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Sustainable Aviation Fuel regulations in the EU

The influence of EU regulations on EU-based airlines' sustainable aviation fuel adoption

International Business
Bachelor's thesis

Author:
Paavo Schultz

Supervisor:
D.Sc. Riikka Harikkala-Laihinen

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Abstract

In recent years, action towards a sustainable aviation industry has been taken to reach carbon neutrality by 2050 in the EU. Sustainable aviation fuel (SAF) has been regarded as a promising alternative to replace traditional fossil fuels. The EU has introduced regulations that promote SAF uptake to ensure a sustainable transition for the aviation industry. This thesis seeks to explain how the EU's regulations affect EU-based passenger airlines. The thesis applies institutional theory as a framework to explain similar activities in an organizational environment, with a focus on coercive isomorphism to study how pressures exerted by regulations create similarity in the environment.

The EU's regulations, such as EU Emissions Trading System and ReFuelEU force passenger airlines in the EU to make significant changes in their operations. Challenges in SAF uptake arise from existing issues in the aviation industry. Fuel tankering inflicts disparities between EU-based airlines. Feedstock availability abates the production rates of SAF. High SAF prices and low availability put regional airlines to a disadvantage due to lesser financial resources and their geographical location. High SAF prices lead to ticket price increases for customers. Alternative mechanisms alongside EU ETS and ReFuelEU may mitigate the negative effects of said challenges. ReFuelEU is creating a level playing field in the aviation industry, while EU ETS limits fossil fuel use. Subsidies give financial assistance to passenger airlines to further SAF investments and purchases. A book and claim system detaches purchases from the resource, making purchases less dependent on availability. Customer involvement is implemented by giving an option to offset the customer's carbon emissions on the flight.

The findings showed that the regulations clash with the economic survival for airlines. Low availability feedstock required for SAF production is keeping SAF scarce and expensive, causing extra costs for airlines and ReFuelEU's targets difficult to reach. The thesis identified alternative mechanisms that could help the sustainable transition, such as subsidies, book and claim system and customer involvement. The thesis concludes with suggesting tailoring regulations. The implementation of subsidies distributed to passenger airlines by the EU based on their operating models to help with financing SAF costs is suggested. Use of a book and claim system is encouraged to decrease reporting and risk of facing penalties. Governments are also encouraged to work more closely with airlines to facilitate the success of the EU's climate objectives.

Keywords: airlines, coercive isomorphism, European Union, ReFuelEU, regulation, sustainable aviation fuel

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Tiivistelmä

EU:n ilmailuteollisuudessa on viime vuosina ryhdytty toimiin hiilineutraaliuden saavuttamiseksi vuoteen 2050 mennessä. Kestävät lentopolttoaineet on nähty lupaavana perinteisten fossiilisten polttoaineiden korvaajana. Ilmailualan kestävän siirtymän varmistamiseksi EU on esittänyt sääntelyjä, jotka edistävät kestävien lentopolttoaineiden käyttöönottoa. Tämä kanditutkielma pyrkii selittämään, miten EU:n sääntelyt vaikuttavat EU:n alueella toimiviin lentoyhtiöihin. Kanditutkielma käyttää institutionaalista teoriaa viitekehyksenä selittääkseen samankaltaisen toiminnan tapahtumista organisaatioiden ympäristössä keskittyen pakottavaan isomorfismiin, mikä tutkii sääntelyä painostuksen keinona samankaltaisuuden saavuttamiseksi toimintaympäristössä.

EU:n säänteyt, kuten EU:n vapaakauppapäästöjärjestelmä sekä asetus tasapuolisten toimintaedellytysten varmistamisesta kestävälle lentoliikenteelle pakottavat EU:n matkustajalentoyhtiöitä tekemään merkittäviä muutoksia toiminnoissaan. Ilmailualalla esiintyvät ongelmat aiheuttavat haasteita kestävien lentopolttojen käyttöönotossa. Polttoaineen ylitankkaus aiheuttaa eriarvoisuutta EU-alueen lentoyhtiöiden välillä. Raaka-aineiden saatavuus heikentää kestävien polttoaineiden tuotantomäärää. Korkeat kestävien lentopolttoaineiden hinnat sekä niiden alhainen saatavuus asettavat alueelliset lentoyhtiöt alakynteen vähempien taloudellisten resurssien ja sijainnin myötä. Korkeat kestävien lentopolttoaineiden hinnat johtavat asiakkaiden lippuhintojen nousuihin. Kamppaillakseen haasteita vastaan, vaihtoehtoiset mekanismit EU:n päästökauppajärjestelmän sekä kestävän lentoliikenteen asetuksen rinnalla voisivat lieventää mainittujen haasteiden negatiivisia vaikutuksia. Kestävän lentoliikenteen asetus luo EU:n tasapuoliset toimintaedellytykset ilmailualalla, kun taas EU:n päästökauppajärjestelmä rajoittaa fossiilisten polttoaineiden kulutusta. Rahalliset avustukset auttavat matkustajalentoyhtiöitä kasvattamaan edistämään kestäviin lentopolttoaineisiin kohdistuvia sijoituksia sekä ostoja. Varaa ja lunasta-järjestelmä erottamaa ostot itse resurssista, vähentäen ostojen riippuvuutta saatavuuteen. Asiakkaiden osallistamista toteutetaan antamalla asiakkaille mahdollisuus lennolla syntyneiden hiilipäästöjen kompensointiin.

Löydöksistä kävi ilmi, että sääntelyt ovat ristiriidassa lentoyhtiöiden taloudellisen selviytymisen kanssa. Kestävien lentopolttoaineiden tuottamiseen tarvittavien raaka-aineiden heikko saatavuus pitää kestävät lentopolttoaineet vähäisenä ja kalliina, aiheuttaen lentoyhtiöille lisäkustannuksia ja vaikeuttaen kestävän lentoliikenteen asetuksen tavoitteiden saavuttamista. Kanditutkielma tunnisti vaihtoehtoisia mekanismeja, jotka voisivat auttaa kestävässä kehityksen siirtymässä. Näitä keinoja olivat rahalliset avustukset, varaa ja lunasta-järjestelmä sekä asiakkaiden osallistaminen. Kanditutkielman lopuksi ehdotetaan säännösten räätälöintiä. EU:n jakamien rahallisten avustusten täytäntöönpanoa matkustajalentoyhtiöille toimintamallien pohjalta ehdotetaan kestävien lentopolttoaineiden ostokustannusten rahoittamiseksi. Varaa ja lunasta-järjestelmän käyttöä kannustetaan raportoinnin sekä sakkojen riskin vähentämiseksi Hallituksia kannustetaan myös tekemään tiiviimpää yhteistyötä lentoyhtiöiden kanssa EU:n ilmastotavoitteiden saavuttamisen edistämiseksi.

