



Multi-Criteria Analysis of Policy Interventions for Synthetic Kerosene Production

Stakeholder-inclusive multi-criteria analysis on policy interventions that support a large-scale synthetic kerosene production facility in Rotterdam

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The final step in obtaining my MSc degree in Complex Systems Engineering and Management at the Faculty of Technology, Policy and Management at Delft University of Technology is the completion of this thesis. It has been an intensive journey in which I have learned a lot ranging from professional communication to academic reasoning and from synthetic kerosene production to multi-stakeholder complexities. Before you, as the reader, begin reading my thesis, I would like to take the opportunity to thank some of the people who made the process of writing this thesis easier.

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I hope you enjoy reading this thesis.

Cas Hofstede
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Executive summary

The aviation sector must reduce greenhouse gas emissions. The European Commission introduced the Fit for 55 package and ReFuelEU Aviation regulation to reduce the emissions. Part of ReFuelEU is the obligatory use of sustainable aviation fuels, including synthetic variants (eSAF). eSAF can reduce greenhouse gas emissions by around 90% compared to traditional kerosene. Power2X and Advorio have decided to partner up and build the first large-scale eSAF production facility in Rotterdam by 2030, producing 250,000 tons of eSAF annually. This accounts for 40% of the needed European supply based on ReFuelEU aviation blending obligations. Currently, the feasibility of these large-scale production facilities remains uncertain due to high production costs, immaturity of hydrogen and eSAF production technologies, and unclear regional (national) policy support that does not align with international policies.

Existing research emphasizes the need for a systemic change apart from technological advancement through implementing supportive policy interventions. Policy interventions that are accepted by a coalition of stakeholders are more likely than technological developments to accelerate large-scale eSAF production. Yet, a stakeholder-inclusive study on such supportive interventions is lacking. There is a lack of research that evaluates which policy interventions are available to support the feasibility of an eSAF facility, as well as what stakeholder perspectives regarding those policy interventions are.

The objective of this research is to identify policy interventions that not only support the feasibility of the planned eSAF facility by Power2X and Advorio but also align with the perspectives of key stakeholders within the socio-technical system. This leads to the main research question: According to key stakeholders in the socio-technical system, which policy interventions support the feasibility of a large-scale eSAF production facility in Rotterdam best?

A stakeholder-inclusive multi-criteria analysis using the Weighted Sum Method was conducted to rank six policy interventions derived from a report from World Economic Forum (WEF). WEF published a report including policy interventions that supports policy-makers to develop national sustainable aviation fuel strategies. The interventions for the multi-criteria analysis were selected based on the bottlenecks identified by Dutch feasibility studies. Including suggestions from WEF ensures international policy harmonization. The selected policy interventions reflect main barriers that limit large-scale production, such as underdeveloped supply chain, uncertain demand, 4-6 times higher price for eSAF than traditional kerosene, and high investment risks. The policy interventions are the following:

1. Investment in infrastructure/feedstock to develop the supply chain;
2. Contracts for difference to close price gaps between eSAF and traditional kerosene;
3. Blending obligations with specific sub-targets for eSAF to ensure predictable demand;
4. Direct investment support for early-stage projects;
5. Carbon pricing/kerosene tax to internalize environmental costs; and
6. The establishment of multi-stakeholder platforms to enhance coordination and trust among stakeholders in the socio-technical system.

A stakeholder analysis is conducted to identify stakeholders to interview for the multi-criteria analysis. Eight stakeholders were interviewed including interviewees of fuel producers, the government, airlines, storage and logistics operators, research organizations, consultancy organizations, financial institutions, and industry associations.

For the multi-criteria analysis, selection criteria must be established. The book by van Wee et al. (2023) describes six criteria that should be considered to achieve healthy policies (effectiveness, efficiency, equity, ease of implementation, flexibility, and long-term robustness). This research used five of those, as flexibility and long-term robustness were considered similar in this rapidly innovating system. The names of the criteria were slightly adjusted to make it better interpretable for the interviewees. The selected criteria are effectiveness, cost-efficiency (derived from efficiency), implementation feasibility (derived from ease of implementation), stakeholder inclusiveness (derived from equity) and flexibility/scalability (derived from flexibility and long-term robustness).

Interviewees assigned weights on the five selected criteria to present the relative importance of that criterion in policy design according to the stakeholder. After assigning weights, the stakeholder assigned scores to the criteria for each policy intervention to present how well a policy intervention performs on a criterion.

Results indicate that no single policy intervention is most accepted by all stakeholders. However, “Blending obligations with specific sub-targets” and “investment in infrastructure/feedstock” consistently score high across stakeholders, particularly due to their impact on demand creation and system-level scalability by developing infrastructure. “Carbon pricing/kerosene tax”, while seen as effective, ranks low due to perceived political infeasibility. “The establishment of multi-stakeholder platforms” score high on inclusiveness but lower on effectiveness and cost-efficiency as these platforms do not directly support production feasibility. “Contracts for difference” and “direct investment support” receive mixed scores due to concerns about the amount public money needed and uncertainties regarding long-term commitments.

The main conclusion is that, according to stakeholders, a combination of the policies “Blending obligations with specific sub-targets” and “infrastructure/feedstock investments” is the most broadly accepted policy strategy that support the feasibility of eSAF production in Rotterdam. These interventions address both supply and demand-side challenges and score high on effectiveness and implementation feasibility across multiple stakeholder groups. The results imply the importance of a mix of policy interventions as interviewees believe one single policy intervention does not support large-scale eSAF production feasibility. Based on different stakeholder perspectives, effective and implementable policies in this complex socio-technical system are needed, which does not exist in this context yet.

Further research can include further refinement of the set of policy interventions and piloting of promising but doubtful policy interventions. “Contracts for Difference” and “Carbon pricing/kerosene tax” in particular, to explore ways to improve transparency, fairness, and political feasibility of such schemes. Interviewees believe “Contracts for Difference” are valuable, but hard to implement as this intervention raises the question who will pay the price difference. “Carbon pricing/kerosene tax” is considered a valuable intervention in long-term as the polluters will pay, but only if implemented on international level and with transparent schemes that redirect money to aviation innovation (Dutch state treasury regulation must change). Additionally, future research can apply agent-based modeling on policy mixes to simulate in real-world conditions and explore governance models for multi-stakeholder platforms. Expanding the stakeholder base would further strengthen the legitimacy and applicability of proposed policies across the broader eSAF ecosystem.

List of abbreviations

eSAF – Electro Sustainable Aviation Fuel, also known as synthetic aviation fuel

SAF – Sustainable Aviation Fuel

ASTM – American Society for Testing and Materials

EU ETS – European Union Emission Trading System

CORSIA – Carbon Offsetting and Reduction Scheme for International Aviation

RED – Renewable Energy Directive

NLR – Nederlands Lucht- & Ruimtevaartcentrum (Royal Netherlands Aerospace Centre)

TRL – Technology Readiness Level

STS – Socio-Technical System

MCA – Multi-Criteria Analysis

RFD – Research Flow Diagram

SCBA – Societal Cost Benefit Analysis

PVE – Participatory Value Evaluation

EIA – Environmental Impact Assessment

SIA – Social Impact Assessment

MCDM – Multi-Criteria Decision-Making

WSM – Weighted Sum Method

WEF – World Economic Forum

MAMCA – Multi-Actor Multi-Criteria Analysis

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1 Introduction

Power2X and Advario have announced a partnership to develop a production and storage facility for synthetic aviation fuel (eSAF) in the Port of Rotterdam which opens in 2030 (Power2X, 2024). The costs of this facility are more than €1.5 billion (Van De Belt, 2024), while uncertainties regarding technological readiness of production processes, feedstock availability and financial viability of eSAF arise (Lau et al., 2024). Power2X will serve as fuel producer, while Advario will provide storage capacity. They aim to produce 250,000 tons of eSAF annually. Other eSAF production facilities in the Netherlands exist, such as Synkero's plant in the Port of Amsterdam and the proposed project Zenid (Ministerie van Infrastructuur en Waterstaat, 2021). Power2X's and Advario's planned production facility is the first large-scale eSAF production facility in the Netherlands (Koster, 2024).

Despite its potential, large-scale eSAF production and therefore uptake faces technical, economic and institutional barriers (Colelli et al., 2023; Lau et al., 2024; Ortega et al., 2021; Scheelhaase et al., 2019). These barriers may limit the feasibility of the planned production facility in Rotterdam and raises the question whether this large-scale production facility is feasible without sufficient government support. Existing literature states facilities of this size are technically and economically infeasible without government support (Santos & Delina, 2021; Scheelhaase et al., 2019). Therefore, this research focuses on the potential role of government support through available policy interventions, and analyses which policy interventions are most accepted by key stakeholders.

The 250,000 tons of eSAF cover around 40% of the needed eSAF in the European Union (EU) annually (Power2X, 2024). This percentage is based on EU obligations set by the EU Fit for 55 (European Commission, 2024). Fit for 55 is a package of policies established by the European Commission to reduce greenhouse gas emissions in the EU by 55% in 2030, compared to 1990. The ReFuelEU Aviation program is part of Fit for 55, which is specifically designed for the aviation sector. ReFuelEU obligates the annual use of sustainable aviation fuel (SAF) at European airports, where eSAF has specific obligation percentages (European Commission, 2024). Currently, the aviation sector accounts for 2.5% of CO₂ emissions and 3.5% of other greenhouse gas emissions annually, and the use of SAF is seen as one of the most promising alternatives to reduce these emissions (Cabrera & De Sousa, 2022). SAF is a sustainable (drop-in) alternative for regular kerosene, mainly derived from biological feedstock (Kallio et al., 2013; Lau et al., 2024). Drop-in means the fuel can be used in existing aircraft and infrastructure, without adjusting the aircraft or infrastructure, after completing tests for the American Society of Testing and Materials (ASTM) (Lau et al., 2024). According to Lau et al. (2024), SAF has several disadvantages compared to eSAF, of which feedstocks that compete with food production and potential environmental footprint reductions are two examples. Power2X produces eSAF with imported methanol, produced with green hydrogen and captured CO₂ (Power2X, 2024), so food competition is not an issue, and emission reductions are higher (Lau et al., 2024).

1.1 European & Dutch Policy

The EU has set a goal to be climate-neutral in 2050 and Fit for 55 marks the start of this effort. The package “ensures a just and socially fair transition, maintains and strengthens innovation and competitiveness of EU industry while ensuring a level playing field, and underpins the EU's position as leading the way in the global fight against climate change” (Council of the European

Union, 2023a). Part of Fit for 55 is, for example, the EU Emission Trading System (EU ETS), which functions as a market based on trades of emissions for energy-intensive industries such as aviation, or the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), which is a global scheme that offsets CO₂ emissions from international aviation. Apart from that, and in this case most relevant, is the ReFuelEU Aviation regulation. This regulation's main goal is to reduce greenhouse gas emissions in aviation by using more renewable and low-carbon fuels, which results in a level playing field for sustainable air transport too (Council of the European Union, 2023b). The most important regulations in ReFuelEU are obligations for fuel suppliers at airports in the EU, who must make a minimum share of eSAF available from 2030 to 2050 (and SAF from 2025 to 2050). Qualified SAFs include certified biofuels, renewable non-biological fuels (such as hydrogen), and recycled carbon fuels that meet the Renewable Energy Directive (RED) sustainability criteria (Council of the European Union, 2023b). The set of ReFuelEU aviation regulations was published on October 9th, 2023.

In 2022, before ReFuelEU Aviation was published, the Dutch Government made decisions regarding SAF ambitions. The Dutch Government aims for a 14% SAF blend at Dutch airports in 2030 (Ministerie van Infrastructuur en Waterstaat, 2020), which is more ambitious compared to the European Commission's obligation of 5% for that year (Council of the European Union, 2023b). The Dutch Government does not specify ambitions or policy for eSAF (studio Gear Up B.V., 2022). The Dutch Government must still comply to ReFuelEU Aviation regulations, which results in the need for 25,000 to 60,000 tons of eSAF at Dutch airports in 2030 (Van der Sman et al., 2022), which can be met through the Power2X/Advario production facility.

1.2 Literature review

A systematic literature review was conducted to examine what is known about the feasibility of large-scale eSAF production facilities and what needs to be studied. For the selection of literature, the Scopus database is used. Specific search strings that were used in Scopus database searching within article title, abstract and keywords are: ("synthetic" OR "sustainable") AND aviation AND fuel AND policy, ("synthetic aviation fuel" OR "eSAF" OR "e-fuel") AND ("Climate Impact" OR "Emission reduction"), synthetic AND fuel AND aviation AND barriers, ("Sustainable aviation fuel" OR "SAF") AND (multi AND stakeholder), and ("synthetic" OR "sustainable") AND aviation AND fuel AND policy AND innovation.

Using these strings, 67 papers were found. Some papers were not relevant, as they focus on topics outside the scope of this study. Based on titles and abstracts, 7 papers were selected. 5 were selected based on snowballing through selected literature, and 3 articles from TU Delft repository were selected. This process resulted in a selection directly linked to this study topic. The articles and reports used are presented in Appendix A.

The complicated and energy-intensive processes required for eSAF production hinder its production (Colelli et al., 2023; Scheelhaase et al., 2019). The technological processes with low Technological Readiness Level (TRL) such as hydrogen production or fuel blending require precise control, which needs to be further developed for better efficiency (Colelli et al., 2023). Also, since the feedstock production processes (hydrogen production) are not efficient, further innovation and optimization of these processes is needed to achieve higher efficiency and compatibility for integration in existing infrastructure (Scheelhaase et al., 2019).

An economic challenge regarding eSAF is the production cost (Colelli et al., 2023; Scheelhaase et al., 2019). The main reasons for this are the early stages of technological processes and a lack of high-capacity production facilities, which makes eSAF less competitive compared to traditional jet fuels (Scheelhaase et al., 2019). Colelli et al. (2023) state that the production costs mainly depend on (renewable) energy and hydrogen prices, which are higher than conventional energy sources, regardless location of production. Even though Power2X and Advorio will import methanol as feedstock, it is still hard to be economically viable. Also because substantial investments in the alternative production processes of the fuels are needed, while financial returns and market readiness are behind (Ortega et al., 2021).

The feasibility of eSAF production is tied to European policies such as Fit for 55 and regional strategies (Colelli et al., 2023; Ortega et al., 2021). It has been found that regional policies and regulatory frameworks are crucial for the feasibility of eSAF production (Ortega et al., 2023; Scheelhaase et al., 2019). However, there's a lack of those strategies (Scheelhaase et al., 2019).

1.2.1 Lack of policy strategies

A mix of policy interventions is needed. According to Scheelhaase et al. (2019), without a regional policy strategy, the eSAF production market does not further develop due to high costs and therefore cannot compete with regular kerosene. Therefore, policy strategies that include financial incentives for eSAF production and use are needed to make eSAF economically viable, apart from setting blending obligations (Scheelhaase et al., 2019). The risk of not integrating a mix of policy interventions (both supportive and obligatory) is that the eSAF production and uptake remain limited to only niche/pilot-scale. Examples of obligated policies are mandates or standards that obligate the use of (e)SAF. Supportive policies are policies that support eSAF production without mandating its use, such as R&D subsidies to produce the fuel or feedstock, pilot plants, investment compensation for high CAPEX and OPEX, or mandates with certain 'sub targets' for eSAF combined with supportive policies to lower the market price and improve the investment climate (Scheelhaase et al., 2019).

Currently, there is a lack in regional (national) eSAF strategies in European countries. And if countries have national strategies, these strategies do not align with international strategies and regulatory frameworks (Scheelhaase et al., 2019). As Scheelhaase et al. (2019) suggest, interventions at the policy level can catalyze eSAF uptake in airline business strategies more effectively than solely focusing on overcoming technical barriers. They state that obligations on their own are not enough as this creates demand certainty but does not directly affect production feasibility.

Ortega et al. (2021), in addition to the supportive policy aspect, review EU policies and innovation for alternative transport fuels, which provides a broader perspective on the innovation and policy landscape. Their paper emphasizes the support through European programs, which in previous situations have proven to be crucial to enable large-scale market introduction through investment in hydrogen and CO₂ infrastructure, and innovation-supportive policy measures. The need for innovations in transportation fuels faces general innovation system problems, such as lock-in effects (when companies find it difficult to switch to another technology due to previous investments) and missing infrastructure, which are addressed by providing subsidies, guarantees, and targeted investment programs (on an EU scale) (Ortega et al., 2021). The combination of a low TRL, high production costs, and uncertainty in demand limits investments

and results in high risk for investors. Therefore, policy interventions must reduce these risks and create a market for eSAF. Otherwise, efforts remain stuck at the R&D stage without market deployment (Ortega et al., 2021).

1.2.1.1 Dutch policy

Since 2020, the Ministry of Infrastructure and Water Management has been in the process of innovating Dutch aviation by presenting the ‘Luchtvaartnota 2020–2050’, in which they aim for a more sustainable Dutch aviation (Ministerie van Infrastructuur en Waterstaat, 2020). The Ministry claims eSAF is part of their innovation strategy, but no specific policy interventions regarding eSAF production have been announced.

NLR suggests that, if the Dutch Government aims to meet European eSAF obligations, it should consider its future energy policy, in which the Dutch Government includes domestic (e)SAF production processes as well (De Waal, 2021). Otherwise, as De Waal (2021) suggests, Dutch supply will not meet demand in 2050. In 2021, NLR provides research on bottlenecks in production which can be solved by a policy strategy to stimulate green hydrogen production and CO₂ supply, to guarantee sufficient renewable electricity, and mainly to coordinate policy, industry, and research efforts to improve technological maturity, infrastructure, and market readiness for eSAF (Van der Sman et al., 2021).

Furthermore, without sufficient coordinated multi-stakeholder collaborations and policy interventions, meeting (e)SAF obligations is challenging (De Vries et al., 2021; E4tech, 2021; E4tech Ltd & studio Gear Up, 2019). In line with this, and the previously described need for supportive policy interventions according to Scheelhaase et al. (2019) and Ortega et al. (2021), the World Economic Forum (WEF) publishes (through the Clean Skies for Tomorrow coalition) a policy toolkit that shows how supply-side, demand-side, and enabling policy measures can be combined to create a feasible (e)SAF ramp-up in production capacity (Gibbs et al., 2021).

As presented, the current Dutch and EU policy landscape for eSAF remains incomplete and speculative. Therefore, it is not only important to understand which policy interventions might be applied or are available (see Chapter 5 – Policy Analysis), but also how different stakeholders perceive these interventions and what interests they represent. This calls for an ecosystem-wide stakeholder analysis considering the complexity of the eSAF innovation system and the interdependent roles of industry, government, research actors, and investors.

These findings suggest that more research into policy interventions should be conducted.

1.2.2 Need of Multi-Stakeholder Collaboration

From the various interdisciplinary barriers described earlier and the need for policy interventions to overcome those barriers, it can be concluded this topic takes place in a socio-technical system (STS). This STS is considered complex because of multi-actor dynamics which involve interactions between actors from technological and institutional organizations. Within this context, policy interventions are more effective when they are accepted by multiple stakeholders (Santos & Delina, 2021). Santos & Delina (2021) analyze this through the example of the coalition “Clean Skies for Tomorrow”. This coalition, consisting of 15 organization across the aviation value chain, proposed a set of policy interventions to the European Commission to support (e)SAF production in November 2020 (Santos & Delina, 2021). Because the different organizations collaborated, the interventions were accepted by mutual stakeholder groups which increased

their effectiveness and resulted in a ramp up in eSAF production and uptake. Interactions like this between stakeholders can mitigate risks, enhance technological and market readiness, and enable transition by combining efforts from government and industry (Santos & Delina, 2021). Despite the proved success, multi-stakeholder collaborations remain limited in practice which leave the policy landscape fragmented with insufficient coordination and limited stakeholder alignment.

The stakeholders in the value chain have conflicting roles, interests and needs in this socio-technical landscape. The complexity lies in synergizing these diverse perspectives and objectives towards a common goal of sustainable aviation. Effective collaboration helps to unity these perspectives into effective coalitions (Santos & Delina, 2021).

