored** for future reference
☐	I have been informed who will **benefit** from the participation
☐	I have been informed how **data will be either destroyed or reused** at the end of the research
☐	I have been informed of the **secondary use of data**

Note: Your participation is voluntary. As an interviewee, you do not have to answer all the questions that are asked; you reserve the right to refuse or cease participation in the interview process without stating your reason and may request to keep certain materials confidential. In addition, you have the right to review any summary or synthesis of the interview at any time up until the data is actually published.
There will be no monetary payment for participating in the research.

Please, sign below to confirm your consent – digital signatures are possible:

	Participant(s)	**Researcher**
Name(s)		Emiliano Vuillermoz
Signature(s)		
Date(s)		

INFORMATION SHEET

This thesis project operates independently and does not receive funding or support from Icelandair or any other corporate or organizational entities. My involvement with Icelandair does not extend to employment, nondisclosure agreements, or any kind of formal collaboration. The selection of Icelandair as the focus company for the case study is solely based on the unique geographical position of its main hub and its peculiar business strategy, making it a particularly insightful case within the scope of this research.

Description of the Thesis Project

Regulation (EU) 2023/2405 on "Ensuring a Level Playing Field for Sustainable Air Transport" will introduce a requirement of 2% sustainable aviation fuel (SAF) blended with conventional aviation fuel (CAF) for aircraft taking off from EEA airports starting in 2025. This policy instrument, crucial to reaching the targets set by the EU's 'Fit for 55' package, will pose numerous challenges for various stakeholders along the fuel supply chain and beyond. The production processes of SAF present technical challenges, while the higher cost of SAF, compared to CAF, will lead to economic and operational challenges as specific processes must be adapted to the Regulation.

The research aim of the thesis is to explore the expected challenges and opportunities for an airline and its stakeholders within a unique geographical and market context following the implementation of the EU SAF blending mandate in 2025. To achieve this aim, the research will focus on the impact of the higher price of SAF compared to fossil fuels, how to address the current limited production of SAF, the resulting uncertainties in the SAF supply chain, and the changes to the operations necessary to adapt to the new Regulation.

To get a more holistic picture of the problem at the core of the thesis, it is crucial to outline and analyse how the focus airline's stakeholders perceive the upcoming SAF mandate and the expected challenges and opportunities it entails. This allows to shed light on the transition towards more sustainable fuels within the European aviation industry.

Purpose of the Interview

Therefore, as part of this thesis program, I invite you to an interview. I aim to deepen my understanding in several key areas, including:

- Your insights and experiences regarding the relevance and impact of SAF within your organization and the broader aviation industry.
- Your familiarity with, and perspective on, the EU's SAF mandate and its implications for the aviation sector.
- The operational, strategic, and competitive impacts of the EU SAF mandate on your organization, as well as the aviation industry more broadly.
- The initiatives and measures your organization is currently undertaking or planning in response to the SAF mandate.
- The challenges and opportunities you foresee in scaling up SAF production and achieving sustainable aviation.
- The role of airlines and industry stakeholders in meeting the SAF mandate's requirements and contributing to the sustainability goals of the aviation industry.
- Your perspective on the effectiveness of the EU SAF mandate as a policy instrument for addressing environmental issues in aviation and any potential improvements to enhance its impact.

The collected information will be used to produce an MSc thesis for the Environmental Management and Policy programme of the IIIEE at Lund University. The research might result in academic publications, online blogs, social media, websites, newsletters, events (workshops, conferences, etc.), as well as public communications, e.g. press and policy briefs.

Data Management

All the data for this project is collected and stored in accordance with the General Data Protection Regulation (GDPR) 2016/679 of the European Union, which entered into force in May 2018. The regulation protects individuals regarding the processing and collection of their personal data. All the research materials, including the participants' data will be securely stored for 10 years. After that time period, any personal data collected will be deleted. In addition, data will be deleted at any time on request of the participant. From the beginning of the process, pseudonymization of personal data is applied. Pseudonyms will also be used for further processing the responses. Special attention is paid to direct quotes, for which we will use indirect identifiers (such as gender, region, role) in the transcription protocols, so that they cannot inadvertently identify respondents. The audio/video-recordings, if authorised by the interviewee, will be deleted after they have been transcribed and analysed, hence they will not be stored for 10 years. Participants can also file a complaint about how their personal data is used.