Avainsanat: Euroopan unioni, kestävät lentopolttoaineet, pakottava isomorfismi, lentoyhtiöt, ReFuelEU, sääntely

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1 Introduction

1.1 Background of the aviation industry and sustainability efforts in the EU

The carbon emissions produced by the global aviation industry make up about 2-3% of all greenhouses gases in the world, contributing to global warming significantly (Detsios et al, 1; Wang et al, 2024, 1). Aviation accounts for 13.4% of all transport emissions in Europe (Erriu et al, 2024, 1). The increase of the number of flights has been rapid for years and passenger records were broken almost annually until the beginning of COVID which made the aviation sector see the biggest decrease in flights for decades (Detsios et al, 2023, 1). As flights decreased for the COVID period, so did emissions of flights. Despite the dive, the markets are expected to revive to similar numbers and to continue the growth of emissions annually, with estimates saying that the emission levels will most likely return to pre-COVID levels (Brodzik et al, 2025, 2; European Commission, 2023, 1). A study conducted by Biggeri et al. (2025, 125) has shown that the issue with thriving markets is that it often causes significant damage to the environment. It is clear that as growth continues, measures need to be taken to mitigate carbon emissions to reach climate goals and simultaneously the viability of the industry (European Commission, 2023, 1).

To tackle the global climate crisis, Sustainable Aviation Fuel (SAF) has been making its way to the aviation industry to offer an alternative for fossil fuels (Wang et al, 2024, 2). Some of the previous literature use other terms and acronyms used for sustainable aviation fuel, such as biofuel, renewable fuel or alternative jet fuel (AJF) (Erriu et al, 2024, 3; Shehab et al, 2023, 299). This thesis will use the term sustainable aviation fuel (SAF) to describe fuels that can be substituted for traditional jet fuels, as the ReFuelEU regulation describes (European Commission, 2023, 3). SAF is regarded as a promising prospect to completely replace conventional jet fuels in the future (Chen et al, 2024, 2, 20). The feedstock to produce SAF is versatile: biomass, various organic wastes such as cooking oil waste, animal fats and captured carbon dioxide can be utilized in the production process (Wang, 2024, 1-2, 4-6). What is especially helpful with the transition to sustainability is the adaptability of SAF. It can be blended with conventional jet fuels, thus there is no requirement to make modifications to aircraft or apply other specific technology (Chen et al, 2024, 2). Estimates show that SAF could potentially reduce carbon emissions by 80% and help reach climate targets (Wang et al, 2024, 2).

Although these numbers promise major advancements with constant development of a new generation of fuels, an underlying issue is threatening the success of climate neutrality. The

available feedstock for SAF is limited, making it difficult for airlines to get their hands on (Erriu, 2024, 5, 12-13). The global production of SAF is expected to reach two million metric tons in 2025, still accounting for only 0.7% of all jet fuel consumption (Yong, 2025). If SAF is not easily accessible, it poses a great risk on replacing traditional jet fuels. In Europe, the situation is not much better than in the rest of the world, as only one percent of all consumed fuel in 2024 was SAF (Braun et al, 2024, 1). The supply of SAF does not meet the demand, showing that actions by industry actors is needed to scale SAF production and boost the markets. If the production is kept at its current state with exponentially increasing minimum share demands, virtually, the only options for airlines to maintain their financial performance will be to either decrease flight frequency or for governmental bodies to give support by distributing subsidies which would stimulate SAF investments (Erriu et al, 2024, 15; European Commission, 2023, 29, Noh, 2016, 313-315,Wang et al, 2024, 2).

The European Union strives towards a climate neutral continent by 2050 through its Fit for 55-campaign, consisting of multiple policies (Chen, 2024, 2; Detsios et al, 2023, 18). A previous EU-made attempt to increase SAF uptake in the industry took place when the aviation section became part of the EU's Emission Trading System (EU ETS) (Development of EU ETS (2005-2020), European Commission, 2025). An issue with EU ETS concerned the loose regulation around flights. The system is only applicable to flights inside the European Economic area, but not to flights with departing or arriving outside of Europe (Mayeres et al, 2023, 3). This was a threat for many airline companies that operated only inside the EU, since airlines with destinations outside of the EU may exploit this loophole (European Commission, 2023, 2).

To take the matter seriously, EU took initiative in 2023 and constructed ReFuelEU, a mandate to promote the uptake of SAF introduced through minimum shares (Chen et al, 2024, 2). This was the first of its kind, no governmental body or institution has previously introduced a law specifically related to SAF (Brodzik, 2025, 3). The mandate is pressuring airlines towards making more SAF purchases and increasing investments to scale up the production, thus creating more opportunities for SAF to grow into a leading fuel source in the industry (European Commission, 2023, 11). The ambitious goal for the EU has been set to 2030, when at least 6% of flights from EU airports will be fuelled by SAF (Shehab, 2023, 2). This will act as an intermediate stage towards the end goal in 2050, where the number will be 70% (Chen, 2024, 2).

The EU's regulations put pressure onto airlines through creating policies that are imposed on them. This is called coercive isomorphism, a part of institutional theory used to explain actions resulting

into similarity caused by influencing organizations, such as governments (DiMaggio, Powell, 1983, 150). Applying the theory to the topic, the influencing power of the EU forces airlines to follow the policies and change their practices to adapt to the changed environment. In the process of adoption, institutions – or in this case, airlines – will start finding the best practices to reach minimum share targets and to facilitate survival in the markets. Institutions will adopt the practices that are regarded as successful, causing similarity in the industry, i.e. isomorphism (Kauppi, 2022, 2).

As the EU conducts regulations that force aircraft operators to increase the uptake of SAF, the amount of feedstock available makes the production levels insufficient to scale SAF production (Wang et al, 2024, 17). To provide perspective on the scarcity issue, EU's biggest airline Ryanair has been investing into SAF to reach an ambitious goal of 12,5% of SAF-fuelled flights by 2030. To reach this goal, Ryanair has made contracts with suppliers to supply flights with SAF until 2030, as well as supporting research and development towards the cause (Ryanair, 2024; Ryanair, 2025; Tanskanen, 2023). The size of Ryanair's fleet poses a problem: the fleet is so vast that even all the SAF produced in the EU would not supply them for a single day (Tanskanen, 2023). This goes to show the disproportionality of supply and demand. Major changes in the industry are required, will it see itself thrive in the future as well.

1.2 Aim for Thesis

Reason for the thesis is to analyse how regulations affect EU-based passenger aircraft airlines' adoption process of SAF. The thesis is divided into three sub-questions:

1) How do EU regulations promote airlines to adopt SAF?

2) What kinds of challenges do the EU's regulations cause for passenger airlines?

3) How can alternative mechanisms alongside regulations mitigate the effects of challenges in the EU's aviation industry?