Given the complexity of the socio-technical landscape and the systematic barriers of large-scale eSAF production, the authors express there is a need of more multi-stakeholder collaborations. The multi-stakeholder collaborations have proven effectiveness in policymaking in the past, as Clean Skies for Tomorrow led to an increase in eSAF uptake and production during the COVID-19 pandemic too (Santos & Delina, 2021).

The current eSAF production process faces significant barriers, as described earlier. These interdisciplinary challenges can be related to the dynamics of technological innovation systems (Bergek et al., 2008; Jacobsson & Bergek, 2004) and transition theory (Alkemade et al., 2011; Sandén & Hillman, 2011). These theories emphasize the need for systemic change that can be supported through well-coordinated and by stakeholders accepted policy mix, rather than single policy instruments that aligns with short-term innovation incentives, as well as long-term system transformation (Alkemade et al., 2011). This aligns with other transition theory perspectives, which express the importance of coordinated networks and system coordination to overcome lock-ins and systematic failures of the transitions (Bergek et al., 2008; Sandén & Hillman, 2011).

Although initiatives like Fit for 55 and ReFuelEU attempt to stimulate the transition to eSAF use by setting obligations, their effectiveness is limited by gaps in practical implementation due to insufficient (financial) government support and limited technical maturity (Scheelhaase et al., 2019). Closing these gaps requires more coordinated multi-stakeholder collaborations for broadly accepted policies (Santos & Delina, 2021). The international nature of the aviation STS and the lack of (inter)national policies call for more alignment in regional policies and commitment across various stakeholders (Scheelhaase et al., 2019).

1.2.3 Lack of Stakeholder Inclusive Research

Multiple master theses focus on (e)SAF production scalability (van Gelder, 2024; Taets-van Amerongen, 2024). Van Gelder (2024) focuses on challenges in balancing public and private sector collaboration for eSAF development in technological innovation systems. Taets-van Amerongen (2024) focuses on a comparison of SAF production pathways. Similarly, both studies discuss, apart from technological barriers of production and costs, a lack of stakeholder-inclusive case studies. A research approach including stakeholders and their perspectives provides a more balanced picture of the different interests and perspectives in an STS (Taets-van Amerongen, 2024).

1.3 Knowledge gap

By combining insights into needed policy interventions (Scheelhaase et al., 2019), proven effectiveness of previous multi-stakeholder collaborations (Santos & Delina, 2021), and dynamics within technological innovation systems and transition theory (Alkemade et al., 2011; Bergek et al., 2008; Jacobsson & Bergek, 2004; Sandén & Hillman, 2011), it can be concluded that technological innovation alone is insufficient to overcome technological, economic, and institutional barriers to make eSAF production feasible.

Despite policies such as ReFuelEU, barriers like high production costs, lack of economic stimulation, and insufficient societal acceptance limit eSAF adoption (Lau et al., 2024; Santos & Delina, 2021; Scheelhaase et al., 2019). A mix of policy interventions such as financial incentives, blending obligations, and regulatory frameworks can reduce these interdisciplinary barriers (Scheelhaase et al., 2019). Especially when this policy-making is backed by multiple stakeholder groups (Santos & Delina, 2021). This creates a level-playing field among actors too, which limits transition risks being delayed or misaligned with market and technology.

Effective development of eSAF production requires a mix of coordinated policy interventions and multi-stakeholder collaborations capable of navigating and shaping the complex STS. These interventions must strategically target the alignment of (inter)national and regional policies, market mechanisms, and stakeholder interests to create an environment where eSAF production can become feasible. Significant innovative shifts require alignment across the technological, economic, and regulatory dimensions (and therefore stakeholder perspectives) to succeed (Alkemade et al., 2011; Sandén & Hillman, 2011).

A knowledge gap remains regarding stakeholder-inclusive analyses to explore misaligned stakeholder perspectives on policy interventions that support the feasibility of a large-scale eSAF production facility. This research adopts a stakeholder-inclusive approach, examining the STS with different stakeholder perspectives on policy interventions for accelerating eSAF production, using the Power2X and Advorio production facility as a real-life case.

The main objective of this research is to investigate policy interventions that support feasibility of Power2X's and Advorio's planned eSAF production facility in Rotterdam, and to explore which policy intervention is most accepted by stakeholders. Considerations of different stakeholder perspectives are included, which ultimately lead to practical insights for policymakers to support the feasibility of the eSAF facility in Rotterdam.

1.4 Research questions

This knowledge gap and research objective emphasize the need for research into policy interventions that support the feasibility of the planned eSAF production facility in Rotterdam. Recognizing that policy interventions on national level in line with current international regulatory trends, rather than technological advancements, are likely the primary catalysts to support eSAF production feasibility and uptake, highlights the importance of coordinated policymaking accepted by stakeholders. This leads to the following research question:

According to key stakeholders involved in the socio-technical system, which policy interventions support the feasibility of a large-scale eSAF production facility in Rotterdam best?

This research question captures the need to address policy and stakeholder-inclusive dimensions of eSAF feasibility while narrowing the scope to a practical case in the Netherlands. The findings aim to present policy interventions that are accepted by stakeholders in the STS based on analysis. Answering the main research question is done by answering sub-questions, which indicate the structure of the project.

The sub-questions are:

1. Which stakeholders, involved in the STS of eSAF production, should be considered?
2. Which policy interventions that exist can be deployed?
3. Which criteria for the evaluation of policy interventions exist, and how do stakeholders weigh the selected criteria?
4. How do the stakeholders score the policy interventions?

1.5 CoSEM alignment

This research topic aligns with the MSc program in Complex Systems Engineering and Management (CoSEM), since the development of eSAF takes place within a complex STS, where the feasibility of production facilities represents an interplay between technological innovation and social factors. These elements are interdependent: while successful integration of eSAF relies on technological capabilities on one hand, it also depends on societal aspects such as the institutional frameworks and acceptance by various stakeholders, including policymakers, the public, and private organizations. Furthermore, due to interactions between technical and institutional actors, and its integration of systems engineering, institutional economics, and process management strategies in addressing a significant environmental and technological challenge, this topic is considered relevant to the CoSEM domain.

1.6 Research Structure

This research will adopt a multi-criteria approach. All stages of this research are presented in in Figure 1 on the next page. Each stage corresponds with certain chapters and sub-questions. Stage 1 identifies the problem domain (chapter 1) and technological background (chapter 3). Chapter 2 focuses on the method of this study and dives deeper in method applied in the different stages. Stage 2 identifies relevant stakeholders for the STS. This is presented in chapter 4, which is a stakeholder analysis. To ensure a stakeholder-inclusive approach, a selection of these identified stakeholders is contacted to be interviewed in a later stage. Stage 3 is a policy analysis, where various policy interventions are analyzed and selected (based on shortcomings in Dutch supply chain) for the stakeholder inclusive multi-criteria analysis (MCA). This is presented in Chapter 5. Stage 4 is a review to select the criteria for the MCA. This is presented in Chapter 6. In stage 5 stakeholders are interviewed to assign weighs for the selected criteria and to assign scores to each criterion for each selected policy intervention. This is presented in chapter 7. Stage 6 is the MCA calculation stage, using collected weighs and scores from the interviews to define stakeholder perspectives on policy interventions. This is presented in chapter 7 too. Stage 7 is a discussion and conclusion, which results in a discussion of the perspectives on policy interventions according to different stakeholders and the answer to the main research question. This is presented in Chapter 8.

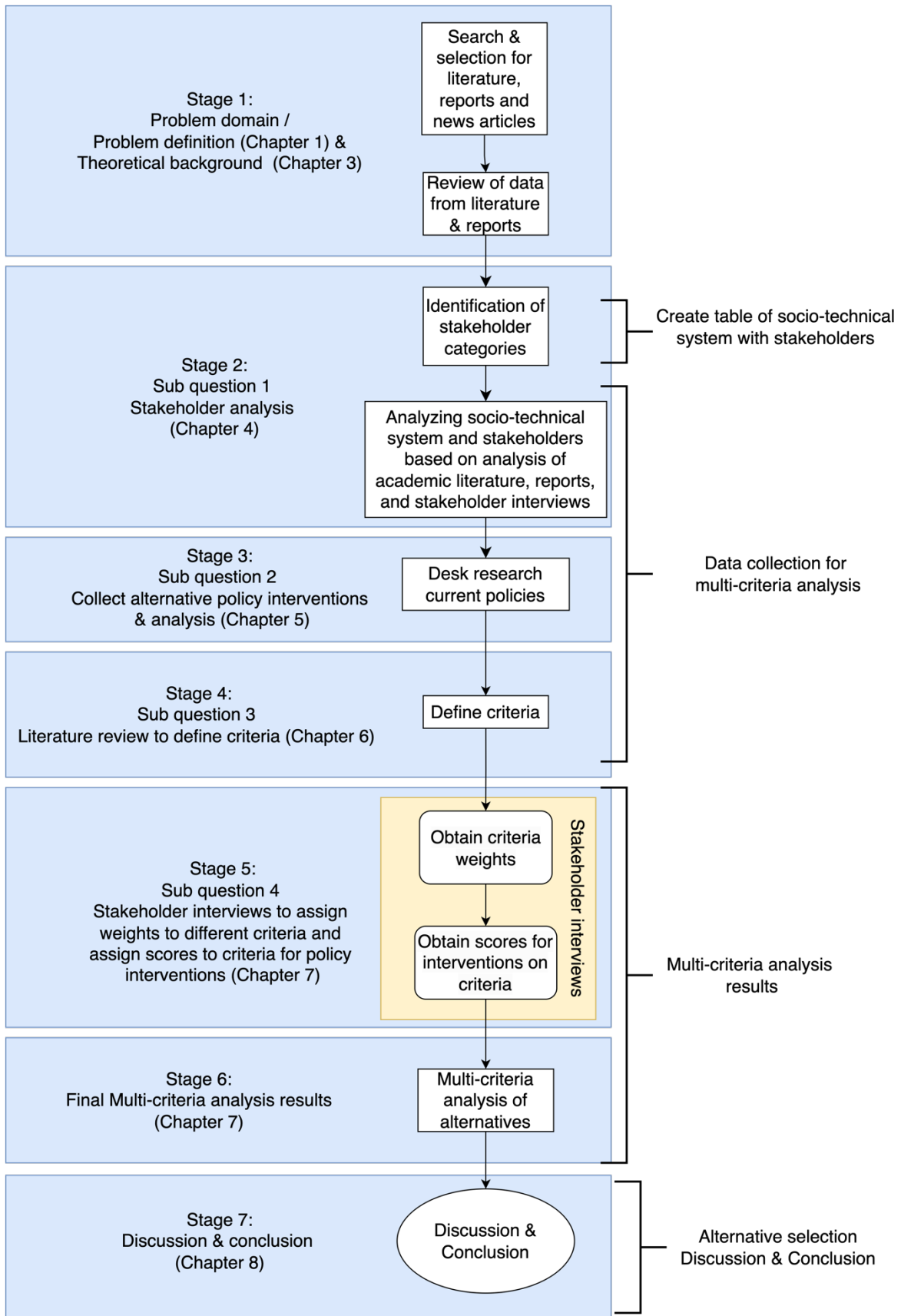


Figure 1: Visualization of research approach.

2 Method

Since various stakeholder perspectives regarding alternative policy interventions must be compared, a comparative analysis method is considered for this research. This chapter presents the reasoning for choosing the comparative method. This chapter presents the method applied per stage as presented in section 1.6 too.

2.1 Analysis method

As the introduction implies, the result of this research is to provide an evaluation of stakeholder perspectives on policy interventions that support the feasibility of Power2X and Advario's planned large-scale eSAF production facility in Rotterdam. This is done by identifying which policy interventions are most accepted by different stakeholders within the socio-technical system (STS). To achieve this, a suitable appraisal method for evaluating, comparing, and ranking policy interventions must be selected. The book by Van Wee et al. (2023) is used to compare these appraisal methods, as this book provides a systematic overview of commonly used appraisal methods, including strengths and weaknesses which make certain methods applicable for the context of this research or not. Commonly used methods are Social Cost–Benefit Analysis, Participatory Value Evaluation, Multi-criteria analysis, Environmental Impact Assessment, and the Social Impact Assessment (Van Wee et al., 2023). Van Wee et al. (2023) describe these appraisal methods which can be considered applicable for a particular context based on criteria as transparency, stakeholder inclusion, monetization requirement and support for decision-making. This allows for academic grounded selection of an appraisal method that fits the nature of this research. The different appraisal methods are summarized below.

2.1.1 Appraisal methods

Social Cost–Benefit Analysis's focus is to monetize all costs and benefits to estimate the net social welfare impact. This method is grounded in economic theory and requires conversion of various aspects into monetary values, which results in subjective and undervalued/overvalued factors that can be crucial in eSAF development. Furthermore, including different stakeholder perspectives, which is a central part of this research, is hard as Social Cost–Benefit Analysis has limited room for participatory input (Van Wee et al., 2023). According to Van Wee et al. (2023), social cost-benefit analysis struggle to transparently offer conflicting values and preferences among stakeholder groups in, making it less effective for this research.

Participatory value evaluation reveals societal preferences under budgetary constraints to evaluate public projects (Van Wee et al., 2023). Even though this method seems to be useful for this research, Van Wee et al. (2023) state this method is most useful for evaluating budget allocations across different public projects rather than comparing policy interventions. Also, it does not allow technical or stakeholder-structured weighting or trade-off analysis necessary for incorporating stakeholder perspectives.

Multi-criteria analysis is particularly suited for context where multiple non-monetizable policy objectives and impacts are considered (Van Wee et al., 2023). According to Van Wee et al. (2023), multi-criteria analysis enables decision-makers to compare and rank policy options across multiple criteria without the need to monetize all impacts. This makes multi-criteria analysis suitable for studies where stakeholder perspectives, and technical feasibility, economic and

environmental impacts of project alternatives must be compared in a structured way (Van Wee et al., 2023).

Environmental impact assessment focuses on the environmental effects of a specific project and is designed for identifying and mitigating environmental harm rather than comparing different strategic policy interventions (Van Wee et al., 2023). Furthermore, according to Van Wee et al. (2023), environmental impact assessment offers limited ability to incorporate the multi-disciplinary nature of topics, while economics, technology, and stakeholder perspectives need to be included in this research. The scope is often procedural, primarily focusing on ecological consequences rather than strategic policy comparison (Van Wee et al., 2023).

Lastly, social impact assessment focuses on social effects, and while this is valuable for capturing qualitative social concerns, it is not designed for comparing and ranking policy interventions (Van Wee et al., 2023). According to van Wee et al. (2023), this method tends to function more as a descriptive and procedural method than as an evaluative framework for designing policy interventions based on multi-dimensional performance.

2.1.2 Advantages of multi-criteria analysis

Applying multi-criteria analysis (MCA) is suited for policy analysis in complex settings with multiple stakeholder perspectives (Macharis & Bernardini, 2024). Analyzing policy interventions per stakeholder can make differences in perspectives more explicit (Macharis & Bernardini, 2024). The other methods are less useful than MCA in this context as with MCA no aspects have to be monetized (requirement for social cost-benefit analysis), this method allows different stakeholder perspectives relative easy (not possible in participatory value evaluation), the research topic has an interdisciplinary nature of (cannot be included in environmental impact assessment), and comparing policy interventions is more important than obtaining qualitative social concerns (which is the main reason for applying social impact assessment).

Regarding feasible eSAF factories with a specific focus on the planned production factory in Rotterdam, applying MCA can address the multifaceted considerations involved in policy making. Applying MCA is effective in settings where a diversity of policy interventions must be balanced against conflicting stakeholder interests in such complex socio-technical dynamics (Triantaphyllou, 2020). Furthermore, applying MCA can integrate both quantitative and qualitative data, which results in assessments across multiple dimensions (Macharis & Bernardini, 2014). Examples such as cost and benefits, but also broader societal implications such as job creation, energy security, or public health, can be considered. When applying MCA, it is possible to incorporate stakeholder perspectives. By incorporating the stakeholder perspective, it is ensured that the selected policies not only ensure technical and economic advancements but are also accepted by stakeholders (Broniewicz & Ogrodnik, 2020). Lastly, applying MCA supports the evaluation of the scalability of eSAF production in Rotterdam, which includes alignment with the city's industrial capabilities with national and European objectives (Yannis et al., 2020).

Furthermore, MCA applications in the past proved its ability to compare and rank policy interventions in the past. This has been done in various contexts, such as alternative fuel buses and renewable energy projects, but also in healthcare policy (Baltussen & Niessen, 2006; Huang et al., 2011; Tzeng et al., 2005). MCA is also applied in the past to analyze and compare various stakeholder perceptions, which makes it more useful to use in this research's specific context (Raaijmakers et al., 2008). Based on these considerations and prior applications in comparable

contexts (e.g. alternative fuels and healthcare), MCA was selected to address the identified knowledge gap in this research.

2.1.3 Selection of method: Multi-criteria analysis – Weighted-sum method

MCA was selected as most suitable method for comparing several policy interventions and ranking them. Particularly Weighted-sum method (WSM) is suitable to obtain, analyze and compare stakeholder perspectives (Broniewicz & Ogrodnik, 2020; Macharis & Bernardini, 2014; Triantaphyllou, 2000; Yannis et al., 2020). WSM is a method to solve Multi-Criteria Decision-Making (MCDM) problems and is considered one of the simplest and most widely known quantitative MCA methods (Lee & Chang, 2018). It is particularly suited for problems with a fixed set of alternatives and predefined criteria (Mulliner et al., 2015; Zavadskas & Turskis, 2011).

In this research, various alternative policy interventions are compared to identify the most accepted option among stakeholders. In WSM assigned weights are multiplied with scores, where the highest value results in the most accepted policy intervention according to the stakeholder (Mulliner et al., 2015). This value is calculated using formula (1).

$$Score_j^s = \sum_{i=1}^n w_i^s \times a_{ij}^s \quad (1)$$

Where:

$Score_j^s$ = Weighted score for policy intervention j according to stakeholder s

w_i^s = Weight of criterion i according to stakeholder s

a_{ij}^s = Score of alternative j on criterion i according to stakeholder s

The different criteria get weights assigned. The sum of the weights of the criteria must be equal to 1. The weights reflect the relative importance of criteria (Mulliner et al., 2015). Then, each alternative is scored against these weighted criteria. The assigned scores indicate how well the alternatives perform on the determined criteria according to the stakeholder.

It is expected that stakeholder perspectives vary. Performance scores are measured on a 0–100 scale, and the weighted score of each intervention is calculated as a weighted sum (formula 1). The WSM is applied in a structured decision matrix. This matrix is presented in Appendix F and organizes the evaluation criteria along the rows, while the columns present the alternatives.

This gives a total weighted score per intervention for each stakeholder. The alternatives are ranked based on the weighted sums. The highest weighted sum receives rank 1, and lower weighted sums are ranked accordingly. This matrix-based method allows a structured approach for interventions ranked on each stakeholders' perspectives for this STS.

2.2 Research flow

Section 1.6 describes the different stages of the research flow. This section describes method used in all stages.

2.2.1 Stage 1 – Technological eSAF background and government’s role

Stage 1 identifies the problem domain (as presented in chapter 1), technological background and policy interventions (as presented in chapter 3) through an extensive literature review. For the selection of literature, the Scopus database is used as described in section 1.2. Figure 3 below presents the search and selection process.