For any enquiries regarding this research, please contact:

Emiliano Vuillermoz

IIIEE / Lund University
Email: **em8748vu-s@student.lu.se**
Telephone: **+39 348 68 27 635**

Interview Protocol

Theme		Main Questions	Sub Questions
INTRODUCTION			
Opening of the chat		Greeting the interviewee, thanking them for their time and availability	
Interviewer and the study		Briefly introduce myself, highlight the topic of the research, the aim, and the relevance of the specific interview/person for the thesis → Purpose of the interview	
Consent + recording		Signature of the 'online consent form' and receive approval to record the interview. (Anonymity or not)	
OPENING QUESTIONS			
Role and organization of the interviewee	*1*	What is your role inside the company? Could you describe the primary objective/mission of your organization or company?	What are your daily tasks? Current projects?
SAF	*2*	How relevant is SAF to the operations and objectives of your company/organization?	
Knowledge of the EU mandate	*3*	How familiar are you with the EU's SAF mandate?	If familiar, have you received some form of formal training on it (seminar, workshop etc.) or just hear about it internally?
Sustainable Aviation	*4*	How would you define 'sustainable aviation'?	
CONTENT QUESTIONS			
Response to its adoption	*5*	Could you elaborate on your organization's *response* to the EU SAF mandate's approval by the EU Parliament in October 2023?	Is it too ambitious or too weak? Do you think the jet fuel market could regulate itself independently thus making SAF more competitive in the short/medium term?
Measures undertaken	*6*	What is your company/organization currently doing to address the upcoming SAF mandate?	
Impact on your organization and the industry	*7*	How will the EU SAF mandate affect operational strategies *(business as usual)* in your organization/company? And the aviation industry overall?	Will the dynamics within the supply chain change? (role of big oil corporations)
Competitiveness	*8*	How will the SAF mandate affect competition in the aviation industry intra- and inter- EEA, based on your experience? In the short and long term. Will the implementation of the EU SAF mandate affect your competitiveness?	Will EEA-based airlines be disadvantaged compared to, for example, US airlines? How to avoid tinkering by non-EU airlines, taking off outside the EEA?
Priorities	*9*	How does your company prioritise investments in sustainability initiatives, particularly in relation to SAF adoption?	
SAF Production	*10*	Current production of SAF is below the forecasted levels. Will this rapidly change? What are the biggest challenges in scaling up production? According to your experience, is there one specific type of SAF among the ASTM certified that seems better than the other in terms of costs and scaling up of production?	
Role of Airlines	*11*	How should the aviation industry prepare for the mass deployment of SAF?	Is this going to happen? If yes, do you consider the target set by ICAO and IATA achievable?
	12	Who holds the primary responsibility in shaping and leading the development of an aviation industry closely tied to SAF?	Is there potential for airlines to increase their blending rates, and could this be considered a viable business strategy moving forward?
Challenges and opportunities	*13*	What are the main challenges your company or organization is facing, or will face in the future, to contributing to more sustainable aviation? And opportunities?	
Stakeholder collaboration	*14*	In what ways are you collaborating (or planning to collaborate) with other industry stakeholders to meet the SAF mandate's requirements?	
Future scenarios	*15*	Looking ahead, how do you see the aviation industry evolving in response to environmental regulations like the SAF mandate?"	
Improvements	*16*	What are the strengths and limitations of the EU SAF mandate as a policy instrument for addressing environmental issues in aviation, and what improvements could be proposed to enhance its effectiveness?	
CLOSING INSTRUCTIONS & REMARKS			
Additional comments		Do you have any additional insights or comments about how the SAF mandate will impact the aviation industry?	
Final remarks		Thank the interviewee and remind them of how the data gathered during the interview will be managed	