The first sub-question is important to study to find out the methods that the regulation uses, which drive the industry towards carbon neutrality (Braun et al, 2024, 1). If the regulations become overwhelming, it may cause harmful costs to airlines and impair their performance. Hence why it is important to see whether defects on the economy outweigh the benefits of environmental achievements (Makovcová et al, 2025, 84; European Commission, 2023, 3). The challenges discussed are fuel tankering, SAF availability, the disadvantages harming smaller and regional passenger airlines, and ticket price increases. These selected challenges directly affect the

performance of airlines and have been stated in ReFuelEU as existing challenges, which is why it is important to collect knowledge on what issues they can cause (European Commission, 2023, 1-3, 5).

The alternative mechanisms have been chosen for the thesis based on previous literature. Previous literature has shown the chosen alternatives to possess characteristics that could improve the sustainable transition and support airlines, such as the book-and-claim system, governmental support, subsidies and customer involvement (Chen et al, 20; Erriu et al, 2024, 9; Makovcová et al, 2025, 78; Pechstein et al, 2020, 10). To include existing measures that have a positive effect on the operating environment of passenger airlines, ReFuelEU and EU ETS will also be taken to discussion in the alternative mechanism section. This will better provide a holistic view on the situation and show what is already being done to mitigate the effects of challenges.

One scarcity in previous literature is assessing the possible problems of a coercive regulation in an immature market (Huang & Sternquist, 2007, 616-617). This is an interesting viewpoint to study, since SAF being still an emerging market (Detsios et al, 2023, 2). Institutional theory will be applied to study how the regulations affect the behaviour passenger airlines. As a law is introduced by the EU, it causes organizations subjected to adopt similar practices which can be illustrated with the help of institutional theory. Coercive isomorphism is the act of organizations putting pressure on other organizations, thus forcing a new code of conduct to the industry (Martínez-Ferrero & García-Sànchez, 2017, 103). The thesis will discuss institutional theory through the lens of coercive isomorphism, as it suits the operational environment of EU and the influence of regulations pressuring airlines to follow new policies.

The thesis' focus will be on passenger airlines. Including other actors in the industry would shift the focus on the bigger picture of the aviation industry's sustainable transition and focus on other actors' roles. The airlines face pressures not only from regulations, but clients and stakeholders as well. The regulations shape the industry to work towards SAF targets, pushing airlines to increasingly adopt more SAF to their fuel mix in the process (Shehab, 2023, 2). The European Commission stated that ReFuelEU will bring challenges to the industry at least for the near future, which is why it is crucial to study what these challenges may entail and how the challenges could be addressed (2023, 2).

2 EU's SAF directive and its implications

2.1 EU's regulations regarding SAF uptake and its adoption to passenger airlines

Although the ReFuelEU mandate was introduced as a first law concerning SAF, it was not the first time within the Union that the EU had made efforts to promote sustainable practices (Detsios et al, 2023, 17-18; Brodzik et al, 2025, 3). In 2012, the aviation sector was included in the EU ETS, a system within the union used as a means to offset carbon emissions (European Commission, 2025). The allowances are bought at auctions that can be traded forward if the emissions fall short of the cap. The number of allowances is decreased annually to facilitate a sustainable transition towards EU's climate neutrality goal in 2050 Similarly to ReFuelEU, the system limits carbon consumption and forces market actors to find new solutions on how to function with less fossil fuels each year (About the EU ETS, European Commission, 2025).

While the system is still very much in effect and encouraging airlines to adopt SAF, it is not capable enough to drive the uptake of SAF (Detsios et al, 2023, 18; Erriu, 2024, 6-7). During the time that EU ETS has been active, there has been little to no progress on the adoption and uptake of SAF. After seven years of being in effect, the annual consumption of SAF was still a mere 0.1% (Chen, 2024, 2). Various articles studying SAF before ReFuelEU had a clear consensus that the EU cannot reach its goals without a new legislation or incentive not being introduced. Afşar et al. (2023, 11) stated that the ETS system was not sufficient to encourage reduction of emissions and suggested a new policy on taxing all greenhouse gas emissions. In another study conducted by Noh et al. (2016, 315), a prospective alternative was an offset control system with subsidies, as well as a minimum fuel mix requirement. Detsios et al. (2023, 20-21) concluded that a unified SAF policy was required to facilitate an effortless transition away from conventional jet fuels. All these articles had a common voice that called for a unified policy on SAF to enable the survival of the aviation sector.

On October 18th, 2023, the EU introduced ReFuelEU as an agreement "on ensuring a level playing field for sustainable air transport" (European Commission, 2023, 1). The main objectives of the regulation were to influence aircraft operators to increase SAF usage ensure the longevity and growth of sustainable aviation, and set increasing expectative shares of SAF in the fuel mix (Detsios et al, 2023, 19; Shebab, 2023, 2; Wang et al, 2024, 2). The aviation industry's growth is so rapid, that it diminishes the achievements of previous carbon reductions. Inevitably, measures were needed that would concern all actors in the industry (European Commission, 2023, 2).

The main objective identified by ReFuelEU regulation is to facilitate sustainable development in the industry. It was also made clear that the regulation promotes the uptake of SAF and attempt to increase SAF usage, meaning that airlines are required to put more of their finances towards SAF. As EU ETS was ineffective in driving this growth, ReFuelEU conducts by mandating minimum share standards (European Commission, 2023, 1-2, 5, 12, 29). The regulation pushes airlines to demanding for more SAF. By driving investments to the markets through regulations, it helps SAF as a product to receive investments from other directions as well. With time, the technology for SAF develops and the market strengthens, hastening the sustainable transition and the adoption of SAF (Erriu et al, 2024, 6; Shehab et al, 2023, 2).

All EU-departing flights were commanded to use SAF fuel in their fuel mix, which would gradually increase over the years (Wang et al, 2024, 2). This would also concern flights that have a non-EU destination (Braun et al, 2024). The minimum shares of SAF will have to be integrated to airlines' fuel mix for each five-year milestone (Erriu et al, 2024, 6). The regulation has set the shares to increase gradually every five years; a 2% minimum required from 2025 onwards, 6% in 2030 and rising until 2050, where the minimum share should account for 70% (European Commission, 2023, 29). Being a part of EU's Fit for 55-package, ReFuelEU is an integral part of reaching these goals (Chen et al, 2024, 2).