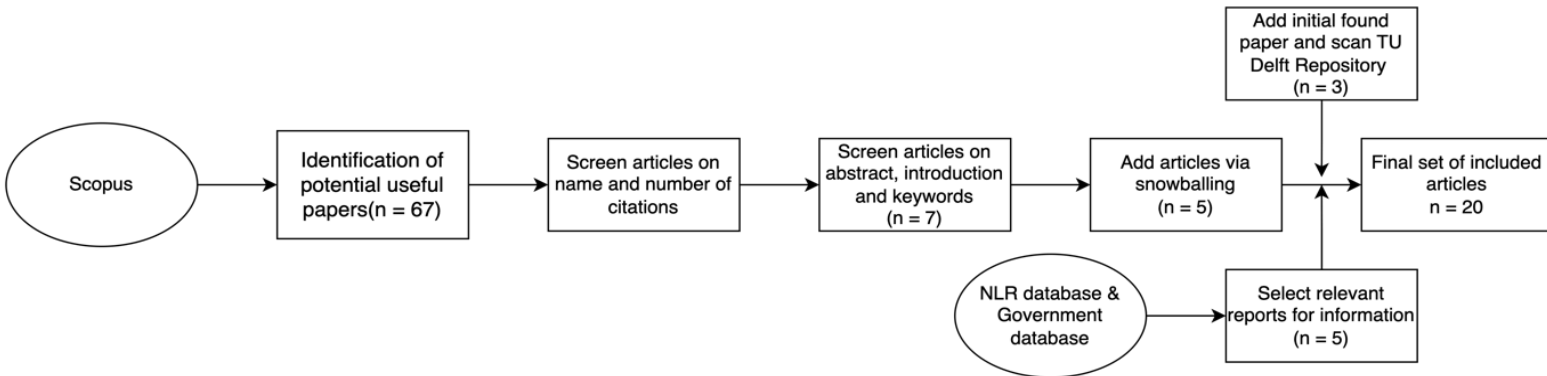


Figure 2: Search & Selection process literature- & report review introduction & theoretical background.

In addition to the academic papers used for the literature review in section 1.2, research reports from Netherlands Aerospace Centre (NLR) and consultancy reports on behalf of the Dutch Government are used. A total of 5 papers is added, as these papers identify key bottlenecks in eSAF production in the Netherlands. These bottlenecks can lead to policy interventions to make eSAF production more feasible.

2.2.2 Stage 2 – Stakeholder analysis

Stage 2 identifies the stakeholders’ roles, interests, and needs operating in the STS, based on the academic papers and used consultancy and research reports in stage 1. This results in the answer to sub-question 1. This sub-question identifies stakeholders in the context. Their roles, interests, needs and potential conflicts are described. As described in the introduction (section 1.2.2), the misaligned interests of the different stakeholders result in policy interventions that are not desired or accepted by all stakeholders, which makes them less effective in scale-up in eSAF production. Even though finding a policy intervention that is accepted by all stakeholders is difficult, multi-stakeholder collaborations seem viable for reducing misaligned interests and therefore creating more effective policies (Santos & Delina, 2021).

The stakeholder analysis starts with identifying stakeholder categories (section 4.1) but must be further analyzed to explain stakeholder perspectives on policy interventions (stages 5 and 6). For this, stakeholders are specified in the context of the planned Dutch eSAF production facility. Multiple organizations of all categories are identified. 32 employees of these organizations in this context are contacted for interviews to identify their roles, interests, needs, and perspectives on policy interventions. Eight were available for and willing to contribute to interviews. In this way, one interviewee from each stakeholder category is integrated. These interviews were semi-structured (interview protocol as defined in Appendix D) and adhered to TU Delft Human Research Ethics Committee guidelines. Each participant was required to sign an informed consent prior to the interview. A copy of this informed consent can be found in Appendix B. The interviewees included are fuel producers (Power2X), storage and logistics operators (Port of Rotterdam), airlines, (Transavia) governmental policymakers (Ministry of Infrastructure and

Water Management), regulatory bodies, industry associations (GroenvermogenNL), research institutes (NLR), consultancy organizations (To70) and financial institutions (Luchtvaart in Transitie). The stakeholders are described and analyzed in chapter 4. Figure 3 below presents a flow chart of how Stage 2 looks. The conclusion of Stage 2 is a table in which stakeholders and organizations, including their roles, interests, needs, and potential conflicts, are presented.

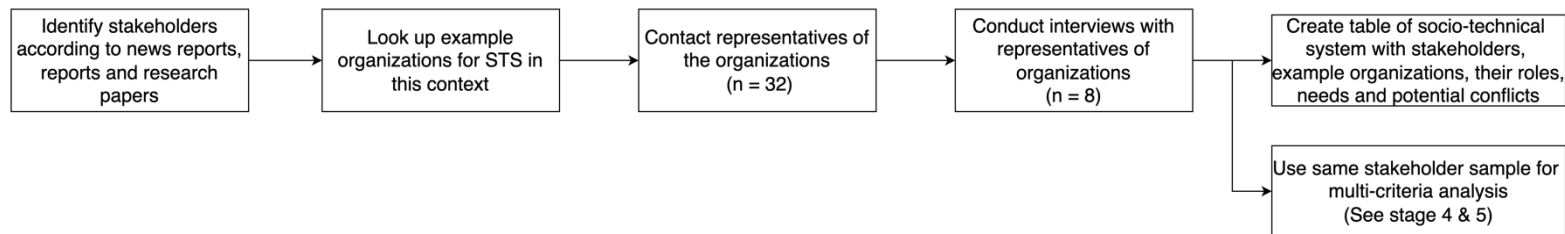


Figure 3: Visual representation of stage 2.

2.2.3 Stage 3 – Collection of policy interventions

As described in the theoretical background section 3.2, various reports from WEF, NLR, or consultancy reports on the instructions of the Dutch Government identify various policy interventions based on shortcomings in the supply chain. In stage 3 policy interventions are selected based on these shortcomings. The shortcomings are based on the same reports as used for stakeholder identification in stage 2. The selected policy interventions, including their design, application context, expected implications for feasibility, and academic rationale are explained. The conclusion of Stage 3 is a table in which the various selected policy interventions for the MCA are presented. The selected policy interventions are the answer to sub question 2.

2.2.4 Stage 4 – Determine criteria for multi-criteria analysis

Based on the selected policies and the concluding table, in Stage 4 criteria for the MCA are selected. This forms the answer to the first part of sub-question 3.

The criteria were selected by analyzing the book by Van Wee et al. (2023), as this book describes six criteria for ‘healthy policies’; (effectiveness, efficiency, equity, ease of implementation, flexibility, and long-term robustness). This research used five of those, as flexibility and long-term robustness were considered equal in this rapidly innovating system.

After that, a literature search using Scopus for the first part of sub-question 3 is conducted. The goal of this literature review is to identify papers that use comparable criteria in MCA to support the selection of criteria. This research included academic papers that analyze policy alternatives in transport innovation, although not specifically for alternative fuels. From the reasons given in Section 2.1 on why MCA was selected, it was concluded that policy interventions in different contexts offer valid justification for applying MCA and provide relevant insights for selecting criteria. Search strings used are “("multi-criteria analysis" OR "mca"), Article title, Abstract, Keywords (Criteria), All fields ("transport policy" OR "sustainable aviation policy" OR "synthetic fuel policy")”.

Searching literature with this string was less useful, as all papers were included in the search, even though only stakeholder-inclusive studies should be analyzed.

A second search string was selected: and ““multi-criteria analysis" OR "mca"), Article title, Abstract, Keywords (Criteria), All fields ("transport policy" OR "sustainable aviation policy" OR "synthetic fuel policy"), All fields ("multi-actor" OR "multi-stakeholder" OR "multi stakeholder collaboration")”.

Book chapters and papers with fewer than 20 citations were considered not valuable and therefore excluded. Papers were analyzed based on title and number of citations and were excluded if considered not relevant. After that, article abstracts were read to assess contextual relevance, ensuring that academic literature in which MCA is applied among stakeholders is included. This resulted in a set of 15 articles and the book by Van Wee et al. (2023), as presented in Figure 4 below.

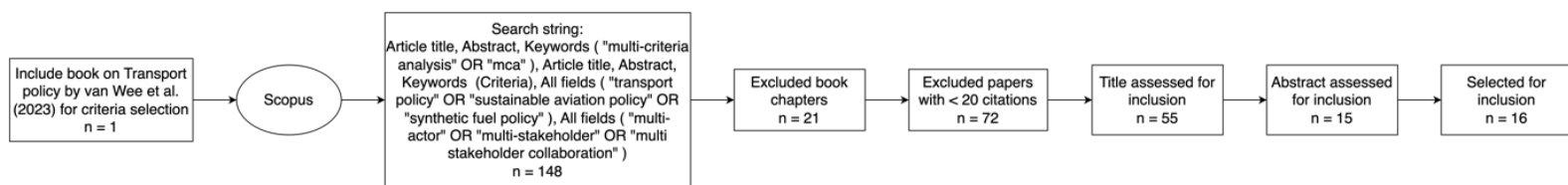


Figure 4: Visualization for search and selection process for literature review conducted for establishment of criteria for MCA.

2.2.5 Stage 5 – Assigning weights to criteria

Once the criteria were determined, weightings were obtained through the semi-structured interviews with stakeholders, using the same interview protocol in Appendix D. This is presented in chapter 7. The interviewees assign weights to the criteria and are asked about the rationale from the organization’s perspective. During the eight stakeholder interviews the criteria weights were defined, which form the answer to the second part of sub-question 3. With these semi-structured interviews, the different perspectives of stakeholders defined in Stage 2 on criteria to evaluate policy interventions selected in Stage 3 were quantified.

Once the criteria are determined and the weightings were obtained, each intervention received scores based on the criteria and weight analysis, also based on rationale from the organization’s perspective. This is presented in chapter 7 too. This forms the answer to sub-question 4. The scores are obtained on a 0–100 scale to maximize interpretability and differentiation between alternatives (Mulliner et al., 2015; Zavadskas & Turskis, 2011).

2.2.6 Stage 6 – Multi-criteria analysis

The weights and scores for each policy interventions are multiplied, resulting in a weighted sum for each policy intervention according to each interviewed stakeholder. This approach is suitable when working with multiple stakeholders, as it provides a transparent, replicable, and inclusive selection process (Macharis & Bernardini, 2014).

The obtained rankings did not require normalization. The weights are already normalized (sum equals 1), the scoring scale is consistent across all stakeholders, and results are directly interpretable and comparable. WSM allows for simple calculation of final scores for each alternative, which results in clear and interpretable rankings (Lee & Chang, 2018). The assigning of weights and scores was done in a preprogrammed spreadsheet. This spreadsheet is displayed in Appendix F.

For each stakeholder, a ranking was created. Due to different stakeholder perspectives, policy interventions are ranked differently according to the stakeholders. Discrepancies and similarities in weights and scores can be compared per criterion and policy intervention. Results of the MCAs are directly comparable across stakeholders (Mulliner et al., 2015; Zavadskas & Turskis, 2011). This method was useful in this context, as conflicting stakeholder perspectives were expected (Lee & Chang, 2018; Triantaphyllou, 2000). By treating each stakeholder with equal importance, this method prevents disproportional influence by dominant stakeholders (Bergek et al., 2008). Dominant stakeholders might otherwise influence the decision-making process (Bergek et al., 2008). This was considered appropriate for the STS context in which eSAF development is situated and supports the formulation of broadly accepted policy interventions.

2.2.7 Stage 7 – Conclusion and discussion

The seventh stage is the final stage, with a discussion and conclusion. In the discussion, the implications of the results, limitations of this study and scientific contribution are described. This functions as a reflection of the MCA. This research ends with the conclusion, in which answers to sub questions are provided too.

3 eSAF production and shortcomings

This chapter focuses on the technological background of eSAF production, current bottlenecks for production on a large scale, the current eSAF production ecosystem and the government's role in these types of innovations.

3.1 Technological background

As discussed in the introduction, aviation contributes significantly to greenhouse gas emissions (Cabrera & De Sousa, 2022). Various papers underscore the importance of using SAF as a pathway to reduce these emissions, where eSAF has the highest impact on the reduction (Cabrera & De Sousa, 2022; Lau et al., 2024; Kallio et al., 2013; Schmidt et al., 2018). In general, the production of sustainable fuel involves sourcing and collecting suitable materials, followed by multiple chemical processing steps to produce usable jet fuel (Kallio et al., 2013). Considering the planned eSAF production facility in Rotterdam and its production process (see Figure 2), it is notable that within the factory, synthetic aviation fuel is produced from (imported) methanol. This methanol is derived from green hydrogen generated via renewable energy, and biogenic (captured) CO₂ (Power2X, 2024).

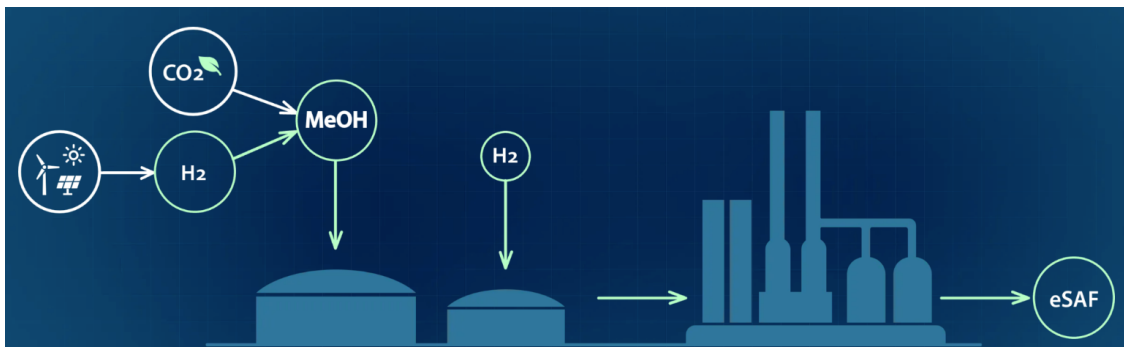


Figure 5: Visual representation of eSAF production according to Power2X. Figure coming from (Power2X, 2024).

This plant is therefore qualified as a Fischer-Tropsch – Power to Liquid (FT–PtL) process (Braun-Unkhoff & Riedel, 2014; Lau et al., 2024; Schmidt et al., 2018). While SAF is typically produced from biological feedstocks, such as fats and oils, FT-PtL utilizes captured CO₂ and hydrogen produced via renewable electricity (Cabrera & De Sousa, 2022; Lau et al., 2024). These feedstocks are particularly advantageous since there is no competition with food, which limits ethical concerns (Braun-Unkhoff & Riedel, 2014). Apart from that, Braun-Unkhoff & Riedel (2014) imply that eSAF emits lower amounts of CO₂, sulfur, and several other pollutants than SAF. Before drop-in fuels can be used, they must be sufficiently available at acceptable prices, with no need to adjust today's aircraft and infrastructure (Braun-Unkhoff & Riedel, 2014), and require ASTM approval (Lau et al., 2024). This production process is approved for a blending percentage of 50% (Deloitte & To70, 2025).

Considering Power2X's production facility, Honeywell's Methanol-to-Jet technology (UOP eFinig) is selected, which drives the conversion of green methanol into eSAF at scale (Ellis, 2024). Honeywell claims their process reduces greenhouse gas emissions by 88% compared to traditional jet fuel (Honeywell UOP, 2025).

On Honeywell's website, a few disadvantages of synthetic fuels are mentioned, namely: the expensive production due to the production process that depends on renewable power plants

and electrolyzers (hydrogen production), and the fact that global capacity must be deployed to supply the needed amount of eSAF (Honeywell UOP, 2025). Literature acknowledges this barrier (Braun-Unkheoff & Riedel, 2014; Colelli et al., 2023; Lau et al., 2024; Ortega et al., 2021; Scheelhaase et al., 2019), and Royal Netherlands Aerospace Centre (NLR) concluded this in 2021 as well.

NLR questions whether the amount of eSAF produced in the Netherlands will meet the required capacity (De Waal, 2021). If so, it highly depends on the amount of available renewable electricity for the aviation sector, available feedstock, infrastructure and market certainty (De Vries et al., 2021; De Waal, 2021; E4tech, 2021; E4tech Ltd & studio Gear Up, 2019)). These are examples of interdisciplinary barriers that cannot be overcome without intervention. Therefore, policy interventions are needed to address them (Ortega et al., 2021; Scheelhaase et al., 2019). More shortcomings in Dutch eSAF production are explained in section 5.1, which leads to a selection of policy interventions for the stakeholder-inclusive MCA in section 5.2.

3.2 Shortcomings in Dutch supply chain

To support the selection of supportive policy interventions for MCA, it is essential to identify shortcomings that require policy interventions. The shortcomings directly hinder the scale-up of production, limit market creation and delay in technological development (Deloitte & To70, 2025). This section addresses these shortcomings based on Dutch consultancy and research reports. The findings are used to determine which areas require policy interventions.

A lack of long-term policy clarity and financial incentives results in weak market signals, which discourages investment in eSAF production (Deloitte & To70, 2025; Scheelhaase et al., 2019). Therefore, policy interventions that stimulate market creation are needed. WEF (through Clean Skies for Tomorrow coalition) identifies key areas where policies can be most effective. This includes ensuring feedstock availability, supporting R&D, de-risking private investments to increase production capacity, and easing trading barriers to support a global playing field (Gibbs et al., 2021). Furthermore, WEF states that national policies should align with international and regional standards (Gibbs et al., 2021), as discussed by Scheelhaase et al. (2019) too. The Dutch Government aims to achieve alignment with international regulations, but specific (long-term) eSAF policies are lacking (Ministerie van Infrastructuur en Waterstaat, 2021). This leads to missed technological opportunities and underinvestment due to market stability concerns (Gibbs et al., 2021).

The Dutch market has limited domestic feedstock available for eSAF production (Meerstadt et al., 2021; E4tech, 2021). Power2X tackled this by importing methanol, but these are also in demand from other sectors like chemicals and road transport. This leads to feedstock competition and hinders development of local eSAF supply. In extension to this, blending and export infrastructure and logistics chains for eSAF are underdeveloped (Meerstadt et al., 2021; Deloitte & To70, 2025; De Vries et al., 2021). Therefore, there should be policy interventions that foster integrated planning for eSAF blending hubs, CO₂ sourcing, and hydrogen and methanol logistics. Without these physical structures, large-scale production remains infeasible (Meerstadt et al., 2021; Deloitte & To70, 2025; De Vries et al., 2021). Furthermore, the current production cost of eSAF cannot compete with traditional kerosene (De Vries et al., 2021; E4tech, 2021). This cost gap with traditional kerosene makes eSAF uncompetitive in the absence of policy support that minimizes this price gap. Lastly, Dutch policies lack clear eSAF strategies and are often fragmented across

departments and sectors which hinders long-term planning (E4tech Ltd & studio Gear Up, 2019). The absence of a coherent national strategy limits stakeholder engagement and multi-stakeholder collaboration. These shortcomings highlight the need for policy interventions in Dutch context, while also aligning with international frameworks as proposed by WEF. The stakeholders are described in chapter 4, while selected policy interventions are described in section 5.2.

4 Stakeholder analysis

This chapter identifies different stakeholders, their roles, interests, needs, and potential conflicts, based on the categories identified previously. For this stakeholder analysis, each stakeholder category was discussed, as well as their roles, interests, values, and potential conflicts with other stakeholders. This information is based on the interviews conducted. The goal is to create an overview of the STS of this innovation, which is presented in Table 1. Section 4.1 identifies stakeholder categories. Section 4.2 defines which stakeholders are contacted. Section 4.3 describes the different stakeholders, their roles, interests, needs, and potential conflicts with other stakeholders.

4.1 Stakeholder categories

Key stakeholders and their roles can be derived from previously referred academic literature (Cabrera & De Sousa, 2022; Colelli et al., 2023; Lau et al., 2024; Santos & Delina, 2021; Scheelhaase et al., 2019) and reports from CE Delft (De Vries et al., 2021), E4Tech (E4tech, 2021; E4tech Ltd & studio Gear Up, 2019), NLR (De Waal, 2021; Meerstadt et al., 2021), and WEF (Gibbs et al., 2021). Stakeholders to consider are those who affect or are affected by the STS and are fuel producers, storage and logistics operators, airlines, governmental bodies/policymakers, regulatory bodies, European and global bodies (market coordination or industry associations), research institutes and NGOs, consultancy organizations, and financial institutions/investors.

4.2 Selection of stakeholders for interviews

Due to time and reality constraints, a selection of stakeholders is included for the MCA. It was considered not realistic to interview European Organizations, as they are hard to reach out to. Therefore, they have been left out of the interviews. Also, due to time constraints, it was considered impossible to reach out to all possible stakeholders and to include all their perspectives in this research. Therefore, all other categories are contacted. 8 respondents were available to be interviewed. The interviewed employees of organizations (in chronological order) are: Luchtvaart in Transitie (financial institution), Ministry of Infrastructure and Water Management (governmental policymakers), Transavia (airline), GroenvermogenNL (industry association), NLR (research institute), Port of Rotterdam (storage and logistics operator), Power2X (fuel producer) and To70 (consultancy). This results in interviews with one person of each stakeholder category to reflect at least each stakeholder category.

4.3 Description of stakeholders

The different stakeholders have different interests, which may or may not be aligned with each other due to differences in the private/public nature of the actor's view (van Gelder, 2024). These misaligned interests result in a lack of coordinated views and needs for eSAF production. Therefore, there is a need for understanding those different interests to foster trust-building between stakeholders. This section describes the different stakeholders. An overview of the stakeholder analysis is presented in table 1.

4.3.1 Financial institution

An employee Luchtvaart in Transitie has been interviewed. This organization is part of the Dutch National Growth Fund, which focuses on the energy transition and sustainability in aviation manufacturing and the knowledge sector by providing funds. Even though no current projects regarding (e)SAF are included in the program, the interviewee has provided European policy insights, particularly on European policy alignment and government funding.

The generic role of this type of organization is to finance a project. Through these investments, long-term development can be ensured. Luchtvaart in Transitie specifically funds projects regarding aviation innovation. The main interest of these organizations is to enable large-scale investments at an early stage of developing a production facility. This directly leads to de-risking, which is according to the fuel producer the most important in the early stages of commercialization. For financial institutions, clear investment frameworks must be established to ensure security. This de-risking tool can be met through stable policies or market mechanisms.

As described, eSAF is currently unprofitable. Therefore, large investments are risky currently. Organizations mainly invest when national strategies regarding development are clear. If this is the case, investment attractiveness will rise.

4.3.2 Governmental policymaker

An employee from the Dutch Government has been interviewed. The Ministry of Infrastructure and Water Management is responsible for national (sustainable) aviation policies. The design of these policy instruments can provide financial incentives or obligations. The ministry oversees regulatory compliance, too. The primary interest of policymakers is to ensure an effective implementation of policies aligned with Fit for 55/ReFuelEU. In this context, it is to ensure the effective rollout of eSAF in the Netherlands. The government aims to promote innovation in production and use, and aims to stimulate the market through enabling policies, rather than taking all financial responsibility.

To meet these objectives, the government needs insights into the operational and financial needs of the stakeholders. Coordination with EU institutions and alignment with national goals are essential. Potential conflicts arise in balancing industrial support with emission reduction targets and legal timelines. Furthermore, a constrained budget results in trade-offs between long-term innovation and short-term financial support. Coordination in national ambitions with EU policies is hard, as stakeholders must be satisfied too.

4.3.3 Airline

An employee from Dutch airline Transavia has been interviewed. Transavia, in this context, is a potential off-taker of the fuel produced in the eSAF production facility. Organizations as Transavia play a key role in demand creation and operational deployment of eSAF through offtake agreements. Transavia aims to meet the company's sustainability targets and EU blending mandates without compromising operational costs. They seek to have a reliable, sustainable fuel supply. To ensure this affordable and scalable eSAF, Transavia is interested in clear long-term strategies from the government. Price stability is also important. Risks of eSAF are the prices remaining high or policies being delayed, or changes over time. For Transavia, eSAF deployment results in pressure on (rising) ticket prices. Therefore, conflicts between sustainability commitments and the profitability of the organization arise.

4.3.4 Industry association

An employee from GroenvermogenNL has been interviewed. GroenvermogenNL is part of the Dutch National Growth Fund and focuses on green hydrogen by investing in R&D projects, regulation for pilot projects, demonstration and scale-up projects, and human capital. For eSAF, GroenvermogenNL conducts research on green hydrogen development as a feedstock and tries to foster stakeholder collaborations in the STS. Industry associations represent sector-wide interests and needs of stakeholders and coordinate international frameworks. Their main interest in this context lies in promoting eSAF uptake and ensuring fair market conditions for all stakeholders. This leads to industry growth. Their main needs lie in alignment with global rules and national policies and establishing collaborative platforms to align stakeholders' goals.

Therefore, conflicts arise between commercial objectives and regulatory targets among different stakeholders. It results in misaligned perspectives, mainly in project-oriented funding, producers' and offtakers' needs.

4.3.5 Research institute

An employee from the NLR has been interviewed. NLR is an independent research institute that provides objective and science-based insights to government and industry in the field of aerospace. It was a government agency before but now operates as a semi-public organization researching on behalf of stakeholders. NLR does not directly develop or fund SAF facilities but has conducted studies on, for example, SAF performance, climate impacts, and techno-economic feasibility. The organization provides research to inform decision-makers.

The main role of research institutes is to conduct R&D and feasibility studies to evaluate environmental and social impact, validate innovations, and advise governments on policymaking. Economic viability and bottlenecks of eSAF production are part of this. Their main interest lies in research-based advice on decision-making and sustainability impact validation. The organizations aim to drive innovation through their expertise in technology, policy, or the economy. Their research aims to drive innovation in production and use. Their needs are participation in stakeholder dialogues and transparent technology assessments through access to pilot projects and funding for testing technology. Conflicts arise in differing evaluation frameworks and timelines, which may delay implementation. The different timelines or criteria slow down implementation, and conflicts between commercial and political agendas on research findings arise.

4.3.6 Storage and logistics operator

An employee from the Port of Rotterdam has been interviewed. Port of Rotterdam is an organization that manages and develops the port and industry in Rotterdam. In this socio-technical system, the Port of Rotterdam can be seen as a storage and logistics operator. The organization is responsible for the provision of storage and distribution of eSAF at the port. It enables logistical feasibility in Rotterdam, the Netherlands and the EU.

Storage and logistics operators' main interest lies in ensuring sufficient throughput to justify investments and ensure predictable volumes and infrastructure subsidies for storage needs. These organizations need, therefore, predictable long-term eSAF volumes and clarity on infrastructure planning. This results in the desire for subsidies and permits for new storage and pipelines. On the other hand, storage and logistics operators depend on (international) policy,

which affects fuel producers' success and airlines' uptake. If this isn't sufficient, potential pressure to invest in unproven logistics arises. Furthermore, the organizations as the Port of Rotterdam, compete with other potential port users and face uncertainty if government cooperation is limited.

4.3.7 Fuel producer

An employee from Power2X has been interviewed. Power2X in this STS is responsible for fuel producer. Power2X as a fuel producer develops and operates the production facility and related technologies. In specific, Power2X's role is a market-maker for eSAF in the Netherlands.

For fuel producers, their main interest lies in securing market demand to justify large investments to eventually scale up production. Their goal is to produce the fuels needed through established market demands. Fuel producers need long-term policy support to ensure security for investors, as the process remains expensive for traditional fuel production. Reliable access to both financial and feedstock inputs and offtake is essential. Conflicts may arise due to the high capital costs needed, current uncertainty in policy continuity and therefore demand, competition over renewable inputs for feedstocks, or uncertainty over fuel price. These uncertainties can undermine investments and therefore limit the security of feasibility. Fuel producers seek secure investments for the cost-intensive phase, mainly before final investment decisions are made.

4.3.8 Consultancy

An employee from To70 has been interviewed. To70 is an aviation consultancy organization, aiming to help society and industry address challenges in aviation. They help by delivering consultancy services and conducting research on behalf of both private and public organizations. Consultancy firms can be seen as an independent stakeholder category from research institutes, as consultancy firms do not follow standard scientific methodology but synthesize expert input and existing knowledge to deliver practical client-oriented insights.

Consultancy organizations advise public and private organizations on sustainable aviation and policy. The organizations, therefore, contribute to strategic projects and the feasibility of (e)SAF development. Their main interest lies in creating a practical and cost-effective policy environment to stimulate investments. For this, consultancy needs collaboration among sectors to align interests and clarify with customers' problems to advise on. Conflicts arise due to the limited direct role of consultancy. This can result in a disconnect from commercial implementation. As collaboration among sectors is needed, conflicting stakeholder agendas can complicate the trust-building for these collaborations. Lastly, conflicts may arise between consultancy recommendations and political feasibility and stakeholder resistance.

4.3.9 European/International body

European/international bodies are not interviewed. Representatives of these organizations did not respond to any invitations. International (aviation) organizations as the European Commission, the International Civil Aviation Organization (ICAO), or the International Air Transport Association (IATA), coordinate global sustainability standards, such as fuel obligations. The organizations are responsible for monitoring progress and alignment with policy. ICAO stimulates through financing SAF projects, too.

The main interest of these organizations lies in establishing international harmonization for regulations and reliable data for global aviation decarbonization. In this STS, these organizations need to collaborate with the Dutch government for regulatory rollout and certification processes. Current conflicts arise due to limited coordination of national policies, which leads to fragmented regulations across EU member states. On the other hand, organizations such as ICAO and IATA do have limited enforcement power as the organizations are not meant to enforce law and regulations, but mainly to monitor progress and are relevant for mapping problems in the STS.

Table 1: Summary of stakeholder analysis presented in table format.

Stakeholder Category	Organizations in this context	Role	Interest	Need	Potential Conflicts
Fuel Producers	Power2X, SkyNRG	Develop and operate the eSAF production facility and related technologies. Power2X as market-maker for eSAF in NL.	Secure market demand to justify large investments. Scale-up production.	Clear long-term policy support and investment security. Reliable access to inputs and offtake is essential.	High capital costs, uncertainty in policy continuity, competition over renewable inputs. Can undermine investment. Tension over fuel price.
Storage and Logistics Operators	Advario, Port of Rotterdam	Provide storage and distribution of eSAF; enable logistical feasibility in Rotterdam/Netherlands/EU. Port enables assess and utilities for production.	Ensure sufficient throughput to justify investments. Predictable volumes and infrastructure subsidies for new storage needs.	Predictable long-term eSAF volumes and clarity on infrastructure planning. Subsidies/permits for new storage and pipelines is needed.	Dependency on fuel producers' success and airline uptake; potential pressure to invest in unproven logistics. Compete with other port uses or projects and face uncertainty if government cooperation is limited.
Offtakers (Airlines)	KLM, Transavia, easyJet	Create demand; adopt and operationalize eSAF on flights; engage in offtake agreements with producers.	Access to affordable eSAF to meet EU SAF obligations without compromising cost competitiveness. Maintain reliable fuel supply.	Affordable and secure eSAF supply to fulfill obligations. Price gap compensation.	Risk of rising costs if eSAF prices remain high, exposure to policy delays or changes. Pressure on ticket prices. Conflicts between sustainability commitments and profitability.
Governmental Policymakers	Ministry of Infrastructure and Water Management	Set national aviation policy. Design policy instruments, provide financial incentives, and oversee regulatory compliance.	Effective implementation of Fit for 55/ReFuelEU national policies through effective eSAF rollout. Support innovation through industry support for policies.	Insights into stakeholder needs; coordination with EU and Dutch SAF strategies.	Challenge of balancing industrial support with emission targets and legal timelines. Limited budgets and ambitious goals. Coordination challenges between national and EU policies.
European/ International Bodies	European Commission, ICAO, IATA	Coordinate global and EU fuel standards and sustainability standards; monitor regulatory compliance.	International harmonization for regulations and reliable data for global aviation decarbonization.	Collaboration with Dutch government regulatory rollout and certification processes.	Limited national coordination may lead to patchwork regulations across EU states. Limited enforcement power.
Industry associations	NAG, Groenvermogen NL	Represent sector-wide interests, coordinate international frameworks. Represent member needs.	Promote broad SAF adoption and fair market conditions for all stakeholders. Ensure industry growth	Alignment between global rules and national policies. Collaboration platforms to align goals	Conflict between commercial objectives and regulatory targets. Misalignment in project-oriented funding and eSAF producer's needs.
Research Institutes, NGOs	CE Delft, NLR, TNO, To70	Conduct scientific R&D and feasibility studies. Evaluate environmental/social impact, validate innovations, and advise government.	Research-based decision-making and sustainability impact validation. Drive innovation through technical expertise on production and use.	Participation in stakeholder dialogues and transparent technology assessments through access to pilot projects and funding to test technology.	Differing evaluation frameworks and timelines may stall implementation. Different timelines or criteria slow down implementations. Tension between commercial and political agendas on different research findings.
Consultancy	To70	Advise public and private organizations on sustainable aviation and policy. Contribute to strategic projects and feasibility for (e)SAF development.	Create policy environments that are practical, cost effective and stimulate investment.	Collaboration across sectors to align interest. Clear customers with questions to advise on.	Limited direct role can create disconnect from commercial implementation. Conflicting stakeholder agendas can complicate trust building. Potential conflicts between consultancy recommendation and political feasibility/stakeholder resistance.
Investors and Financial Institutions	National Growth Fund, CPP Investments, Luchtvaart in Transitie	Finance projects, investments, and enable long-term development. Luchtvaart in Transitie funds aviation innovation.	Enable large-scale investment by de-risking projects. Support aviation's transformation with finance.	Clear investment frameworks and de-risking tools. Stable policy and market mechanisms.	High investment risks if eSAF remains unprofitable. Delay in project execution or unclear national strategies reduce investment attractiveness.

5 Policy interventions

NLR research identifies shortcomings in current Dutch eSAF development (De Waal, 2021; Meerstadt et al., 2021), which have also been noted by the Dutch Government previously (E4tech, 2021; E4tech Ltd & Studio Gear Up, 2019). These shortcomings are explained in section 3.2 already. This chapter dives into the policy interventions to overcome those shortcomings. Section 5.1 presents selection criteria for selecting policy interventions for the MCA, while the selected policy interventions (as identified by Gibbs et al. (2021) and Dutch consultancy and research reports) are described in section 5.2. The selection of the interventions for this MCA has been made based on proven effectiveness and feasibility in academic literature, and their link to the concepts of supportive policy and multi-stakeholder collaboration, described in section 5.2 too. An overview of the final selection of policy interventions is presented in table 2. The selected policy interventions are used in the stakeholder-inclusive MCA.

5.1 Selection criteria for policy interventions

To ensure international policy harmonization in the selection of policy interventions, which is needed according to Scheelhaase et al. (2019), WEF suggests 14 standard policy interventions. Not all policy interventions can be selected for the MCA, as MCA can facilitate six to seven alternatives maximum (Rezaei, 2015). Furthermore, evaluating 14 policy interventions in one interview is not realistic in terms of time availability in the interviews. These reasons are more practical, but methodological necessary considerations to make.

Secondly, selected policy interventions must be suited for the context (van Wee et al., 2023). According to van Wee et al. (2023), selected policy interventions for comparison must be connected to local barriers. In this case, the policies must be suited for shortcomings in Dutch context, as explained in section 3.2.

Thirdly, policy interventions must be selected based on empirical proof or success in similar applications (Van Wee et al., 2023). In this case, the selected policy interventions are selected based on academic literature that identifies proven effectiveness of similar policy interventions in similar context.

Furthermore, the WEF report states markets are generated through implementing three categories of policy interventions: demand-side, supply-side, and enabling policy interventions (Gibbs et al., 2021). According to Gibbs et al. (2021), a combination of these three categories is needed to create a ramp-up in supply capacity, which is also described in section 1.2.1. Deloitte suggests this too, by stating that Dutch industry should focus on creating a market (creating demand), which should be stimulated and served (supply) via strengthening the Netherlands as a production location (enabling) (Deloitte & To70, 2025).

Lastly, the selected policy interventions must align with concepts described earlier. The selected policy interventions must foster international policy harmonization, it must be a mix of supportive and not-supportive policy interventions, and the selected policies must be relevant in multi-stakeholder context. This means selected interventions must be based on, or be aligned with, international policies, the selected policy interventions are a mix of supportive and non-supportive interventions and interventions must be dependent on corporations between different stakeholder groups.

Based on these selection criteria, a selection of six policy interventions is made, eight are eliminated. All policy interventions suggested by WEF are presented in Appendix C. Only the selected policy interventions, including their links with above-described selection criteria, are described in section 5.2.

5.2 Selected policy interventions

This section describes the selected policy interventions for the MCA. An overview of the selected policy interventions is presented in table 2.

5.2.1 Investment in infrastructure/feedstock development

There is a need for supply-side policy interventions for both feedstock prioritization and tax incentives for feedstocks (Gibbs et al., 2021). Feedstock prioritization is meant to increase fuel production by redirecting feedstock towards aviation by limiting its use in competitive sectors, while tax incentives are meant to increase local feedstock production (Gibbs et al., 2021). This requires developed infrastructure, too. Combining these policy interventions leads to a supply-side policy intervention that includes investing in infrastructure/feedstock development. This policy intervention lowers eSAF production costs, making it a supply-side policy intervention.

CE Delft, NLR, and E4tech have expressed concerns about current infrastructure and feedstock investment, which could result in insufficient quality and quantity of feedstock (De Vries et al., 2021; E4tech, 2021; Meerstadt et al., 2021). Therefore, they independently suggest national planning and investment in these areas in terms of (e)SAF blending infrastructure. H₂ production or CO₂ is not needed for this project, as Power2X uses imported methanol as feedstock. But the fact Power2X can provide 40% of the European need of eSAF in 2030 annually, results in the need of functional infrastructure. According to Meerstadt et al. (2021) and E4tech (2021), the investments provide essential system inputs and reduce current operational barriers. Future sustainability projects (apart from Power2X) can also benefit from this. This eventually leads to consistent and scalable eSAF production. Without sufficient system input for H₂, CO₂, and methanol, eSAF production cannot be scaled, leading to higher costs and delayed implementation (Peeters & Papp, 2024).

This policy intervention can be considered supportive, as this is not an obligatory policy intervention. Furthermore, it can enhance international exportation of the fuel through the infrastructure and fosters collaboration among multiple stakeholder groups.

5.2.2 Contract for Difference schemes

According to De Vries et al. (2021) and Deloitte & To70 (2025), Contracts for Difference (CfD) is a government-backed pricing mechanism. This supply-side economic policy intervention aims to increase fuel production through variable government payments. This intervention reduces the price gap between (e)SAF and traditional jet fuel by guaranteeing fuel producers a pre-agreed price per ton of SAF (Gibbs et al., 2021). This mechanism aims to bring long-term certainty to investors by guaranteeing purchase. In this way, projects are de-risked by locking in demand to return capital investments (Gibbs et al., 2021). In general, if the market price is higher than the pre-agreed price, governments pay the difference (Gibbs et al., 2021). This is particularly useful in early commercial projects, especially when technologies have high initial cost and relatively

low TRL, since it helps bring emerging technologies to market and inspires private investment in eSAF.

This policy intervention reduces price uncertainty in the future and narrows the cost gap with fossil kerosene. This potentially increases investor confidence in eSAF projects. Literature describes CfDs as an effective price mechanism for rising markets, which has proven to be an effective policy intervention in the steel industry (Vogl et al., 2020). According to Vogl et al. (2020), CfDs contribute to bringing markets with high CAPEX and low TRL to commercial scale by mitigating investment risks and accelerating learning curves.

This policy can be considered supportive as it reduces investment risks and supports economic viability. It furthermore requires collaboration between governments and industry players.

5.2.3 Blending obligations

This demand-side regulatory policy intervention aims to increase the fuel offtake where industry/consumers pay for the fuel (Gibbs et al., 2021). This policy intervention focuses on establishing obligations that progressively increase over time. This ensures a stable demand and therefore investment security. Part of these obligations are so-called be sub-targets for specific production pathways (Gibbs et al., 2021). These obligations should be well-quantified.

National blending obligations with specific sub-targets for eSAF have been considered relevant to foster eSAF uptake and create demand (De Vries et al., 2021; Deloitte & To70, 2025; E4tech Ltd & studio Gear Up, 2019). The national blending ambitions for SAF in general have already been developed by the Dutch Government, but these ambitions do not include specific eSAF targets (Ministerie van Infrastructuur en Waterstaat, 2020). The establishment of national blending ambitions with specific sub-targets would create long-term demand certainty and therefore incentivize production and reduce investment risks (E4tech Ltd & studio Gear Up, 2019). This policy intervention is considered most effective to raise demand and directly create a predictable market (Mayeres et al., 2023). This predictable market results in increase of investment security, which is needed to ensure alignment between supply and demand (Ng et al., 2021).