2.2 EU regulations through the lenses of isomorphism and coercive pressure

Institutional theory is used to explain why similar activities take place in an organizational environment and what causes the similarity (Kauppi, 2022, 2). It is widely utilized in studies due to regulations emerging in various industries, creating similar activity in environments, such as markets or actions within a firm (Lammers, 2017, 198¸ Huang & Sternquist, 2007, 613). In institutional theory, governments or other governing bodies are the ones who put pressure on organizations. When a regulation is presented, it imposes a coercion. Hence, the influenced organizations are to follow the new regulation (Huang & Sternquist, 2007, 616-618). Under the coercive pressure, organizations will adopt the practices that seem the most legitimate and adopt them to receive support from other organizations in the environment (Kauppi, 2022, 2). The similar activities are described as isomorphism, that ultimately leads to a homogenous environment (DiMaggio and Powell, 1983, 103; Lammers, 2017, 199). Isomorphism can be explained as organizations beginning to take on similar practices when they are given guidelines or regulated (Martínez-Ferrero & García-Sànchez, 2017, 103). Kauppi (2022, 1-2, 5) links isomorphism to organizations becoming more similar by shape, DiMaggio and Powell (1983, 149) describe it as a

process that makes institutions conform to similar activities. The reason isomorphism happens is due to organizations striving for legitimacy (Kauppi, 2022, 2). Legitimacy is described by Kauppi as a "perception or assumption that the actions of an organization – are desirable and appropriate in the institutional environment the organization operates within" (2022, 4). Lammers (2017, 197, 200) said that with legitimacy the organization can receive social acceptance for complying with the policies and that "is an important resource for organizations, particularly in highly regulated environments."

The practice of an influential organization pressuring organizations "to conform to -- regulations" was explained as "coercive isomorphism" by DiMaggio and Powell (1983, 150). Coercive pressure is imposed on an organization, when another organization (e.g. a governmental body such as the EU) sets certain requirements for the pressured organization. The influenced organization have a dependency on the influential organization, meaning that there is a difference in power (DiMaggio, Powell, 1983, 150; Kauppi, 2022, 4-5). The influential organizations shape the environment with their power (Lammers, 2017, 201). There has been discussion on whether coercive isomorphism is influence from formal or informal institutions (Martínez-Ferrero & García-Sànchez, 2017, 103). In the context of the European aviation industry and the uptake of SAF, the EU can be considered as an influencing institution. Kauppi stated that coercive pressure can stem from other institutions or actors as well, including suppliers and investors (2022, 5).

Coercive isomorphism can be applied to the current environment of SAF uptake in the aviation industry. The characteristics of coercive isomorphism are comparable with the objectives of EU regulations. The EU is a formal institution that produces regulations, rules and incentives that airlines are to follow (European Commission, 2023, 2, 5, 25; Furusten, 2023, 46). The EU is pressuring airlines to increase the use of SAF, or they will face penalties (European Commission, 2023, 10). Airline operators try and find solutions to this problem collectively – and over time – making their code of conduct congruent. As they use SAF and reach minimum share percentages, they receive acceptance through financial reliefs, subsidies from the EU ETS (EU allocates €100m-worth of ETS allowances to help airlines buy Sustainable Aviation Fuels, European Commission, 2025) and access to new resources of SAF that are supported by suppliers that they have financed (European Commission, 2023, 11).

In DiMaggio and Powell's article (1983, 154), it is said that the more dependent an organization is on a certain resource, the more it will adopt the practices of the organization that possesses the resource. In the EU, a healthy SAF market would mitigate the dependency on fossil fuels (Wang et

al, 2024, 17). A dependency on a certain resource causes isomorphism and the strength of isomorphism intensifies the greater the need for resources (DiMaggio & Powell, 1983, 155). These findings propose a dependency on a scarce resource stimulating the adoption of similar practices and organizations becoming more similar through the process. The EU coerces airlines to move more of their resources onto SAF by every milestone year, forcing them to find the most legitimate practices. As airlines submit to regulations, the achievements receive support, acceptance and access to resources needed (European Commission, 2023, 29; Kauppi, 2022, 8; Lammers, 2017, 195, 197).

In Figure 1, the influence of isomorphism is demonstrated how it would work in SAF promotion once a law is introduced by a governmental body. The first phase describes the situation of low supply and little activity of airlines and suppliers due to low motivations towards making investments (Erriu et al, 2024, 9). After the regulation is introduced, it coerces the airlines to adopt the industry-legitimate practices that help adapt to new regulation set by the EU (DiMaggio & Powell, 1983, 150). The airlines try to find the legitimate solutions as a collective industry maintain competitiveness, slowly creating similar practices and making the airlines methods more homogenous under the circumstance (Kauppi, 2022, 2; DiMaggio & Powell, 1983, 149). Ultimately, the industry environment becomes more similar, meaning that the airlines' practices have become more similar from the imposed regulation, i.e. coercive isomorphism has taken place (DiMaggio & Powell, 1983, 150).

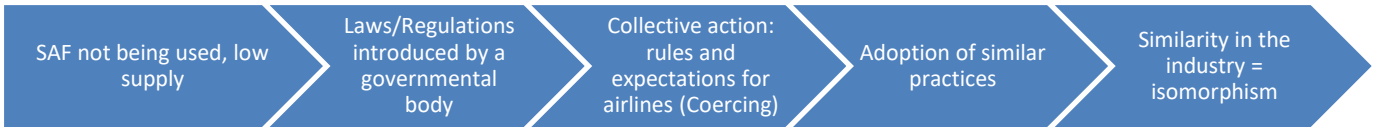

Figure 1 **Coercive Pressure in SAF promotion**

The figure showcased a best-case-scenario where everything would go accordingly to coercive isomorphism. The EU ETS could not bring in investment traffic, but ReFuelEU's policies create a coercion that forces airlines to comply. If ReFuelEU cannot propel airlines' actions to uptake SAF, it may be that coercion would only lead to a continuous cycle of unnecessary harm and costs (Martínez-Ferrero & García-Sànchez, 2017, 104).

3 Challenges caused by EU regulations and alternative mechanisms to mitigate the challenges

3.1 Challenges caused by EU regulations affecting airlines

The concern for a skewness of markets comes through clearly in ReFuelEU (European Commission, 2023, 2-4). The regulations make no distinction between airlines operating flights inside the EU and ones that have non-EU destinations, causing disparities with fuelling policies (Kranich & Haas, 2024, 138). Flights arriving to non-EU destinations are enabled to a wider range of fuelling points, thus having no obligations to refuel with SAF. The fuel costs will likely be cheaper outside the EU, since the regulation does not apply (Erriu et al, 2024, 14; Mayeres et al, 2023, 9). The regulations are thus prone to manipulation and misuse, especially to fuel tankering (European Commission, 2023, 2). Fuel tankering is essentially the act of intentionally refuelling in an area that has lower prices (Erriu et al, 2024, 6). This practice is extremely unfair, especially on airlines that only fly between European destinations. Essentially, the tank is fuelled over its allowed fossil fuel capacity to prevent refuelling at a more expensive airport (Shehab et al, 2023, 3).