This policy is not supportive, as there is an obligatory component in it. On the other hand, literature proves this policy intervention might be most effective in creating demand, de-risking projects in early stage.

5.2.4 Investment support

This demand-side economic policy intervention aims to increase the fuel offtake where the government provides subsidies through well-defined cost profiles (Gibbs et al., 2021). The direct subsidies include tax incentives for eSAF offtakers, producers, or blenders. This results in a reduction in the cost differential between eSAF and traditional jet fuel (Gibbs et al., 2021). These incentives reduce the cost gap between eSAF and conventional jet fuel. This results in lower production costs and therefore higher offtake. This supports high GHG-reducing fuels, which increases eSAF demand (Gibbs et al., 2021).

The investment support for production can take different forms, but the focus is on government grants, tax benefits, or subsidized loans (De Vries et al., 2021; Deloitte & To70, 2025; E4tech Ltd & studio Gear Up, 2019). This support can be used to reduce upfront CAPEX for the Rotterdam eSAF facility, which is expected to cost at least €1.5 billion (Besteman, 2024). By including

governmental capital, eSAF production becomes more financially viable, which helps launch early commercial-scale facilities. Previous research has shown that direct government support leads to accelerated cost reductions, also for feedstock development (Wang et al., 2021). Furthermore, these investments are needed to ensure eSAF competitiveness compared to traditional kerosene, especially in early commercial stages (Peeters & Papp, 2024).

This policy intervention is supportive as it does not contain obligatory components, reduces investment risks and supports economic viability. Furthermore, it allows for cooperation between government, private investors, fuel producers and offtakers.

5.2.5 Carbon pricing/kerosene tax

WEF analyzes traditional jet fuel tax based on carbon emissions to decrease the price differential as tax subsidy on eSAF. The report implies including this demand-side policy measure stimulates SAF demand (Gibbs et al., 2021). Dutch sources have implied this too (De Vries et al., 2021; E4tech, 2021). Aligning this with EU-ETS fosters international regulation harmonization, which is needed (Scheelhaase et al., 2019). The harmonization of this international policy improves market transparency, as polluters pay. WEF emphasizes the importance of consistent carbon pricing to prevent market distortion, carbon leakage, and policy inefficiency (Gibbs et al., 2021).

Carbon pricing mechanisms are established to penalize the use of traditional jet fuel and reward low-emission alternatives like eSAF (De Vries et al., 2021; E4tech, 2021). The inclusion of carbon pricing or ETS alignment improves the cost competitiveness of eSAF against traditional jet fuel by reducing the price gap between eSAF and fossil fuels (Mayeres et al., 2023). This is especially useful in early high-cost production phases. Furthermore, a consistent and internationally coordinated carbon pricing mechanism prevents market disruption and fosters transparency, which contributes to creating a level playing field for investors (Gibbs et al., 2021). Gibbs et al. (2021) state that this is essential for international markets such as aviation.

5.2.6 Coordinated multi-stakeholder platforms

A multi-stakeholder platform is an enabling policy measure that includes coordination is suggested to ensure alignment in fragmented regional policy and stakeholder interests (Deloitte & To70, 2025; Meerstadt et al., 2021). Interactions between government, industry, and NGOs are needed to increase (e)SAF deployment (Gibbs et al., 2021). This administrative enabling policy intervention focuses on the establishment of collaborative platforms in which government, industry, research organizations, and investors are integrated. WEF emphasizes the need for these platforms, as they foster collaboration between government, business, and civil society. These coordinated platforms stimulate collaboration, which fosters policy development, standardization, and market structures (Gibbs et al., 2021). The platform is important to align the perspectives of all stakeholders involved. WEF does not consider this policy a policy intervention on its own, but the organization has highlighted the importance of these platforms as crucial for policy development, market structuring through feasible production, and international policy harmonization.

Through this platform, trust is built, and ecosystem-wide scale-up for eSAF production can be guaranteed (Santos & Delina, 2021). This platform functions as a governance body that includes government, industry, research, and investors, so (e)SAF development can be steered. A platform like this is essential for systematic transformation and policy integration (Santos & Delina, 2021).

These platforms foster innovation by facilitating shared knowledge, shared objectives, and risk reduction in policy engineering and market development (Ng et al., 2021).

This policy intervention is not supportive, while it does not contain obligatory elements. On the other hand, it is considered essential as a mechanism for systematic change by combining stakeholders' perspectives, goals and interests.

Table 2: Overview of selected policy interventions for MCA.

Policy intervention	Description	Concept supportive policy (Scheelhaase et al., 2019)	Concept Multi-stakeholder collaboration (Santos & Delina, 2021)	Academic rationale	Sources
Blending obligation, with specific sub-targets	National ambitions for SAF use are established, but no specific eSAF targets are present. This policy intervention will include specific sub-targets for eSAF.	No, not supportive, but identified reports express the need for blending obligations to foster and stimulate demand.	Requires acceptance by producers, offtakers and regulators.	Blending mandate directly increases demand, creating a market (Mayeres et al., 2023; Ng et al., 2021). Needed to support feasibility of production facility.	Gibbs et al., 2021; De Vries et al., 2021; Deloitte & To70, 2025; E4tech Ltd & studio Gear Up, 2019.
Investment support (direct subsidies)	Funding by government to reduce capital investment costs of building of production facility. Also, operational costs of fuel production will be lower.	Yes, reduces investment risks, and supports economic viability.	Requires collaboration between funders (private investing), government (public investing) and industry.	Direct subsidies for building facility leads to strong reduce of operating costs, and feedstock production benefits from it (Wang et al., 2021). Furthermore, subsidies/investments in (e)SAF production led to lower costs (Petters & Papp, 2024)	Gibbs et al., 2021; E4tech, 2021; Deloitte & To70, 2025
Investment for infrastructure and feedstock development	Infrastructure and feedstock development are needed for inputs of eSAF production (H2 and CO2)	Yes, supports infrastructure, which is considered a precondition for eSAF production.	Must align with energy systems, CO2 and H2 supply actors, and regulations.	Limited supply of renewable energy for production of H2 or CO2 capture leads to constrained growth (Petters & Papp, 2024).	De Vries et al., 2021; E4tech, 2021; Meerstadt et al., 2021
Contracts for difference	Limits risks for extra payments of eSAF production/use, since government will guarantee pay differences (predetermined price vs. market price) via predetermined contracts.	Yes, reduces investment risks, and supports economic viability.	Requires collaborations between Government, suppliers and offtakers.	Considers most promising policy intervention for early-stage commercialization (in steel sector), but CfD can lead to unequal distribution of costs (Vogl et al., 2020). In other sectors, CfDs showed effectiveness and showed drive in technological learning curves (Richstein et al., 2024).	Gibbs et al., 2021; De Vries et al., 2021; Deloitte & To70, 2025
Carbon pricing / kerosene tax with ETS alignment	Implementing carbon pricing or kerosene tax will make the use of traditional jet fuel less attractive due to higher (environmental) costs. Therefore, eSAF demand will rise. Can be done via inclusion of (aviation specific) ETS or separated carbon taxes.	Yes, can be considered supportive as if the proceeds are redirected to SAF investments. The tax income of fossil kerosene will pay SAF investments.	Needs agreement across multiple sectors to ensure fairness and effective policy.	Has relative low effects on (e)SAF price compared to blending obligations but is effective too (Mayeres et al., 2023). Emission trading system via ETS is most cheap option (Mayeres et al., 2023).	De Vries et al., 2021; E4tech, 2021; Gibbs et al., 2021
Multi-stakeholder platform with innovation fund	Establishment of multi-stakeholder platform for collaboration across sectors to align goals, interests and actions. The government takes place in platform.	Not supportive but considered essential al mechanism for systematic change.	Core recommendation of Santos & Delina (2021), mainly to resolve fragmented interests.	Multi-stakeholder collaborations are considered as key to accelerating uptake (Ng et al., 2021; Santos & Delina, 2021).	Gibbs et al., 2021; Deloitte & To70, 2025; Meerstadt et al., 2021

6 Criteria

As discussed previously, in an MCA, multiple alternatives are evaluated regarding several criteria by decision-makers (Rezaei, 2015). In the context of this research, the decision-makers are the interviewed stakeholders. In Section 6.1, the set of criteria is selected. The criteria are based on the Transport System and Transport Policy book by Van Wee et al. (2023).

6.1 Criteria selection

The selected criteria for this study are derived from the book of van Wee et al. (2023) and are adjusted to the actual context based on the concepts of needed policies by Scheelhaase et al. (2019) and multi-stakeholder collaboration (Santos & Delina, 2021). Apart from that, literature shows that policy evaluation of early commercialized projects is conducted against similar criteria (Vogl et al., 2020). The selected criteria have been present in earlier MCAs. Section 6.1 describes the chosen criteria. Appendix E presents each analyzed article, the criteria used, and how they relate to this context.

The book by van Wee et al. (2023) describes six criteria that should be considered to achieve healthy policies: effectiveness, efficiency, equity, ease of implementation, flexibility, and long-term robustness. This research used five of those, as flexibility and long-term robustness were considered similar in the context this rapidly innovating system. Flexibility relates to how well policies can be adapted based on foresee changes. Long-term robustness refers to whether a policy is no regret under uncertain developments over longer term. According to van Wee et al. (2023), long-term robustness is strongly related to flexibility. Since long-term robustness is incorporated in flexibility, but also in implementation feasibility, it is left out for this research. It is incorporated in implementation feasibility as implementation feasibility not only refers to ease of introducing the policy but also includes long-term implementation feasibility. This reflects robustness too.

The names of the criteria are slightly adjusted to make it better interpretable for the interviewees.

6.1.1 Effectiveness

According to Van Wee et al. (2023), effectiveness refers to whether a policy intervention does what it is supposed to do. In this case, it is considered to what extent the policy intervention fosters the feasibility of the planned production facility? Any transport policy aims to have an impact, whether societal or contributing to accessibility, sustainability, or system transportation (Van Wee et al., 2023). Effectiveness, therefore, is a crucial criterion in policy evaluation to determine whether interventions achieve the intended objective. Furthermore, government support needs to be effective, both regarding feasibility and the environmental goals that have been set (Santos & Delina, 2021). This applies directly to the planned Rotterdam production facility.

6.1.2 Efficiency

Secondly, policy interventions must be efficient (Van Wee et al., 2023). This is mainly expressed in terms of cost-effectiveness or cost-benefit ratio. It considers dominant effects and primarily monetary costs. Furthermore, it offers a straightforward comparison. In this context, the main question for this criterion is: to what extent does the intervention create impact relative to the required public investment? This includes not only direct financial investments but also

considers benefits or trade-offs, and therefore efficiency (Van Wee et al., 2023). Research on green steel commercialization shows that high investment costs hinder industrial transitions, but well-targeted subsidies maximize the output of policy interventions (Vogl et al., 2021). Therefore, efficiency is a key criterion in this MCA, where effects are considered relative to the required public investments. Because of this and to prevent confusion with effectiveness, this criterion is named cost efficiency.

6.1.3 Ease of implementation

Policy interventions must be easy to implement in terms of institutional, legal, and administrative structures, as Van Wee et al. (2023) stress. Decision-makers must understand barriers to implementation and learn from similar policy interventions elsewhere. Barriers must be overcome or minimized. Considering this, and Scheelhaase et al.'s (2019) statement regarding the need for harmonization across national and international frameworks, the main question in this context is: is this policy realistic in the Dutch context, given the current regulatory and administrative system, and to what extent does it align with policies in Europe? This inclusion directly supports ease of implementation as a key MCA criterion. The name is adjusted to implementation feasibility

6.1.4 Equity

In a participatory decision-making process, the inclusion of stakeholders is necessary (Van Wee et al., 2023). This is through equity of policy interventions. This study's analysis includes different interests and parties affected by the STS, as previously discussed. The inclusion of stakeholders through multi-stakeholder collaboration is essential to foster eSAF production and adoption (Santos & Delina, 2021). To ensure better understanding of this criterion, the name of this criterion is adjusted to stakeholder inclusiveness, to make it easier for the interviewee to understand the criterion. The main question for this criterion is: to what extent is the intervention accepted by or aligned with the interests of the different identified stakeholders in the ecosystem? All stakeholders support their interests, while policymaking requires a balanced approach by aligning those interests.

6.1.5 Flexibility

Lastly, flexibility is a criterion. Policy interventions should be flexible so they can be adjusted based on changes (Van Wee et al., 2023). In this context, technological, economic, or regulatory developments may require policy adjustments. Generally, policy interventions serve as catalysts for emerging technologies (Scheelhaase et al., 2019). They therefore must be adaptable/scalable to changes or economies of scale. Since policies foster innovation (Roukouni et al., 2018), they are considered enablers of eSAF uptake (Scheelhaase et al., 2019). Flexible/scalable policy interventions, therefore, are necessary. The main question for this criterion in this context is: to what extent is this policy flexible enough to scale up over time and adapt to market or technological changes? In this context, it is relevant to consider scalability of policies (such as public investments) too. Therefore, as this includes flexibility and long-term robustness, the name of this criterion is changed to flexibility/scalability.

The selected criteria are effectiveness, cost-efficiency (derived from efficiency), implementation feasibility (derived from ease of implementation), stakeholder inclusiveness (derived from equity) and flexibility/scalability (derived from flexibility and long-term robustness). A table of stakeholder-inclusive MCA studies and their selected criteria is presented in Appendix E.

7 Weights, Scores & Weighted sums

As previously described, weights in the MCA reflect the relative importance of criteria according to decision-makers (Macharis et al., 2012; Macharis & Bernardini, 2014). Based on the inclusion of stakeholders in this research, it is expected that stakeholders assign different weights to the criteria (Macharis et al., 2012). According to Macharis et al. (2012), this type of MCDM allows for the representation of goals and objectives of different stakeholders. Transport (technology) projects often do not get implemented or face delays when stakeholders are not heard, especially when multiple stakeholders with conflicting interests are involved (Macharis et al., 2012). Therefore, the inclusion of stakeholders is essential in the transport sector for the successful implementation of projects (Macharis & Bernardini, 2014).

In the context of transport policy and infrastructure projects, this step of assigning weights is important due to the stakeholder-sensitive nature of this decision-making process (Macharis & Bernardini, 2014). Stakeholders are asked to assign weights to each evaluation criterion, which reflects the relative importance of each criterion in relation to the support of a feasible eSAF production facility in Rotterdam. All stakeholders' perspectives are treated independently and equally to prevent bias, and no forced consensus is imposed. This approach is recommended by social MCA frameworks and ensures that results reflect a balanced compromise rather than the dominance of any single actor group (Macharis et al., 2012). Section 7.1 presents the weights assigned per criterion by stakeholders. Their weights are used to determine a weighted sum after each policy intervention is scored among the defined criteria. Section 7.2 presents the scores assigned per criterion by stakeholders. Section 7.3 presents the weighted sums and rankings.

7.1 Weights

This section presents the weights assigned by stakeholders. Five weight tables are discussed based on the explanations on the five criteria provided by the interviewees. The stakeholders' results are presented in the order in which the interviews were conducted. Section 7.1.6 is an overview of and reflection on the assigned weights, including Table 8 that presents all weights assigned by the interviewed stakeholders.

7.1.1 Effectiveness

All interviewed stakeholders consider effectiveness a relative important criterion, as all criteria are weighted 0.2 or higher. Transavia (airline) and Power2X (fuel producer) weigh effectiveness the highest, assigning a weight of 0.4. Transavia and Power2X prioritize policy interventions that significantly support large-scale eSAF production feasibility. Transavia's main reason is they must meet sustainability goals and therefore prefers effective interventions that directly lead to contribution to achieving those goals. Power2X's main reason for this is they seek to have market certainty to justify investments and enable scaling. Policies that are effective and support the feasibility of the production facility are important for these organizations. Transavia must comply to goals, while Power2X needs investment security.

Luchtvaart in Transitie (financial institution) and GroenvermogenNL (industry association) weigh this criterion 0.2. GroenvermogenNL focusses on creating fair market conditions and broad stakeholder alignment. Even though a lower weight is assigned, the organization prefers effective policies. They represent the interest of supporting more balance with corporation and honesty. They are not against effectiveness but see it as part of a larger system. Luchtvaart in Transitie aims

for more efficient use of financial resources. Ministry of Infrastructure and Water management (government institution) and NLR (research institute) weigh effectiveness in between, 0.3, as they value effective policy interventions that are also cost efficient and feasible for implementation. The Ministry aims to find a balance between political feasibility and policy objectives.

The assigned weights for the criterion effectiveness are presented in the table below.

Table 3: Weights assigned by interviewed stakeholders for criterion Effectiveness.

	Weights
Luchtvaart in Transitie	0.2
Ministry of Infrastructure and Water Management	0.3
Transavia	0.4
GroenvermogenNL	0.2
NLR	0.3
Port of Rotterdam	0.3
Power2X	0.4
To70	0.25

7.1.2 Cost efficiency

The assigned weights in cost efficiency differ more compared to effectiveness. Luchtvaart in Transitie and To70 assigned the highest weights because these organizations express the need of effective policies in relation to the invested money. Also, GroenvermogenNL and the Port of Rotterdam (storage and logistics operator) weigh this criterion higher than other criteria. Their reasoning entails they value effective policies on one hand, while they value financial viability and economic sustainability of policy interventions on the other hand. GroenvermogenNL believes cost efficiency is a mean to maintain policy support and acceptance from stakeholders. Lower weights are assigned by the Ministry of Infrastructure and Water Management, Power2X and Transavia. The ministry acknowledges the government is willing to invest money if a policy intervention is effective and feasible, within established rules regarding state aid and budget. Power2X weighs this criterion lower compared to other criteria. From their project perspective, priority lies in receiving governmental support, even if that comes with significant public spending. However, they fully recognize the importance to spend money effectively and efficiently. Transavia assigned almost no weight to this criterion. For an airline it is most important to achieve climate goals, which weighs more heavily than the costs. Especially if the costs are borne by public organizations, and not by the private organizations themselves.

These differences reflect how stakeholder with different interests and needs have conflicts regarding their perspective on the needed amount of public money. Private organizations as Power2X and Transavia assign less importance to cost efficiency of policy interventions and therefore would accept higher public costs than organizations that must implement or fund policies or have to advise based on the overall view of the STS. Important to consider is that, unlike governmental organizations or organizations that have view of the entire STS like GroenvermogenNL, they are less aware of the broader financial trade-offs, such as what other projects may or may not get funded. This highlights a difference between actors with a sectoral focus and those with a system-wide (financial) oversight.

The assigned weights for the criterion cost efficiency are presented in the table on the next page.

Table 4: Weights assigned by interviewed stakeholders for criterion Cost Efficiency.

	Weight
Luchtvaart in Transitie	0.4
Ministry of Infrastructure and Water Management	0.15
Transavia	0.02
GroenvermogenNL	0.3
NLR	0.25
Port of Rotterdam	0.3
Power2X	0.1
To70	0.3

7.1.3 Implementation feasibility

Implementation feasibility is most important for the fuel producer. The organization believes policy interventions must be realistic and quickly implementable to secure investments. The Ministry of Infrastructure and Water management, Transavia and the Port of Rotterdam weighted this criterion relatively high, assigning weights of 0.25 or higher. These organizations highly value feasible policy interventions, as they realize political/practical infeasible policy interventions do not contribute to feasibility of eSAF production and they believe policy interventions can be adapted to current operational barriers. In contrast to the relative high weights, assigned GroenvermogenNL the lowest weight of all interviewees. The organization focusses more on broad cooperation and long-term development of the STS. Therefore, the organization supports more ambitious interventions too, even if these interventions are hard to implement. This reflects their relative low weight. To70 assigned a slightly higher weight, as the organization believes that with good coordination policy ideas are feasible and that impact and costs are more important in this consideration. NLR assigned a weight of 0.2, which can reflect their role of research institute. They see implementation as condition for impact. There is a difference in long-term and short-term perspectives among stakeholders. GroenvermogenNL believes there is a systematic change and therefore considers long-term effects of policies too. Power2X wants investments right now and therefore prefers policies that are effective and can be implemented soon.

This pattern shows that parties responsible for policy or investments pay attention to feasibility, while sector-wide stakeholder look more beyond short-term strategies.

The assigned weights for the criterion implementation feasibility are presented in the table below.

Table 5: Weights assigned by interviewed stakeholders for criterion Implementation feasibility.

	Weight
Luchtvaart in Transitie	0.2
Ministry of Infrastructure and Water Management	0.3
Transavia	0.25
GroenvermogenNL	0.1
NLR	0.2
Port of Rotterdam	0.25
Power2X	0.4
To70	0.15

7.1.4 Stakeholder inclusiveness

Stakeholder inclusiveness is most important for GroenvermogenNL. All parties assigned no weights higher than 0.15, while GroenvermogenNL assigned a weight of 0.3. This suits their role to represent the interests and needs of the entire sector and promote a level playing field. The organization believes policy interventions that are built on stakeholder inclusiveness are silver

bullets. The organization values policy interventions that are broadly supported by and fair for all stakeholders. Furthermore, they consider stakeholder inclusiveness as strategic instrument for systematic change. They believe that policies that are supported by all actors have a greater chance of success and prevent resistance from the STS.

The Ministry of Infrastructure and Water Management and NLR assigned lower weights (0.15). They acknowledge that support and fairness are important but is not primary concern for their organizations. The organizations do not ignore inclusivity. They consider support among stakeholders important, but not decisive in decision-making. Also, as the criteria reflect relative importance, they weigh effectiveness and implementation feasibility over stakeholder inclusiveness. Same occurs for Luchtvaart in Transitie and To70. These two organizations value stakeholder inclusiveness limited (0.1). They support collaboration among the STS but prefer effectiveness and cost efficiency in policymaking rather than ensuring stakeholder inclusiveness.

Private organizations Transavia and Power2X consider stakeholder inclusiveness not relevant, assigning wights of 0.03 and 0.05 respectively. They focus primarily on their own operational needs, in which they could consider stakeholder inclusiveness as delaying or complex. Transavia wants affordable eSAF for its business operation and Power2X wants investment security. This reflects conflicts that occur: Transavia struggles with sustainability goals versus profitability, while Power2X is concerned about investment risks and uncertainties.

Summarizing, only industry associations believe stakeholder inclusiveness is most important in policymaking, while private and public organizations believe stakeholder inclusiveness is more side issue.

The assigned weights for the criterion stakeholder inclusiveness are presented in the table below.

Table 6: Weights assigned by interviewed stakeholders for criterion Stakeholder Inclusiveness.

	Weights
Luchtvaart in Transitie	0.1
Ministry of Infrastructure and Water Management	0.15
Transavia	0.03
GroenvermogenNL	0.3
NLR	0.15
Port of Rotterdam	0.1
Power2X	0.05
To70	0.1

7.1.5 Flexibility/scalability

Only Transavia assigned high a relative high weight to this criterion. The airline assigned the highest weight of all interviewed stakeholders. Main reason for this is that the airline believes it’s crucial for policy interventions to be scalable to make policies future proof to reach their goals in the long-term (2050). Transavia states they want to assure the eSAF market can develop flexible and over long-term to meet growing demand. Policy interventions must therefore be flexible to adapt as they benefit from policies that can evolve with future markets. To70 assigned a relative high weight too compared to the other interviewees. The organization prefers robust policy interventions that are future-proof and flexible to change with technological innovation and market developments.

Other interviewed stakeholders assigned lower weights to flexibility of 0.1 or lower. Public stakeholders focus more on immediate implementation and effect of policy interventions, rather

than long-term flexibility. Mainly Power2X and the Port of Rotterdam assigned low values, both 0.05. These organizations' focus is on short-term demand certainty and stable policy strategy as they invest now and prefer a stable strategy over changing strategy. Power2X nuanced by stating they believe they need to build a market first (short-term) that has operating plants and paying customers etc. in order for there to be a market to scale. Future policy adjustments are of less important as their main goal is the realization of the large-scale facility first.

These differences suggest that offtakers and consultancy organizations like to build policy interventions with possibility to adapt in the future, while other organizations mainly prefer stability and direct impact to overcome current barriers. There also is a difference between organizations that focus on short-term and long-term.

The assigned weights for the criterion flexibility/scalability are presented in the table below.

Table 7: Weights assigned by interviewed stakeholders for criterion Flexibility/Scalability.

	Weight
Luchtvaart in Transitie	0.1
Ministry of Infrastructure and Water Management	0.1
Transavia	0.3
GroenvermogenNL	0.1
NLR	0.1
Port of Rotterdam	0.05
Power2X	0.05
To70	0.2

7.1.6 Reflection & Overview

The differences in assigned weights reflect the differences in interests and needs between different stakeholder groups and tensions between those.

First, there is a difference in assigned weights between private and public (or semipublic) organizations which reflects the different interests and needs of the organizations. For example, interviewees of Power2X and Transavia weigh effectiveness highest of all interviewed stakeholders. They also weigh implementation feasibility (together with Ministry of Infrastructure and Water Management) highest. These weights reflect these organizations focus on realizing their own goals, such as meeting climate goals (Transavia) or ensuring security for investments (Power2X). On the other hand, public organization do have more balanced considerations, where effectiveness is important, but in proportion to cost efficiency and implementation feasibility. Furthermore, GroenvermogenNL differs from these two perspectives. This industry organization values stakeholder inclusiveness and bringing stakeholder perspectives together most. The interviewee assigned the highest weight to stakeholder inclusiveness and considers effectiveness and cost efficiency within the broader system of fair market structures and cooperation.

These interests reflect the role and responsibility of the different parties in the STS. Private parties operate from business goals and prefer interventions that strengthen their operational process, while public organizations must weigh interests within legal, social and budgetary frameworks.

Apart from that, there is more tension between interests. First, short-term stability of policies (mainly producers) and long-term flexibility (desired by airlines and consultancy). This can be seen in the different weights assigned for the criterion flexibility/scalability. Second, cost efficiency creates tension between organizations that finance such projects or create policies

and organizations that directly benefit from the policies but do not bear the costs themselves. This points to conflicts around public investments and their (long-term) legitimacy. As stated in the previous paragraph, stakeholder inclusiveness is seen important by the party with cross-sector interest. For private parties, stakeholder inclusiveness is seen as a side issue, and they consider stakeholder inclusiveness as potential problem for policymaking as stakeholder inclusive policymaking can lead to resistance to or delay of implementation if interests are not moderated.

Although inclusiveness is seen as difficult by private actors, its absence can lead to resistance in later phases. Sector-wide organizations see inclusivity as strategy as they believe this is a driver and condition for system transitions.

The assigned weights for the criteria are presented in the table below.

Table 8: Table of the criteria and weights according to all interviewed stakeholders.

	Effectiveness	Cost efficiency	Implementation feasibility	Stakeholder inclusiveness	Flexibility/scalability
Luchtvaart in Transitie	0.2	0.4	0.2	0.1	0.1
Ministry of Infrastructure and Water Management	0.3	0.15	0.3	0.15	0.1
Transavia	0.4	0.02	0.25	0.03	0.3
GroenvermogenNL	0.2	0.3	0.1	0.3	0.1
NLR	0.3	0.25	0.2	0.15	0.1
Port of Rotterdam	0.3	0.3	0.25	0.1	0.05
Power2X	0.4	0.1	0.4	0.05	0.05
To70	0.25	0.3	0.15	0.1	0.2

7.2 Scores

After assigning weights, stakeholders provide scores on a 0-100 scale for each policy intervention on each criterion to present how well the policy interventions perform on the criteria. Low scores mean the stakeholder believes a policy intervention has limited potential regarding that criterion, while high scores indicate the stakeholder believe a policy intervention strongly contributes to the criterion. Different perceptions can then be easily noticed. Section 7.2 dives into the scores per policy intervention according to the different stakeholders.

7.2.1 Blending obligations with specific sub-targets

In general, the stakeholders assign high scores to the criteria for blending obligations, but motivations differ. Transavia scores effectiveness high, as this intervention creates an eSAF market and ensures long-term certainty which directly supports production feasibility, from their perspective. Power2X assigns maximum score to effectiveness as this intervention guarantees demand which justifies investments but foresees risks in future policy changes that can undermine effectiveness (therefore assigns lower scores to implementation feasibility). Luchtvaart in Transitie, the Ministry of Infrastructure and Water Management and To70 score this intervention maximum on effectiveness too, as they believe blending obligations are effective and relatively easy to implement. GroenvermogenNL scores effectiveness lower, as they believe this intervention can be effective, but as an instrument for generating demand that must be embedded in a broader market. The Port of Rotterdam and NLR have doubts about implementation feasibility, as they believe blending obligations without supportive policy strategy will not be feasible. Conflicts are in the criteria cost efficiency, implementation feasibility

and flexibility/scalability. For cost efficiency, Port of Rotterdam assigns a score of 0 due to expected high implementation costs and a lack of associated support for logistics and infrastructure requirements, which makes the policy more expensive in the long end. Power2X assigns a score of 100. The high score of Power2X can be explained through their motivation that blending obligations passes the additional costs of eSAF to end users which is required because otherwise no one would ever buy eSAF (with other sustainable alternatives being half the price). Furthermore, from their perspective, it will make no sense to develop such eSAF plant if the EU says they want eSAF in Europe, then the obligations must be stable for developers to further develop technologies at scale. Transavia assigned a score of 10, as they think this policy intervention might lead to increase of ticket price and taxes. To70 and NLR assign high and low scores to implementation feasibility respectively. To70 believes this intervention is relatively feasible to implement on national level, as the European Commission already set blending obligations, while NLR believes applying obligations on national level might be harder once they differ from European blending obligations. This reasoning of both organizations explains the relative low scores for stakeholder inclusiveness too, as they believe nationally imposed obligations without alignment with EU-framework may lead to resistance or lack of support among key stakeholders. Lastly, Transavia assigned a score of 100 for flexibility/scalability as they believe this intervention can be easily adjusted to market developments, while NLR and the Ministry of Infrastructure and Water management assigned low scores. NLR expresses concerns about limited flexibility of the blending obligations because adjustments to establish EU legislation can be difficult.

In summary, all stakeholders acknowledge that blending obligations are a powerful measure to ensure a scale-up in demand for eSAF, while some suggest this only works in combination with other interventions and this does not directly support large-scale eSAF production facility. Only the port of Rotterdam assigns low scores to all criteria (50 or lower).

The assigned scores on each criterion for blending obligations with specific sub-targets are presented in the table below.

Table 9: Table of scores assigned on each criterion for policy intervention blending obligations with specific sub-targets.

	Effectiveness	Cost efficiency	Implementation feasibility	Stakeholder inclusiveness	Flexibility/ scalability
Luchtvaart in Transitie	100	60	50	10	20
Ministry of Infrastructure and Water Management	80	70	60	40	30
Transavia	90	10	80	20	100
GroenvermogenNL	70	50	80	30	70
NLR	85	85	5	20	10
Port of Rotterdam	50	0	25	20	20
Power2X	100	100	50	75	80
To70	100	80	100	50	90

7.2.2 Direct investment support

The scores for direct investment support differ more, as there are discrepancies in scores in all criteria. To70 believes this intervention is effective, cost efficiency, stakeholder inclusive and flexible. Main reasoning for the high scores is that the organization believes this financial support for the fuel producer can foster production feasibility directly. Also, Power2X assigns a high score to effectiveness, as they believe substantial financial support is needed in early stages (before

final investment decisions) of projects like theirs. NLR and the Port of Rotterdam believe this intervention can be effective to support the start of (current) infeasible large-scale production projects. Luchtvaart in Transitie and The Ministry of Infrastructure and Water Management acknowledges this too but believes that providing unlimited subsidies is not sustainable or desirable in the long term. This reflects their lower scores for implementation feasibility and flexibility. Luchtvaart in Transitie assigns a low score to cost efficiency and implementation feasibility as they believe huge amount of capital investment is needed for supporting feasibility of large-scale eSAF production facilities and they prefer market mechanisms over structural investments from the government. On the other hand, the Ministry acknowledges that implementing subsidy schemes is feasible to implement, but not that flexible, which reflects the high score for implementation feasibility and moderate score on flexibility/scalability. Transavia, GroenvermogenNL, NLR and Power2X assign low scores to stakeholder inclusiveness, as the organizations state that subsidies are beneficial for the fuel producer only and are therefore not stakeholder inclusive.

These scores present the different roles of the stakeholders. Stakeholders that are linked to high capital investments or advice on projects express the need for enough public funding to kickstart (currently infeasible) projects. On the other hand, policymakers, financial institutions and researchers express their worries about costliness of subsidies and potential market disruptions they cause. Furthermore, during the interviews the danger of dependency was described. If the industry gets used to subsidies, innovation incentives and cost reductions may decrease. This shows there is conflict on interests between short-term need for financial support and long-term need of an independent market. Parties that need immediate success and seek for de-risking of projects score high on average, while parties that prefer systematic market development and budgetary sustainability value it lower.

The assigned scores on each criterion for direct investment support are presented in the table below.

Table 10: Table of scores assigned on each criterion for policy intervention direct investment support.

	Effectiveness	Cost efficiency	Implementation feasibility	Stakeholder inclusiveness	Flexibility/scalability
Luchtvaart in Transitie	40	20	20	50	50
Ministry of Infrastructure and Water Management	80	60	40	70	50
Transavia	30	20	90	30	90
GroenvermogenNL	60	70	80	35	80
NLR	80	60	50	20	60
Port of Rotterdam	80	80	20	50	10
Power2X	75	50	75	25	50
To70	100	100	50	80	100

7.2.3 Investment in infrastructure/feedstock development

Stakeholders that work on the STS (Luchtvaart in Transitie, GroenvermogenNL and NLR) believe investing in infrastructure is crucial. From their perspective, investing in transport pipes, storage and green hydrogen production strengthens the entire eSAF supply chain. Which reflects GroenvermogenNL's goal of strengthening the ecosystem too. During the interviews, the interviewees underscore that a well-functioning physical infrastructure and supply chain fosters eSAF production feasibility. They state that this well-functioning infrastructure and supply chain

is a precondition for feasible production. On the other hand, the Ministry of Infrastructure and Water Management and Power2X wonder whether investments in infrastructure development directly support the feasibility of the Power2X/Advario production facility. They focus more on policy interventions that directly create demand or limit price gaps between eSAF and traditional kerosene, which reflects the relative low scores on implementation feasibility and flexibility/scalability. Policymakers state that infrastructure is needed, but without policies that create demand, a well-functioning infrastructure remains unused. This reflects the relative low score on cost efficiency, as high costs of this intervention not directly lead to the support of feasibility of the production facility without supporting policy interventions. On the other hand, Power2X, the Port of Rotterdam, and NLR score cost efficiency high, as they believe this intervention is important for the entire chain. The lower scores from Transavia, NLR and the Port of Rotterdam on stakeholder inclusiveness represent their perspective that mainly logistics operators benefit from this policy intervention, rather than the entire STS. The interviewee of To70 believes this policy intervention is effective, but foresees limitation in cost efficiency and implementation feasibility, mainly because the public investments might be high, complex and long-lasting, without security for returns.

The differences in assigned scores present tensions between stakeholders. Some stakeholders foresee investment in infrastructure and feedstock development as a key mechanism to support the feasibility of the eSAF production facility, while others think these investments are more of a precondition for the long-term. Nevertheless, most stakeholders acknowledge that without infrastructure and feedstock, eSAF production is not scalable. Main differences exist in how this measure directly supports this current case.

The assigned scores on each criterion for investment in infrastructure/feedstock development are presented in the table below.

Table 11: Table of scores assigned on each criterion for policy intervention investment in infrastructure/feedstock development.

	Effectiveness	Cost efficiency	Implementation feasibility	Stakeholder inclusiveness	Flexibility/ scalability
Luchtvaart in Transitie	80	80	80	100	100
Ministry of Infrastructure and Water Management	70	50	60	70	40
Transavia	80	30	100	30	70
GroenvermogenNL	90	80	80	70	70
NLR	70	85	60	50	60
Port of Rotterdam	70	80	10	30	10
Power2X	80	75	50	85	40
To70	80	40	60	90	90

7.2.4 Contracts for Difference

Even though some stakeholders consider this policy intervention effective or cost efficient, most consider this policy is not feasible for implementation or scalable as CfDs are complex and risky. Only GroenvermogenNL scores this policy intervention good on all criteria, while implementation feasibility scores 50. GroenvermogenNL considers CfDs as effective mechanism that can trigger investments as CfDs cover of price difference which ensures more certainty for offtakers. NLR considers this intervention effective too as this mechanism ensures price certainty for offtakers. Both organizations acknowledge this intervention is hard to implement too, mainly because the

organizations wonder who will be held responsible for paying the price difference in the long-term or for short-term international offtakers. For example: who’s paying the costs for international offtakers at Dutch airports? This is something considered by Transavia and the Port of Rotterdam too. Transavia and the Port of Rotterdam believe this mechanism is complex and sluggish and risky for the long-term. Luchtvaart in Transitie scores all criteria low, as the organization doubts whether this intervention prove its value for effectiveness and implementation feasibility in the past. The ministry of Infrastructure and Water Management considers this policy intervention suited too, but mostly for the short term and has serious doubts for the long-term. The Government and research institutions acknowledge the economic rationale of CfDs but foresee barriers in implementation and political feasibility.

Summarizing, stakeholders that prefer interventions that foster investment security consider CfD suitable and effective for the short term. Organizations that are paying for eSAF or the differences according to the CfD are reserved about positivity as they foresee political or practical complications when implementing this intervention (mainly for the long term). The limited positive perspectives for this intervention are also related to the uncertainty of future eSAF prices/markets. The different interests of stakeholders can also be seen in this. Industry associations, research organizations and consultants (that have a more holistic view of the STS) consider this intervention highly effective, while all three acknowledge the complicated feasibility. Power2X considers this intervention effective as CfDs might boost investments due to their de-risking effect. This is mainly through expected stability, duration and increase in revenue certainty of this intervention.

The assigned scores on each criterion for CfDs are presented in the table below.

Table 12: Table of scores assigned on each criterion for policy intervention contracts for difference.

	Effectiveness	Cost efficiency	Implementation feasibility	Stakeholder inclusiveness	Flexibility/ scalability
Luchtvaart in Transitie	50	20	10	20	0
Ministry of Infrastructure and Water Management	60	70	40	75	50
Transavia	40	50	50	60	30
GroenvermogenNL	90	90	50	70	90
NLR	90	70	20	20	50
Port of Rotterdam	60	70	10	30	10
Power2X	90	55	40	90	10
To70	100	0	10	90	10

7.2.5 Carbon pricing/kerosene tax

Carbon/pricing kerosene tax scores different on all criteria among stakeholders. From the perspectives of different organizations, interviewees believe the intervention has winners and losers. Power2X believes this intervention is very effective, cost efficiency and feasible for implementation. Transavia is more reserved in awarding scores, as this intervention makes traditional kerosene more expensive. Luchtvaart in Transitie, Transavia and Power2X acknowledge this intervention might result in a strong economic incentive as ‘the polluter pays’ and it strengthens the competitive position of eSAF. To port of Rotterdam considers this intervention effective too, mainly because paying for carbon emissions stimulates demand of sustainable fuels, produced in the Port of Rotterdam. Luchtvaart in Transitie, GroenvermogenNL, The Port of Rotterdam, Transavia, and the Ministry of Infrastructure and Water Management

foresee limitations in implementation. According to Transavia, such taxes will increase ticket prices for their flights, which creates uncertainties in their business model. The Ministry of Infrastructure and Water Management and NLR foresee huge political implications if a national carbon tax on kerosene will be applied. They believe it limits the position for international competition and public support that make this intervention unrealistic, especially in the short term. To70 too, but more than political implications, is the fact that it hampers the capacity of the aviation industry to invest in its decarbonization. NLR and To70 acknowledge an effective kerosene tax is possible at global/EU level, while it remains difficult in current politics. GroenvermogenNL considers this intervention effective, cost efficient, stakeholder inclusive and flexible, but not feasible for implementation. The organization believes this intervention is a strategic supportive mechanism to stimulate eSAF attractiveness but express the need of such interventions to be aligned with international policy strategies as EU ETS or ReFuelEU to create a level-playing field and prevent unfair competition among stakeholders. Simply, GroenvermogenNL emphasizes that such measures are only successful if they are embedded in a coherent policy in which various stakeholders are included. The measure must be explainable to citizens and market parties. Luchtvaart in Transitie believes carbon pricing is a useful instrument to influence market behavior, as they emphasize that such taxes are necessary to make fossil fuels less attractive. The organization expresses this intervention is only effective when implemented in international context (via EU or ICAO), as they are concerned about competitive disadvantages for Dutch aviation if other countries do not participate, such as the Ministry of Infrastructure and Water Management also states. Luchtvaart in Transitie believes this intervention can be implemented when part of a broader policy mix.