Applying coercive isomorphism to a scenario of fuel tankering, the main issue stems from the lack of power that regulations possess. The weaker the regulation, the less demand it creates for SAF (Martínez-Ferrero & García-Sànchez, 2017, 103-104). If the end goal is to ensure a fair market and a climate neutral industry, airlines counting their consumption falsely or resorting to outsourcing to evade extra costs would only destroy the end goal (Braun et al, 2024, 1; Erriu et al, 2024; 6, 14). Coercive isomorphism – in this case, a sustainable transition – can only take place if the pressure is applied by a more powerful organization (Lammers, 2017, 201). Inadequate actions by governments will not facilitate accessibility of SAF, keeping demand disproportionate compared to production and keeping the prices high (Erriu et al, 2024, 9).

In a competitive environment, the costs of SAF adoption will have an apparent impact on the future of air transport and passengers in the EU (Erriu et al, 2024, 14; European Commission, 2023, 3). Estimates have speculated that SAF will possibly triple the costs of fuels for airlines, creating a detrimental disadvantage to those airlines that compete against non-EU airlines (Noh et al, 2016, 307). Airlines may also decide to pass on to customers the add-on costs for SAF (Chen et al, 2024, 10).

Figure 2 presents a continuum that demonstrates the issue with limited SAF feedstock availability. ReFuelEU imposes a minimum share target increasing every five years, that airlines will have to

integrate to their fuel mix. (European Commission, 2023, 15-16). The price of SAF is multiple compared to fossil fuel, creating excess costs for airlines. To cover the excess costs, it is almost inevitable that airlines will increase ticket prices, which may lead to decreased passenger traffic (Erriu et al, 2024, 8, 14). If the prices increase too much, it may backfire to the airline and cause them to lose a great deal of customers (Chen et al, 2024, 20). Under pressure, airlines attempt to find resources to reach the targets. The feedstock for production limited due to low availability, which limits rates of production. The competition to acquire SAF intensifies. keeping the SAF prices high. Those who cannot obtain SAF, will have no other options than to fuel with the only available option, fossil fuels (Erriu et al, 2024, 8-9). The airlines that do not meet the minimum share target, will receive fines (European Commission, 2023, 10, 21-23). The figure shows the same issue repeating itself, each time making the airline companies' situation worse. It shows the need for a bigger resource basis of feedstock, which can only be achieved by scaling SAF production (Wang et al, 2024, 17).

Figure 2 Continuum of SAF feedstock availability issues

The objective of ReFuelEU's SAF mandate was to create fair market conditions for all actors and prevent any harmful effects on any level of actors in the industry (European Commission, 2023, 2). To facilitate a level playing field, it is necessary to ensure that there are different methods used for

regions, types of airlines and their size (Shehab et al, 2023, 13). The biggest airline operators have an advantage access SAF, they have connections to major airports where great amounts of SAF is allocated (Detsios et al, 2023, 6-7). In the aviation industry, the regulations will create a dependency on SAF by coercion, which could mean that smaller airlines will be more dependent on the actions of bigger competitors and their supplies (DiMaggio & Powell, 1983, 154). Here the role of suppliers can also create coercive pressure in the adoption of SAF (Kauppi, 2022, 5). If there is not enough action taken by airlines to help suppliers scale production, SAF will maintain its high price and limited availability (Detsios et al, 2023, 20; Erriu et al, 2024, 1-2). If there is no sustainable aviation fuel used, airlines will face penalties, which will lead to significant economic losses. Some geographically challenged areas that rely on airline transportation could suffer from ReFuelEU's mandates, which is why it requires special attention (European Commission, 2023, 5).

Small and regional airlines fear that all SAF resources will be centralized to areas where bigger competitors' airports are located. An uneven distribution would deny them of access of SAF, even if they were motivated to adopt SAF (European Commission, 2025, 22-23). Due to their size, regulations will have a relatively greater impact on smaller airlines, requiring bigger changes (Makovcová et al, 2025, 79). It is crucial that the smaller airports, which smaller and regional airlines rely on, will be kept vigorous (European Commission, 2023, 5).

National-level regulations may have more influence on SAF scaling than EU itself. The EU has given freedom for countries to increase the SAF minimum share targets for their domestic airlines, which could create significant and harmful differences between member states' requirements, endangering the unification and fairness of the market (European Commission, 2023, 4, 7). Lazy national governments would cause harm to airlines if airlines do not have the possibility to access SAF at airports, meaning that the idle governments would set a hindrance to sustainable transition (Erriu et al, 2024, 11). The passive mindset could affect the development of SAF and put airlines at a disadvantage and sabotaging the playing field (Wang et al, 2024, 5). ReFuelEU has given the authority for member states to create its own policies and support systems to foster SAF uptake. Member states are also allowed to set higher standards to decarbonisation, if the policies created do not cause disparities (European Commission, 2023, 7). SAF adoption does not develop enough if the cost liabilities are left on the backs of airlines (Makovcová et al, 2025, 85). The input of member states' governments could propel development of SAF adoption across the national market, if incentives or other subsidizing mechanics were established (Erriu et al, 3; Makovcová et al, 2025, 85).

An uncertainty in acquiring SAF is caused by high volatility of prices and its availability. SAF can be up to ten times more expensive than its competitors (Mayeres et al, 2023, 12). The high production costs caused these two factors to create superfluous costs, posing a question on who should cover these costs; the EU, the airlines or the customers (Chen et al, 2024, 10; Erriu et al, 2024, 8-9). The most likely action by airlines will be increasing ticket prices and making the customers pay for the mandate (Chen et al, 2024, 10).

A study conducted by Chen et al. investigated the different outcomes between Full-service- and low-cost carriers when a mandate is introduced (2024, 10). The study found that under the influence of a mandate, ticket prices will increase. The mandate takes a harder hit on Full-service-carriers, as their costs per passenger are higher due to services provided than what it is for low-cost carriers. Due to higher passenger volumes, low-cost carriers can transport with less emissions. This would ultimately lead customers to use low-cost carriers' services (Chen et al, 2024, 6, 10). It is also important to notice that the ticket price may increase in tandem with the minimum share increases set by ReFuelEU (European Commission, 2023, 29). The problem in ticket price increases is that airlines may have to decrease flight activity, if customers are not able to afford the tickets. When there are less flights, there will be even more demand for the available tickets, which would drive up ticket costs even more and make a loss of clientele, giving and edge to low-cost carriers once more. It would be a question of time until airlines will force a decrease in fleet size or even worse, exit the market. A mass exit would mean immense losses of revenue, investments for SAF and failure for sustainability efforts (Chen et al, 2024, 13, 19-20).