The different scores present a conflict of interests. Parties with long-term environmental or economic system view value the ‘polluter pays’ principle as ethical, but also as signal for the market as it stimulates cost competitiveness of eSAF. On the other hand, the interviewee of Transavia fears the organization’s profitability and consumer impact, while policymakers and research experts consider this intervention not feasible for implementation. Transavia points out the risk that these high taxes will discourage consumers and offer little predictability, while Power2X emphasized that without carbon taxes, the playing field remains uneven. The stakeholders agree on the aspect this intervention cannot be implemented on national level as stand-alone policy, but on international level part of a broader policy mix.

The assigned scores on each criterion for carbon pricing/kerosene tax are presented in the table below.

Table 13: Table of scores assigned on each criterion for policy intervention carbon pricing/kerosene tax.

	Effectiveness	Cost efficiency	Implementation feasibility	Stakeholder inclusiveness	Flexibility/ scalability
Luchtvaart in Transitie	100	100	20	0	20
Ministry of Infrastructure and Water Management	80	80	30	30	40
Transavia	60	60	35	20	50
GroenvermogenNL	100	100	30	50	70
NLR	10	10	10	70	20
Port of Rotterdam	100	50	20	50	50
Power2X	95	90	75	40	80
To70	10	10	90	30	10

7.2.6 Establishment of multi-stakeholder platforms

For the establishment of multi-stakeholder platforms, the scores vary. GroenvermogenNL assigns the highest scores, as they believe multi-stakeholder platforms are key to strengthen the ecosystem. They believe multi-stakeholder platforms will lead to technological advancements and score effectiveness high. The Port of Rotterdam considers multi-stakeholder platforms less effective but very cost efficiency and feasible for implementation as bringing stakeholder together does not require a lot of (public) money and time. The Ministry of Infrastructure and Water Management believes this intervention is an effective instrument to foster collaboration and coordination between organizations, which fits their interest of creating support among stakeholders and creating a planning. As this intervention does not directly supports the feasibility of this large-scale production facility, the Ministry assigned lower score to effectiveness. Transavia, NLR, Power2X and To70 have the same reason regarding the lower scores on effectiveness. They doubt whether this intervention have impact on the actual production and targets. Transavia indicates that such platforms contribute little to feasibility of eSAF as it does not deliver direct carbon emission reduction of fuel production, and rather results in ‘much talk, little action’. The Ministry acknowledges this can be a pitfall. NLR considers this intervention not effective or cost efficient, as there is little concrete output for the effort needed. Power2X has doubts about the effectiveness, feasibility and flexibility of such platforms as the organization is more interested in hard guaranteed (to de-risk projects in early stages) than such consultation bodies, and fears that setting up a platform will be slow or leads to discussions that might hinder short-term increase in production.

These differences in scores show conflicts in interests of collaboration on one hand and direct results on the other hand. The Government and industry associations that focus on trust, knowledge exchange and joint support see a platform as a foundation for success of other measures, which reflects on high scores of stakeholder inclusiveness and flexibility. Private organizations assign scores based on the contribution to production feasibility and costs from their position. From their perspective, a platform feels indirect and non-binding, which is why they assign lower scores. Something else that can be noted is that no one organization is against cooperation among the STS, but the discrepancies lie in expectations. GroenvermogenNL and the Ministry believe this intervention is a necessary enabler for policy success, while Transavia and Power2X foresee platforms can be a distraction if no concrete legal or financial policy measures emerge.

The assigned scores on each criterion for the establishment of multi-stakeholder platforms are presented in the table below.

Table 14: Table of scores assigned on each criterion for policy intervention establishment of multi-stakeholder platforms.

	Effectiveness	Cost efficiency	Implementation feasibility	Stakeholder inclusiveness	Flexibility/ scalability
Luchtvaart in Transitie	50	50	80	80	20
Ministry of Infrastructure and Water Management	60	70	90	90	80
Transavia	50	40	30	70	30
GroenvermogenNL	80	100	50	100	80
NLR	20	0	85	100	80
Port of Rotterdam	50	80	70	70	70
Power2X	50	100	20	90	10
To70	10	25	100	100	80

7.3 Weighted sums

This section presents the weighted scores assigned by stakeholders. The policy interventions are ranked based on the weighted sums, so that differences in assigned scores are eliminated, and the different perspectives of stakeholders can be explained by means of the ranking. The highest weighted sum of 89 does not say much more about the relative acceptance of a stakeholder towards a policy intervention than the highest weighted score of 67.

Blending obligations are ranked first one time and second four times. Transavia ranks it first, as the airline believes this policy intervention creates market demand and ensures long-term security. Power2X ranks it second because it supports long-term demand security, which ensures investing security. Also, Luchtvaart in Transitie, the Ministry of Infrastructure and Water Management, and To70 rank this policy intervention second, mainly because the stakeholders consider it effective and easy to implement. GroenvermogenNL and Port of Rotterdam rank this intervention last, while NLR ranks it fourth. GroenvermogenNL thinks this policy intervention is more of a precondition, while Port of Rotterdam and NLR question its effectiveness and implementation feasibility. The main reason for this is that parties close to the market (producers and offtakers) see blending obligations as a key mechanism for rapidly scaling demand, while policy and research stakeholders think this policy intervention is ineffective without sufficient supporting policies.

Direct investment support is ranked first by only To70. The consultancy organization values this policy because of its direct impact. Power2X ranks it third. The fuel producer believes this policy intervention is essential in the early stages of development, before final investment decisions are made. NLR and Port of Rotterdam rank this intervention second, as both organizations believe it is effective. The Ministry of Infrastructure and Water Management ranks it last, as the important weighted criteria do not score well. The ministry does not think this intervention is sustainable in the long term. The reasoning is that investment-oriented parties value concrete and sufficient financial support, while policymakers doubt whether the long-term effects of this policy intervention are desirable.

Investment in infrastructure/feedstock development is ranked first by Luchtvaart in Transitie and NLR and is ranked second by Transavia. None of the interviewed organizations ranked this intervention lower than fourth. Both Luchtvaart in Transitie and NLR believe this intervention is crucial for the development of the entire eSAF supply chain. Other organizations score it lower, mainly because they wonder whether this intervention has a direct effect on the feasibility of eSAF production. The main reasoning can be that infrastructure is valued by stakeholders who consider system conditions important. Policymakers desire more strategic interventions, such as blending obligations and multi-stakeholder platforms.

No organization ranks CfD first. GroenvermogenNL and NLR rank it second and third, while Luchtvaart in Transitie ranks it last. The other organizations rank it fifth. GroenvermogenNL believes this intervention is highly effective, as it functions as an investment incentive. NLR values this intervention as a powerful price assurance measure. Luchtvaart in Transitie wonders whether this intervention offers value and questions its implementation feasibility, while Transavia and Port of Rotterdam think it is complex, sluggish, and risky to implement. The main question is who pays for the actual price difference. CfDs seem attractive for policymakers and research

institutions, mainly due to economic rationale. Industry organizations foresee risks in political feasibility.

Carbon pricing/kerosene tax is ranked first by Power2X, second by Luchtvaart in Transitie, and third by Port of Rotterdam. The main reasoning is that this policy intervention is seen as an effective economic incentive. The organizations express ethical considerations regarding ‘polluters pay’. On the other hand, NLR and To70 (both ranking this intervention last) foresee major political limitations that result in infeasible implementation. Transavia fears negative impacts on ticket prices and limited predictability. The main reasoning may be that financial and environmental stakeholders value the explained ethical consideration. In contrast, operational and market-oriented stakeholders foresee negative impacts on their organizations’ profitability, while research institutes and policymakers mainly foresee political implementation limitations.

The establishment of multi-stakeholder platforms is ranked first three times. During the interviews, this policy intervention received the highest weighted score from interviewees of GroenvermogenNL, Port of Rotterdam, and the Ministry of Infrastructure and Water Management. GroenvermogenNL sees the ecosystem-building policy intervention as a “silver bullet” for eSAF development, while the Port of Rotterdam believes this intervention is highly cost-efficient and feasible to implement, and the Ministry sees it as an effective coordination instrument. On the other hand, this policy intervention receives low weighted scores from Transavia, NLR, and Power2X. Transavia believes this policy intervention does not support the feasibility (and therefore production) of eSAF. NLR believes this policy intervention is not effective or cost-efficient, while Power2X believes it is not feasible to implement or flexible. The reasoning may be that government organizations and those focused on STS development value collaboration and inclusivity, while private organizations find these platforms vague and sluggish and question their effectiveness.

In summary, private stakeholders seek to establish market and financial security, public stakeholders rely heavily on coordination and cooperation, and research institutes and consultancy organizations value concrete, feasible, and scalable interventions.

The tables on the next page present the weighted scores (weights multiplied with scores) and corresponding ranking of policy interventions according to all stakeholders based on the MCA.

Table 15: Weighted sums of each policy intervention according to the interviewed stakeholders.

	Blending obligations	Direct investment support	Investment in infrastructure/ feedstock development	Contracts for difference	Carbon pricing/kerosene tax	Establishment of multi-stakeholder platforms
Luchtvaart in Transitie	57	30	84	22	66	56
Ministry of Infrastructure and Water Management	61.5	60.5	61	56.75	53.5	77
Transavia	86.8	62.8	79.5	40.3	49.55	39.4
GroenvermogenNL	53	59.5	78	80	75	89
NLR	51.75	58	67.75	56.5	20	46
Port of Rotterdam	24.25	58.5	51	45	57.5	67
Power2X	77.75	68.75	65.75	62.5	83	43
To70	87	90.5	68	37.5	24	51

Table 16: Presentation of ranking of policy interventions based on MCA according to all interviewed stakeholders. Ranking is based on weighted scores.

	Blending obligations	Direct investment support	Investment in infrastructure/ feedstock development	Contracts for difference	Carbon pricing/kerosene tax	Establishment of multi-stakeholder platforms
Luchtvaart in Transitie	2	5	1	6	2	4
Ministry of Infrastructure and Water Management	2	4	3	5	6	1
Transavia	1	3	2	5	4	6
GroenvermogenNL	6	5	3	2	4	1
NLR	4	2	1	3	6	5
Port of Rotterdam	6	2	4	5	3	1
Power2X	2	3	4	5	1	6
To70	2	1	3	5	6	4

8 Discussion & Conclusion

This chapter discusses the obtained MCA results' implications in section 8.1. Limitations of this research are described in section 8.2. The obtained and discussed results contribute to answering the main research question, which are formed based on the identified knowledge gap. The conclusions are presented in section 8.3.

8.1 Discussion of results

This research aims to explore stakeholder perspectives on different policy interventions that support the feasibility of large-scale eSAF production. This is done through identifying the stakeholders active in the STS and interviewing them. The stakeholders are identified based on desk research. Through the interviews, the stakeholders are analyzed, and their perspectives on a set of policy interventions based on selected criteria are obtained. This set of policy interventions is made based on Dutch and international reports that identify policy interventions to address shortcomings in the eSAF supply chain.

The interviews reveal that stakeholders have different perspectives on policy interventions. The interviewees think government support is needed to develop large-scale eSAF production facilities. Their distinct roles, interests, and needs in the STS make their perspectives vary. This results in discrepancies in the ranking of policy interventions based on the different MCAs stakeholders completed during the interviews. Similarities are also discovered. The discussed results have implications and contribute to science.

8.1.1 Implications of MCA results

The discrepancies and similarities in MCA results (assigned weights and scores) show a divide between different stakeholder groups regarding the criteria of the different policy interventions to support the feasibility of eSAF production. The discrepancies reflect their different roles and interests in the STS and have implications that are relevant for policymakers to accelerate eSAF production scale-up in a broadly accepted way.

8.1.1.1 Implications of assigned weights

Stakeholders assign different weights to the same set of criteria which reflects their interests, roles and responsibilities in the STS. For policymaking, the different perspectives must be considered to come to more accepted and therefore more effective policy interventions (Santos & Delina, 2021).

First, there is difference in different interests, based on the roles of the organizations. An airline and fuel producer assigned highest weights to effectiveness and implementation feasibility, as they directly expect benefits from policies that are quickly implementable and ensures investment security. A governmental policymaking body divided the weights more in a balanced way, which reflects their need to come up with policies that aligns with an industry association that value stakeholder inclusiveness more, which indicates that they prefer policies that are broadly supported by the entire STS. Policymakers must take this variation in priorities in account.

Second, there is tension between long-term and short-term perspectives. For example, a fuel producer and storage and logistics operator assigned small weights to flexibility/scalability as they seek for stable and predictability for short-term investment decisions. On the other hand, an airline and consultancy organization foresee flexibility as an important criterion in policymaking

for long-term as they believe it is crucial to have policies that adapt with technological and market developments. Policy strategies that are designed to attract investment in short term may be unsuitable for the long-term. Therefore, a trade-off between short-term certainty and long-term adaptability is needed.

Third, there's tension between public costs and legitimacy. A financial institution, industry association and consultancy organization assign big weights to cost efficiency, as they consider legitimacy of public money spend, budgetary justification and support from society. An airline and fuel producer believe cost efficiency is less important, if the policy is effective, and costs are borne (externally). Policies with high public costs (direct investment support or investment in infrastructure/feedstock development) can be supported by private stakeholders but may come under pressure if public actors and system players or society doubt about their legitimacy or long-term sustainability.

Lastly, private organizations consider stakeholder inclusiveness in policymaking as a delay or potential obstacle to policy development, while an industry association considers inclusiveness as precondition for success. A lack of inclusiveness can lead to less accepted interventions. Policymakers should therefore not only effective policy measures, but also at support and cooperation between stakeholders in the STS.

8.1.1.2 Implications of assigned scores

The differences in scores assigned show that stakeholders view the expected effectiveness, cost efficiency, implementation feasibility, stakeholder inclusiveness and flexibility/scalability on the different policy interventions different. This can lead to tensions in policy choices and delays in implementation if certain stakeholders do not agree with the proposed direction. The differences show that the interventions are differently interpreted by stakeholders, depending on their role in the STS. Therefore, policymakers cannot assume that there is one best policy option. Interventions must be considered in relation to who they affect and where they are in the value chain.

Also, differences in scores show the importance of the role of the organization in the STS and the orientation on the time horizon. Airlines and fuel producers score policy interventions that direct support market creation and investment security, while a research organization and governmental policymaking body value interventions that support long-term changes and collaborations. The patterns can help policymakers to identify which interventions attractive to whom and why, so policies can be better suited to different phases in transition to eSAF.

No intervention scores high on all criteria according to all stakeholders. The different scores also show how potential resistance from stakeholders or feasibility problems might arise. If these differences are known in early stages of policy development, this can help the development of policy packages or combinations of interventions that are broadly accepted. This underlines that policy-making benefits from a combination of policy interventions that combine short-term needs (subsidy schemes) with long-term conditions (infrastructure and price incentives) and cooperation (platforms).

8.1.1.3 Implications of weighted scores/rankings

The differences in weighted scores and rankings combine the perspectives on criteria importance (weights) and scores.

First, blending obligations appear to be one of the most accepted policy interventions, mainly by stakeholders close to the market. The stakeholders suggest obligations can create market certainty, which justifies high initial investments and predictability. Given the acceptability across different stakeholders and the current European mandates set by the European Commission, this intervention appears to be a short-term, actionable national policy aligned with international standards. However, it must be supported by other supportive policy interventions such as direct or infrastructure/feedstock investments, to ensure supply keeps pace with the created demand.

Second, investment in infrastructure/feedstock development is broadly accepted. None of the stakeholders rank it last or next to last. This implies that this system-level measure is considered important by financial institutions, research institutions, airlines, and the government. These investments do not directly trigger large investments from private organizations but are considered an essential precondition for scaling up production. Also, direct investment support is not ranked last by stakeholders. Mainly consultancy, research organizations, storage and logistics operators, and fuel producer value this intervention, particularly in early-stage projects with high CAPEX. Public actors are more skeptical about the long-term sustainability of this intervention, but targeted and time-bound financial support remains essential in de-risking early-stage development.

Third, CfD shows limited support from all stakeholders, except the industry association and research institute. The main concerns are about long-term government commitment and the developing market price of eSAF, and therefore, its implementation feasibility. Besides that, the stakeholders still see potential in CfDs as an early-stage tool to bridge price gaps and attract investors. To make this intervention viable or more transparent, pilot-based experimentation is needed, together with clear governance models for pricing mechanisms.

Fourth, carbon pricing/kerosene tax is considered polarizing. Producers support this intervention on economic grounds, while airlines, consultants and interviewees related to the government express their concerns due to political sensitivity. Given this resistance from the STS, this intervention can be considered a long-term policy tool, introduced at the EU level to avoid competition amongst regions.

Fifth, the establishment of multi-stakeholder platforms is highly valued by public and networking actors. Private actors rank this intervention lower. While these platforms do not directly stimulate production and the feasibility of eSAF production, they offer coordination and trust-building functions considered relevant in this STS. Therefore, policymakers should reposition platforms not as end goals, but as vehicles to jointly design and monitor interventions. Participation must be inclusive to foster multi-stakeholder collaborations.

In summary, the findings imply that an effective policy mix should be considered. This mix should combine short-term market mechanisms (blending obligations and investment support) with long-term enabling measures (establishing infrastructure and multi-stakeholder platforms). Controversial interventions (CfD and carbon pricing) require additional design, pilot phases, and stakeholder alignment.

8.1.2 Scientific contribution

This research contributes to academic literature on eSAF policy interventions by offering a stakeholder-inclusive evaluation of policy interventions in a real-life context based on the planned production facility of Power2X and Advorio. By combining MCA with semi-structured interviews, this study provides a structured and comparative assessment of how stakeholders prioritize and justify policy interventions. This research shows how MCA can be applied in early uncertain early stages of system transitions when technological, political and market conditions are rapidly changing.

This analysis helped in defining different stakeholder perspectives which can be used to structure policy mixes that are effective and broadly accepted. The analysis on stakeholders' perspectives provides empirical evidence of often assumed challenges of stakeholder perspectives that are rarely indicated which provides insights into the alignment and misalignment of the different roles in the STS.

By identifying diverging stakeholder priorities, this study supports the design of effective and broadly supported policy mixes that can guide the sustainability transition in aviation fuel. Furthermore, this research shows the applicability of MCA as a decision-making tool in complex innovation systems.

8.2 Study limitations

Despite the structured method applied in this research and the carefully selected data for the MCA, various methodological and data limitations occur.

8.2.1 Methodological limitations

Eight stakeholders were interviewed for this research. As discussed before, not all stakeholders are contacted due to time and reality constraints. This is a limitation, as not the entire STS is represented. Also, only one stakeholder from each stakeholder category is included. Discrepancies between perspectives of (for example) different airlines as off-takers in this STS are not included. Multiple airlines can have different perspectives on policy interventions, as they might have different interests. EasyJet, as an airline, might have a different perspective on eSAF adoption than Transavia, while both are active in the same STS with the same role. Also, the MCAs consider the perspective of one individual of the organization, which may not fully reflect the organization's perspective.