3.2 Alternative mechanisms to tackle challenges in the EU's aviation industry alongside of regulations

The cost of SAF compared to fossil fuels is putting the economic survival of the EU's aviation industry at risk (Noh et al, 2016, 307). A balance between the economic survival and a sustainable environment must be achieved to transition successfully. SAF is manifoldly more expensive than conventional jet fuel, causing the exploitation of extra-EU airports' fuel resources to create distortions in the aviation industry inside the EU (Erriu, 2024 6, 8, 15). This is where the regulations step in mitigate these harmful practices. ReFuelEU mandates that at least 90% of all fuel needed must be supplied from airports inside the EU. To make things more fair, small aircraft operators with small flight activity will be ruled out of this mandate (Kranich & Haas, 2024, 137-38). On top of that, ReFuelEU mandates structured reporting on SAF usage to ensure transparency and prevent fuel tankering. When airlines do not play by the rules, they will face correlative

penalties based on the degree of noncompliance. Revenues from the penalties will be allocated towards the development of SAF accessibility (Detsios et al, 2023, 20; European Commission, 2023, 8, 10).

Making reporting mandatory and setting minimum fuel mix standards creates pressure for airlines to be transparent in their fuel consumption and tanking (European Commission, 2023, 7). Adding to the pressures created by ReFuelEU, the pressure of facing penalties will likely push the airlines towards the right direction. Heikkila and Isett (2004, 5) described institutions (in this case, airlines) to be driven "by rewards and sanctions" (penalties).

Setting up mandates to buy more SAF will not solely increase SAF uptake. Time is of essence for airlines in Europe, and it is crucial to find a quick and simple way to make SAF accessible for every airline in the industry, so that the market will see a sustainable future (Kranich & Haas, 2024, 155). In the centre of this crisis, a new system is introduced that could accelerate SAF investments. Kranich and Haas (2024, 154-157) saw that the best opportunity for an increase in the uptake of SAF was to create a "book and claim" system. The book and claim/certificate system could potentially increase production levels and make purchases without depending on the route of flight. SAF usage must be reported based on true consumption because of EU ETS. SAF must be obtained for it to be recognized as a purchase. Purchasing of book and claim certificates can be virtually done anywhere, the purchase does not require for the resource to be given upon purchase (European Commission, 2025, 21-23; Pechstein et al, 2020, 6-7). Essentially, a book and claim system separates a purchase from the product. It is not tied to the exchange of material, but rather a record of a purchase and its environmental benefits. (Kranich & Haas, 2024, 146)

The simplicity of a book and claim makes it easy to apply to the EU ETS. Kranich and Haas (2024, 149) said that a book and claim system would make the EU ETS more powerful against harmful activities. The adoption of similar practices happens in highly uncertain and regulated industries. meaning that if seen as a legitimate practice, an addition of the book and claim system as a part of SAF uptake could be adopted quickly in the industry (Kauppi, 2022, 2; Lammers, 2017, 200). As the EU ETS would be a legitimate system, certificates showing purchases would decrease the need for reporting or other proof to show the purchase. The allowance will be allocated to SAF, and the SAF could be uplifted elsewhere. Although book and claim system would not give a solution to low feedstock supply, it would create a positive cycle of investments that would be put towards financing the development of SAF. This way investments could be made to SAF, even if the feedstock availability is low (Kranich & Haas, 2024, 147, 149-152, 155). Although the

compatibility would be effective under EU ETS, the European Commission has not seen the concept of certificates to boost SAF purchases will not be of much benefit under the ReFuelEU regulations. Voluntary purchases of SAF could help reach the farthest regions and airlines with difficulties to obtain SAF could replace their supply by buying virtual certificates which would account for the SAF purchase. Even if it would give a lifeline for short-term, the goal is to create SAF supplies across the Union. Having clustered supply areas would become futile as the industry grows and supplies will be built evenly and would only cause other issues (European Commission, 2025, 27-28).

The cost issues caused by regulations put a great burden on the back of airlines. Previous attempts by governments to promote SAF uptake have led to financial losses, but new systems could be applied by a combination of tax exemptions and subsidies. Their liability to reach the minimum shares without any assistance of public actors creates immense costs due to high prices (Noh et al, 2016, 313-315). Subsidies have been seen to be improving factors in alleviating costs and adopting SAF in the eyes of stakeholders in the aviation industry (Erriu et al, 2024, 11). Airlines in Europe have different operating models, putting some to a disadvantage when regulations are introduced. When subsidies are used (and tailored based on airlines' operating model), the money can be used to reduced extra costs which will then benefit the wellbeing of the airline. Being able to buy SAF with subsidies enables more flights, preventing a risk of decreasing flight activity due to financial issues. With more finances, ticket prices will not have to be raised, and demand for tickets can be maintained. These combined, the airlines receive more revenue and keep markets and customers paying reasonable prices (Chen et al, 2024, 19).

Subsidies would help greatly with the coercive pressures that the EU as a regulator has set upon passenger airlines (Kauppi, 2022, 4). If the subsidies gave every airline the chance to invest in SAF purchases, it would drive organizations to collectively increase SAF demand. If subsidies spurred all airlines to put the received subsidies towards SAF, it would shift the actions towards the isomorphic end goal that ReFuelEU strives for (DiMaggio & Powell, 1983, 149; European Commission, 2023, 11). Although subsidies could widely benefit the industry, the EU must remain conscious of the risks with subsidies. As previously mentioned, these subsidies will create losses for governments. The subsidies will likely not work by themselves. A study conducted by Mayeres et al. (2023, 10) showed that the subsidies had better effects on price with a tax system on traditional fuels. A mixture of these could create a system that drives airlines out of fossil fuels and towards SAF (Mayeres et al, 2023, 10, 12).

In 2024, the European Commission decided on a new EU ETS implementation of alleviations to their trading system. A dedicated system made for airlines to accelerate the uptake of SAF. The system hands out free allowances that are namely used for free uplifts on top of their allowances, thus receiving more funds to purchase SAF. At the same time, establishing this mechanism was a way of the EU showing its commitment to supporting SAF uptake. (European Commission, 2025)

As the minimum share requirements increase, airlines will most likely have to simultaneously increase ticket prices to cover SAF-costs (Chen et al, 2024, 10). An alternative mechanism may be able to involve customers. A sustainability conscious customer base may understand the ticket increases, perhaps even justify them (Chen et al, 2024, 14). The European Commission (2025, 27-28) argued that airlines buying voluntary amounts of SAF could sell them forward to their customers that are willing to buy the SAF to offset their carbon emissions. Airlines have recently begun to involve customers in SAF use through voluntary SAF purchases (Chen et al, 2024, 3). To provide an example, Finnair has taken the first steps to include a compensation option for their carbon emissions. Corporate customers will be able to choose to compensate their flights by an investment on SAF, then receiving certificates for it. This practice follows the book and claims system: corporates can compensate their emissions with the certificate without SAF being required to physically be fuelled. (Gill, 2025)

From the customer base of airline transport, the business-class flyers could assist in SAF adoption. Wealthier people use flights more than other segments, meaning that they could also be able to financially cover the costs for SAF-fuelled flights. Promoting green aviation to this customer segment that already can pay more for ticket prices could aid significantly by offsetting their emissions (Makovcovà et al, 2025, 78). As the European Commission has stressed, the extra SAF costs cannot become a liability for airline customers. If airlines can demonstrate their integrity of offering SAF-fuelled tickets, it is likely that customers will gladly make their contributions to help SAF scaling (European Commission, 2025, 27-28, 30-31).

Table 1 summarizes the challenges affecting airlines and the alternative mechanisms that may help in mitigating the effects of challenges.

Table 1 Effects on airlines caused by challenges and alternative mechanisms

Challenges affecting airlines	Alternative mechanisms to mitigate challenges
Fuel tankering • Regulations lack influence • Endangering the equality of markets • Fuel demand shifted away from the EU	**ReFuelEU's existing mandates** • Decreased risk of fuel tankering • Driving demand to EU • Fairer competing conditions for airlines flying only intra-EU flights
Feedstock availability • Risk for the success of SAF transition • Limited availability hinders adoption • Unfair advantage to bigger airlines with more finances and access to airports	**Book and claim system** • SAF purchases can be made regardless of supply • Diminished dependency on availability • Certificates decrease need for reporting purchases
Lack of support for smaller and regional airlines • SAF supply difficult to obtain due to less financial resources • No initiative taken by national governments for supporting the industry	**Incentivizing airlines through subsidies in the EU** • Subsidies given to airlines can be used to make SAF investments • If SAF can be made available through subsidies and/or tax systems, SAF costs would have less effect on airlines' finances • Maintaining financial survival of airlines
Ticket price increases • Higher ticket costs for all kinds of passenger airlines • Full-service carriers put to disadvantage, Low-cost carriers will benefit from Full-service carriers' losses • Decreased flight activity, which may lead to weak markets	**Customer involvement to assist SAF scaling** • Customers can voluntarily compensate carbon emissions by SAF purchases • Increase in SAF purchase investments by the fundings received from voluntary purchases

ReFuelEU fights against harmful actions like fuel tankering by turning the fuel uplifts towards the EU and creating fairer market conditions for airlines flying only inside the EU (European Commission, 2023, 2). The book and claim system could improve the situation with low feedstock availability by driving investments towards SAF, which could be used to express demand to increase the development of SAF. The investment is made and proven by certificates, decreasing the need for reporting (Kranich & Haas, 2024, 147, 158). Incentivizing through subsidies could also help in covering SAF costs (Erriu et al, 2024, 11). Customer involvement by voluntary SAF purchases could turn additional costs from unjustifiable ticket price increases to a conscious choice (Chen et al, 2024, 14). Making customers feel encouraged to partake in the cause could be make

crucial difference for the survival of airlines (Makovcová et al, 2025, 78). All the alternative mechanisms would have a positive effect on smaller and regional airlines. ReFuelEU is already striving for an equal market between all airlines in the EU (European Commission, 2023, 2). Book and claim system could help small operators to make SAF investments even if they do not have access to SAF, thanks to the mechanism of detaching resource from the purchase (Pechstein et al, 2020, 6-7). Subsidy incentives can help in covering the price differences between SAF and fossil fuels (Erriu et al, 2024, 14). Finally, adding voluntary customer involvements may assist in the cost covering as well (Chen et al, 2024, 3).

4 Conclusions

This thesis analysed the effects of EU regulations on EU-based passenger airlines. The aim was to understand how EU regulations promote airlines' adoption of SAF and to study the challenges and alternative mechanisms caused by regulation effecting passenger airlines. The challenges were examined to spot possible defects and harmful events that may take place due to regulations. The alternative mechanisms investigated possible pathways and tools that could help airlines adapt to changes more efficiently and address the negative effects that regulations will cause.

The EU is trying to reach carbon neutrality in the aviation industry by replacing fossil fuels with SAF. The ReFuelEU mandates the airlines to adopt SAF at an increasing rate and coerces more investments towards the scaling of production. The EU ETS sets limits to fossil fuel consumption by capping the maximum consumption, each year decreasing the allowances for fossil fuels. These regulations together force airlines to make significant changes in their operations and to find solutions to maintain competitiveness in the markets. For European airlines, the fuel costs make up about a third of all costs (Noh et al, 2016, 307). The cost of SAF is substantially higher than the cost of fossil fuel, meaning that the mandates of ReFuelEU will challenge the economic survival of airlines. Airlines with their own financial resources cannot withstand an increase of expenses alone. It is critical to find balance between sustaining a sustainable transition and simultaneously keeping the aviation industry competitive.

Challenges caused by regulations posed similar affects towards airlines. Across the challenges, the feedstock availability reoccurred. Feedstock availability hampers advancements with SAF uptake, since shares of SAF in the fuel mix cannot be increased if there is no SAF to fuel flights. With lack of feedstock, there is a lack of supply. The low supply and regulations set up a dilemma, where the EU is coercing airlines to modify their business operations towards a resource, that currently cannot cover even a fraction of flights due to the resource's low availability. The cost of this transition will affect airlines' operations and compromises may have to be made to cover higher fuel costs. If airlines cannot cover the costs, they may resort to fuel tankering and cause unfair market conditions. Smaller and regional airlines are at a disadvantage to obtain SAF, therefore putting them at a disadvantage. The extra costs are reflected to ticket prices, affecting customer's travel options as well.

The findings showed that the stages of coercive isomorphism correlate with the EU's objectives. The regulations are imposed on airlines in the aviation industry, coercing airlines to change their

practices by setting targets, policies and mandating a minimum share of SAF in the fuel mix. Under pressure, airlines try to follow the regulations and find ways to reach the targets. Some may invest into the research and development of accelerating SAF use, like Ryanair (Ryanair, 2025). Others may incorporate customers to partake in the funding of SAF purchases, like Finnair. In the process of working towards the shared goal of carbon neutrality in the industry, airlines begin to take on similar practices. This ultimately leads to similarity in the industry, i.e. isomorphism.

The research showed a need for the EU to more intensively partake in the process of airlines SAF uptake. There are weaknesses in the regulations, such as the issues with applicability to extra-EU flights and the lack of incentives by the EU to motivate airlines to take part in SAF uptake. Involving member states more in SAF promotion and regulations on a national level would encourage SAF activities and monitor the sustainable transition. Unfair markets caused by weak regulations do not facilitate the level playing field that the EU strives for, which is why closer cooperation between airlines and the EU is required.

The results from studying the alternative mechanisms showed that regulations already can make a significant difference, but other mechanisms and the result from studying the challenges shows that more action from the EU and its member states' governments is required. The EU ETS and ReFuelEU together shape the future for EU-based passenger airlines. To facilitate a sustainable transition, airlines can not solely increase SAF uptake. There is a clear clash between the pressures of the mandate and airlines trying to facilitate survival to cover SAF costs. Airlines require more financial support from governments to increase SAF investments. Subsidies and the book and claim system were presented as alternative solutions. Book and claim system could scale SAF purchases not only by airlines but also involve customers to contribute to the cause. The quicker SAF can be distributed across the industry, the quicker passenger airlines will be able to adopt SAF to their fuel mixes, avoiding penalties and sustaining competitiveness. Utilizing a book and claim system throughout the industry could not only see a surge in investments and hasten sustainable transition but decrease the need for constant reporting and make investments detached from availability.

Despite ReFuelEU's improvements for a level playing field in the aviation industry, there is a need to create support for airlines that would cater to each operating model. When regulating the aviation sector, the mandates could be tailored to different airlines based on their operating models, accessibility to SAF in the operational area, size and contribution to emissions. Having a unified framework is fitting and needed, but having the same rules for every airline creates a disparity that can ultimately lead to market growth into a market slope.

For full-service airlines, it would be beneficial for them if fund collection of voluntary customer-made SAF purchases was put into use. Full-service-carriers' cost per passenger is significantly higher and volume of flights lower, thus enabling an option to voluntary action could incentivize the customers and promote sustainability commercially to boost SAF purchases. The voluntariness of these purchases would not pressure customers but instead encourage them to partake in a good cause. The book and claim system has already been adopted by Finnair to incorporate customers in covering SAF costs (Gill, 2025). The mechanism could help other airlines as well to adopt it to their operating models. Full-service carriers' customer base could significantly help in funding SAF purchases, as they have a wealthier customer base.

Low-cost carriers could be regulated based on their flight frequencies and unit costs. Their flight volumes are a lot higher, which makes it essential that these companies would adopt SAF as quickly as possible, even though costs per passenger lower compared to full-service carriers. When SAF-related regulations enter the equation and begin to increase fuel costs through minimum shares in the fuel mix, more money is required to cover the costs. With the combination of high passenger volumes and regulatory policies, financial aid is required. Low-cost carriers assisted with subsidies by the EU would increase SAF purchases and develop production rates. Among the biggest airlines are many low-cost carriers, such as Ryanair, and these types of passenger airlines have more effect on emissions than small and regional airlines (Tanskanen, 2023). Subsidizing could prevent harmful activities like fuel tankering and improve motivation towards SAF uptake. Similarly to full-service-carriers, adding a voluntary option for customers to compensate emissions would assist in the funding. With a high passenger volume, there is a large customer base that may be willing to compensate their emissions. Comparing with full-service carriers, the fuel costs per passengers are lower, meaning that the price for a voluntary purchase on a low-cost-carrier flight will likely cost less, which may lower the threshold for passengers to make the purchase.

To maintain the competitiveness of small and regional passenger airlines, they would be allowed remissions or exemptions to some extent. Other options could be to prioritize these airlines' sustainable transition. If governments would help ensure smaller airlines' flights with SAF, it would secure the vision of a Union wide and equal connectivity also to those who live in geographically challenged areas (European Commission, 2023, 1, 5). Many people rely on these flights, and their transport mode availabilities should not be taken away to maintain connectivity.

SAF is still an emerging stage of entering the aviation industry, therefore it is still not sure to say, what challenges airlines may face as the ReFuelEU regulation progresses with their minimum share

requirements. The thesis left out the role of suppliers in SAF adoption, limiting research to passenger airlines only. Hence discussion on feedstock availability and the low supplies of SAF were not covered as in-depth. Further research on the role of suppliers' influence on feedstock availability could better explain why the supply has stayed limited. This could also give insights on how the issue of feedstock availability could be acted on in the aviation industry. Empirical studies on which challenges or issues airlines see as the biggest challenges in the sustainable transition could be considered. Sourcing the perceived biggest challenges from the affected airlines would give a better understanding on where the regulations lack giving support to airlines, and which support mechanisms airlines would perceive as most beneficial.

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Appendices

Appendix 1 Declaration of use of Artificial Intelligence

In the writing process of the thesis, I have used artificial intelligence tools in the process of ideation, bringing out my thought process and search for literature. I confirm that I have used AI with caution and critically, complying with the university's policies, and take full responsibility for all the content that is presented in this thesis. All tools, their purpose and verifications on the suggestions are described below.

I used UTU Volter's AI Assistant on finding fitting literature for the topic to find relevant sources.

Prompt 1 (UTU Volter AI Assistant): Find me literature based on these keywords: SAF, EU, ReFuelEU, sustainable transition.

The tool gave me literature suggestions based on the prompt, as well as a summary on what the articles mentioned about the keywords. However, the sources gave minimal information, because most of the sources given were not accessible and thus, neither was the information given by the summary not able to be utilized.

I used OpenAI's ChatGPT in the ideation process of my thesis to narrow down the topic and to make my reasoning for chosen topics clearer. The tool gave me suggestions based on my prompts and I evaluated each suggestion carefully, doing personal research and reflecting on the suggestions by searching for literature.

Prompt 1 (OpenAI's ChatGPT): The current title of my thesis is "Regulation-driven markets: The influence of EU's mandates on the commercial aviation industry in Europe". How could I narrow it down?

ChatGPT notified me that commercial aviation industry will mean more than just passenger airlines. Had I included the commercial aviation industry in the research question, the structure of my thesis could have been disintegrated into many small sections with little in-depth research. I decided to narrow my thesis' topic to airlines and asked ChatGPT for suggestions on how I could narrow the topic to passenger airlines.

Prompt 2 (OpenAI's ChatGPT): How could I narrow my topic and title to passenger airlines?

The suggestions gave a few possible topics to shift the title towards a focus on passenger airlines. The listed suggestions were:

1. *Regulation-driven markets: The influence of EU mandates on the business environment of European passenger airlines*
2. *Regulation-driven markets: EU mandates and their impact on the business environment of passenger airlines in Europe*
3. *The influence of EU mandates on the business environment of passenger airlines: A regulation-driven market perspective*

I used these suggestions as a basis for formulating my own title, without copying any of them. The suggestions gave me insights on which way I could go with my thesis. This prompt was not used to generate a title but to indicate how my thesis title could be limited to a certain topic in the context of sustainable aviation fuel adoption. As my thesis progressed, the title and topic did as well.

Lastly, I used ChatGPT on the Aim for thesis -section to make my reasoning clearer as to why I had chosen the topics for alternative mechanisms.

Prompt 3 (OpenAI's ChatGPT): How can I make my reasoning clearer on the topics I have chosen to study in my thesis?

ChatGPT suggested to reason by listing a few sources to justify the chosen topics. I then reshaped the paragraph to justify the chosen topics and researched literature that spoke about each one. I did not use the tool for generative purposes to create the reasoning, but rather for guidance to improve showing my thinking process.