Second, stakeholders give scores and weights once, without feedback loops. The MCAs reflect only a single moment in time. Stakeholder perspectives and policy landscapes may shift over time, especially in the emerging energy transition and current geopolitical tension.

Furthermore, MCA assumes simple trade-offs between criteria, which may oversimplify the complexity of the real world.

8.2.2 Data limitations

Since no European/International bodies are interviewed, the results could have been different if these organizations are included.

As the interviewees quantify their perspectives in the MCA, there might be an interpretation bias. Even though the interviewees scored on the same scales, restraint in high/low scores could have

biased the interviewees. The policy interventions are scored based on the perceived perspectives on the criteria set. This does not always reflect actual data or historical performance.

There is a geographical constraint, too. The analysis focuses on the Dutch context, while the policy context is considered EU-wide. This limits generalizability.

Furthermore, before conducting the interviews, the criteria for MCA were selected. This research supports the selection of those criteria. Long-term robustness was left out due to the assumption and consideration flexibility and long-term robustness have similar meaning in this context. However, interviewees stated statements regarding short-term and long-term policy interventions. It might have been good to include long-term robustness in the MCA.

Lastly, the MCA includes six set policy interventions. Two interviewees consider the set of policy interventions to be complete. The Port of Rotterdam misses interventions regarding licensing, while Power2X thinks the set of policy interventions misses interventions that could be used before final investment decisions are made. Furthermore, the predetermined set of criteria could have resulted in biased answers. A selection of other criteria might have led to different results.

These limitations in methodology and data selection can be used for further research.

8.2.3 Further research recommendations

Further research can expand the stakeholder base. This can be done through either expanding the stakeholder categories or by including more stakeholders from each stakeholder group. Conducting research in different contexts than the Dutch policy context is therefore suggested to explore more diverse regional perspectives.

The implementation of Multi-Actor Multi-Criteria Analysis (MAMCA) can validate and deepen stakeholder engagement in studies (Macharis et al., 2012). This method focuses on the inclusion of different stakeholders who are involved in projects. According to Macharis et al. (2012), MAMCA lets each stakeholder category formulate their goals and criteria, so no interest of stakeholders excluded. Even though stakeholders assign weights and scores to the criteria in this study, this study does not let the interviewed stakeholders select the criteria most relevant from their perspective.

The same occurs for the selected policy interventions. As said, organizations miss some interventions. The limited set of policy interventions can be expanded or changed to ensure a more inclusive MCA.

Furthermore, a mix of policy interventions is suggested by multiple stakeholders but is not included in the MCA. The mix of policy alternatives can be simulated in real-world conditions by, for example, agent-based modelling.

Lastly, stakeholders value multi-stakeholder platforms to foster collaboration or align stakeholder interests. On the other hand, stakeholders question their effectiveness as they have limited legitimacy and actions. Further research can be done into the governance structure of such platforms in this context.

8.3 Conclusion

This section presents the conclusions of this research. The results discussed in the previous section are brought together to formulate an answer to the main research question.

The main research question of this research is: According to key stakeholders involved in the socio-technical system, which policy interventions support the feasibility of a large-scale eSAF production facility in Rotterdam best?

The analysis shows that implementing a single policy intervention is insufficient. Instead, a mix of interventions that suits the interests of all stakeholders is needed to support feasibility of eSAF production in Rotterdam. The results recommend a coherent package. Short-term policy interventions that directly stimulate demand and investments (such as blending obligations and direct subsidies), combined with structural long-term policy interventions (such as investment in infrastructure/feedstock and multi-stakeholder platforms) in the medium to long term is most accepted by all stakeholders. This mix is in line with the objectives of Power2X/Advario and the current EU requirements for eSAF.

The interest of having a balanced mix of market and cooperative measures is explained in this chapter. Multiple stakeholders addressed blending obligations with specific sub-targets and investment in infrastructure/feedstock as precondition to ensure both short-term market certainty and long-term scalability. Subsidy schemes can be feasible in short-term for de-risking projects and incentivize early-stage investments in capital intensive production facilities as Power2X/Advario's. Multi-stakeholder platforms can help in aligning stakeholder perspective but must be aware of the possible consequence that relying too much on these platforms can delay policymaking. Multi-stakeholder platforms can be established to stimulate dialogue between stakeholders but must not be seen as intervention on its own. CfD or carbon pricing/kerosene tax can be valuable when implemented on international level with legitimate schemes and governance to know who is responsible for what costs.

In conclusion, stakeholder-informed policy design not only reveals shared priorities, but also highlights where tailored governance is needed in complex multi-actor socio-technical systems. This research concludes that stakeholder-aligned and internationally harmonized policy innovation, not technological innovation alone, is essential to enable large-scale eSAF production, as intended by Power2X and Advario.

Declaration

This master thesis is my own work. During the preparation of this work, I used OpenAI's ChatGPT to rephrase some complex sentences and to minimize repetition of information. I also used Grammarly to ensure correct English sentences and vocabularies to minimize incorrect English sentences. After using these tools, I reviewed and edited the content as needed and I take full responsibility for the content of my Master Thesis report.

Regarding the interviews, all participants were asked during the interview whether they agreed with the upfront provided informed consent and whether they had questions regarding the informed consent. Some indicated they wished to be contacted to review my interpretation and use of the interview data in the results section. These participants have been contacted to verify what was written and the way their views are reflected in this thesis. Some adjustments were made. For other participants, no such preference was communicated. Therefore, in line with TU Delft Human Research Ethics procedures (Data Management Plan, informed consent and HRX checklist) all data have been processed ethically as agreed.

Lastly, it is relevant to note that all interviewees agreed with the results based on the method applied. While some interviewees expressed disagreement with certain results based on personal opinion, they acknowledged these outcomes logically followed from the applied method. Furthermore, the results do not necessarily represent official perspectives of the organizations the interviewees work at.

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Appendix A – Used papers for Theoretical Background

Source	Author	Year	How found	Search string	Crossref	#citations in Scopus
Power-to-Liquids as Renewable Fuel Option for Aviation: A Review	Schmidt et al	2018	Scopus search string	sustainable AND fuel AND aviation		176
Use of Sustainable Fuels in Aviation—A Review	Cabrera & De Sousa	2022	Scopus search string	sustainable AND fuel AND aviation		98
Renewable jet fuel	Kallio et al	2013	Crossref		Yilmaz & Atmanli	121
Soaring sustainably: Promoting the uptake of sustainable aviation fuels during and post-pandemic	Santos & Delina	2021	Scopus search string	("Sustainable aviation fuel" OR "SAF") AND (multi AND stakeholder)		26
Emerging technologies, policies and challenges toward implementing sustainable aviation fuel (SAF)	Lau et al	2024	Already knew this article			6
Synthetic fuels in aviation - Current barriers and potential political measures	Scheelhaase et al	2019	Scopus search string	synthetic AND aviation AND fuel AND barriers		43
Alternative fuels in aviation	Braun-Unkhoff & Riedel	2015	Scopus search string	("synthetic" OR "sustainable") AND aviation AND fuel AND policy		71
Low-emission alternative energy for transport in the eu: State of play of research and innovation	Ortega et al	2021	Scopus search string	("synthetic" OR "sustainable") AND aviation AND fuel AND policy AND innovation		16
E-fuels, technical and economic analysis of the production of synthetic kerosene precursor as sustainable aviation fuel	Colelli et al	2023	Scopus search string	("synthetic" OR "sustainable") AND aviation AND fuel AND policy		32
Analyzing the functional dynamics of technological innovation systems: A scheme of analysis	Bergek et al	2008	Crossref	https://doi.org/10.1016/j.respol.2007.12.003	van Gelder	1.510
Transforming the energy sector: the evolution of technological systems in renewable energy technology	Jacobsson	2004	Crossref	doi:10.1093/icc/dth032	van Gelder	561
Transition policy and innovation policy: Friends or foes?	Alkemade et al	2011	Crossref	doi:10.1016/j.eist.2011.04.009	van Gelder	87
A framework for analysis of multi-mode interaction among technologies with examples from the history of alternative transport fuels in Sweden	Sanden & Hillman	2011	Crossref	https://doi.org/10.1016/j.respol.2010.12.005	van Gelder	164
Identifying the Interactions between the Technological Innovation Systems of Bio-SAF and Synthetic SAF in the Randstad Cluster in the EU and Dutch ...	Bram van Gelder	2024	Google scholar	Found during initial scanning procedure		MSc Thesis
Multi-criteria Analysis of Sustainable Aviation Fuel Technologies	Taets van Amerongen	2024	Repository TU Delft	sustainable aviation fuel		MSc Thesis

Appendix B – Template Informed Consent

Dear [participant],

You are being invited to participate in a research study titled "Master thesis on stakeholder perspectives on policy interventions to establish a feasible synthetic kerosene plant in Rotterdam." This study is being done by Cas Hofstede as a master's student at TU Delft.

The purpose of this research study is to identify possible policy interventions based on a literature review. Subsequently, stakeholders will be interviewed to gather their opinions and/or perspectives of various policy interventions. This will be done by filling in a preprogrammed spreadsheet together. The interview will take approximately 30 to 60 minutes to complete. The data will be used for the master's thesis and will be published in the TU Delft repository. We will be asking you about your views on different policy interventions related to the adoption of synthetic kerosene.

The interview will be recorded and transcribed. These recordings and transcripts will be stored at TU Delft, accessible only to TU Delft people. As with any online activity, the risk of a breach is always possible. To the best of our ability, your answers in this study will remain confidential.

Part of my goal is to determine perspectives on various policy interventions for a multi-criteria analysis. All personal data will be deleted one month after completion of the project.

Your participation in this study is entirely voluntary, and **you can withdraw at any time**. You are free to omit any questions. Any collected data (such as recordings) will be deleted one month after completion of the project.

If you have any questions, please contact me, Cas Hofstede, at the following email address: _____

I have read and understood the above. I consent to participate in the study and data processing as above.

Signature

Name of participant

Signature

[XX-XX-2025]

Date

Appendix C – List of policy interventions

WEF Supply side policy interventions

Innovation funds

This economic policy intervention aims to increase fuel production. CO₂ impact is considered moderate, and governments will pay. This is also called public support and mainly includes funding for academic research, innovation challenges, loan guarantees, investment de-risking agreements, and grants or other fiscal incentives for private sector investments. Apart from that, research can be conducted at their institutions and make results made available to all stakeholders. These innovation funds are more attractive for technologies at lower TRL, like eSAF, since it considered most effective for demonstration or pilot opportunities.

Contract for Difference (CfD) schemes

This economic policy intervention aims to increase fuel production through variable government payments. This intervention reduces the price gap between (e)SAF and traditional jet fuel by guaranteeing fuel producers a pre-agreed price per ton of SAF. This mechanism aims to bring long-term certainty to investors by guaranteeing purchase. By this, investment risks are minimized by locking in demand to return capital investments. In general, if the market price drops below the pre-agreed price, governments pay the difference. This is particularly useful in early commercial projects, especially when technologies have high initial cost and relatively low TRL, since it helps bring emerging technologies to market and inspires private investment in eSAF.

Grants and low-interest loans

This economic policy intervention aims to increase fuel production through variable government payments. This intervention includes capital grants and loans under favorable conditions for the borrowers. This supports the building and operation of production facilities and reduce investment risk and improve cash flow predictability over the production plant's life. This is considered most useful for medium-TRL pathways and mainly incentivizes and attracts long-term private investments. Furthermore, combining this with blending mandates further ensures production viability which directly increases production capacity.

Feedstock prioritization

This more regulatory policy intervention aims to increase fuel production with well-defined cost profiles. These interventions will redirect renewable feedstocks towards aviation by limiting their use in competing sectors through the electrification of those sectors. This ensures more feedstock availability for aviation. Even though this seems a good step, it requires strong intersectoral coordination and careful, complicated policy design.

Feedstock tax incentives

This fiscal policy intervention aims to increase local feedstock production and processing by exempting tax on SAF produced by locally sourced feedstocks. By stimulating regional production, this policy reduces logistics emissions and supports local development. However, well-coordinated oversight is essential to prevent carbon leakage and greenwashing. Therefore, it is considered best suited for the region with existing feedstock production.

WEF Demand-side policy interventions

Blending obligations

This regulatory policy intervention aims to increase the fuel offtake where industry/consumers pay for the fuel. This policy intervention is on establishing obligations that progressively increase over time. This will ensure a stable demand and therefore investment security. Part of these obligations can be sub-obligations, where the obligation can be coupled with sub-targets for specific production pathways. These obligations should be well-quantified. The obligations will increase fuel costs and have a potential distortion risk due to the geographical scope of the obligations. Also, other policies should be incorporated together with the obligations, since there should be enough fuel produced to meet the blending targets set. Furthermore, it is possible that only setting obligations out of place supply-chain capacities.

Direct subsidies

This economic policy intervention aims to increase the fuel offtake where the government pays through well-defined cost profiles. The direct subsidies include tax incentives for eSAF off-takers, producers, or blenders. This will result in a reduction in the cost differential between eSAF and traditional jet fuel. This tax incentive is based on the volume or emission performance of the SAF used, where the higher the GHG, the greater the tax benefit. These tax incentives reduce the cost gap between eSAF and conventional jet fuel. This results in lower production costs and therefore higher offtake. This supports high GHG-reducing fuels, which increases eSAF demand.

Indirect subsidies

This economic policy intervention aims to increase the fuel offtake where the industry/consumers pay through well-defined cost profiles. This policy intervention entails a SAF fee at the point of ticket purchase or fuel usage. This extra payment is used to increase SAF offtake and could be either voluntary or mandatory. This policy intervention creates a more predictable revenue stream for SAF offtake without direct government spending. Costs are then distributed across consumers, which supports market creation and public awareness.

Increase the costs of traditional jet fuel.

This regulatory policy intervention aims to have an impact on fuel offtake via well-defined cost profiles where industry/consumers pay. This policy intervention introduces a domestic carbon price or cap-and-trade scheme. This can be either aviation-specific or not, and the aim is to price in the costs of GHG emissions. Carbon taxes are applied to traditional jet fuel based on the amount of GHG. By including these external costs, eSAF can become relatively cheap. This scheme can reduce the competitive advantage of traditional fuel, which makes it more attractive to switch to (e)SAF. This is somehow like the current EU ETS but specializing it more to aviation can accelerate the shift.

Minimum public procurement

This regulatory policy intervention aims to have an impact on fuel offtake via well-defined cost profiles where the Government pays. The CO₂ reduction impact is low. This policy intervention imposes a minimum procurement quantity for public sector flights (military, state flights, and commercial flights by public servants). Including this policy intervention will help establish an early demand signal and set a precedent for private stakeholders. Furthermore, it can stimulate the lead market development for eSAF and serve as a model for broader procurement practices.

Enabling measures and systems to facilitate SAF scaling

Ownership transfer system

This regulatory policy intervention aims to have an impact on fuel offtake via well-defined cost profiles where industry/consumers pay. This policy intervention introduces the establishment of an attribute ownership transfer system, such as book and claim, to have SAF usage and physical delivery separated into two distinct processes. This enables global trade in SAF credits and increases market flexibility. This promotes cost-efficient procurement but requires transparent traceability and oversight.

Reduce SAF import barriers.

This economic policy intervention aims to have an impact on fuel offtake via variable cost profiles where the Government pays. This policy intervention aims to reduce import/export barriers for fuels and feedstock to increase international trade. By this, domestic demand can be met when local production is insufficient. This prevents regional bottlenecks, but it needs international coordination and alignment in lifecycle assessment (LCA)-based tariffs.

Adoption of certification standards

This regulatory policy intervention aims to have an impact on feedstock and production processing via well-defined cost profiles where the Government pays. The main goal of this policy intervention is the adoption of clear and international (global) sustainability standards for feedstock supply. This reduces administrative problems, improves trust in imports, and avoids messed-up regulation.

Enabling the supply and demand connection

This administrative policy intervention aims to have an impact on fuel production via well-defined cost profiles where the Government pays. This policy intervention aims to support the roll-out of existing production technologies and international capacity building to developing countries to promote global (e)SAF production. This will stimulate a global roll-out and inclusion of industry frameworks, which is considered important for systematic equity and scalability.

Appendix D – Interview protocol

Start by thanking the interviewee for contributing to your master's thesis. Check if the informed consent form has been signed. If not, explain the content of the consent and ask for verbal agreement.

Introduction of the interviewer

Q: Before we begin, could you please introduce yourself?

The interviewer introduces the master thesis project and sub questions. The stakeholder analysis is made.

Q: Could you describe the role of your organization within the socio-technical system?

The interviewer introduces policy analysis. A selection of policy interventions is made for MCA.

1. Blending obligations with specific sub-targets
2. Direct investment support
3. Investment support for infrastructure and feedstock development
4. Contracts for Difference (CfDs)
5. Carbon pricing/kerosene tax with ETS alignment
6. Establishment of multi-stakeholder platforms with an innovation fund

Q: From your role, organizational perspective, or personal view, how do you perceive these policy interventions?

Q: I will not expand the list of interventions, but do you believe an important policy measure is missing? If so, why?

Introduce MCA and the selection of criteria. Explain that for each criterion, a question is defined that the interviewee could ask himself/herself when considering the criteria.

1. Effectiveness

To what extent does the policy intervention foster the feasibility of the planned production facility?

2. Cost Efficiency

What is the expected effect in relation to the required public investment?

3. Implementation Feasibility

Is this policy realistic in the Dutch context, considering the current regulatory and governance framework, and political environment? How well does it align with EU policy?

4. Stakeholder Inclusiveness

To what extent is the intervention supported by, and aligned with, the interests of identified stakeholders within the ecosystem?

5. Flexibility and Scalability

Is the policy flexible enough to adapt to market or technological changes over time?

Instructions for MCA follow. Weights will be assigned for each criterion, and then interventions will be scored.

When finished:

Q: Before presenting the results, is there anything you'd like to further justify, explain, or change?

Present results

Q: From the organization's perspective and personal perspective, can you agree upon the results?

Potentially small discussion.

Thank the interviewee for their contribution and explain their rights from informed consent once more.

Appendix E – List of criteria and academic papers

	Source	Criteria used relevant	Link to eSAF context
1	Sun et al. 2015	Accessibility, Safety, Environment, Society, Cost, Profits, Technology	Costs relate to cost effectiveness, society relate to policy transparency and (economic) regional development
2	Li et al. 2019	Technology, Economy, Environment, Society, Policy	Economy relate to cost of policy, society relate to job creation and market acceptance, policy relate to policy support
3	Kin et al. 2017	Viability (economic), low costs, positive effect, social-political acceptance, employee satisfaction, amount of freight more	Relate to cost efficiency, but also implementation feasibility. Employees were stakeholders, they should accept it. Amount of freight can refer to effectiveness: more eSAF uptake
4	Macharis et al. 2012	Maximizing efficiency, maximizing economic benefits, increase reliability	Effectiveness, cost efficiency, implementation feasibility can be linked
5	Turcksin et al. 2010	Production capacity, investment costs, level playing field , transparency, user friendliness, EU harmonization	Effectiveness, cost efficiency, stakeholder inclusiveness, EU harmonization can be directly linked to this
6	Dimitriou et al. 2016	Mega infrastructure projects require dynamic framing and differentiator among stakeholders. Also need differentiations due to complexities	Must be effective and stakeholder inclusive
7	Rai et al. 2017	Satisfied stakeholders, positive expected return, minimal costs, increase in returns	Effective, cost efficiency, stakeholder inclusiveness, scalable
8	Akgun et al. 2012	Openess, participation, awareness, economic uncertainty, institutional integration, technology	Effective, cost efficiency, stakeholder inclusiveness, scalable, implementation feasibility
9	Broniewicz & Ogrodnik 2020	Paper is about transport projects as roads, but conclusion is it should be effective, cost efficient and not harm nature	Effective, cost efficiency
10	Yannis et al 2020	Minimize implementation cost, maximize internal rate of return, protect environment, maximize capacity, maximize accessibility, amximize regional development and employment	Effective, cost efficiency, stakeholder inclusiveness, scalable, implementation feasibility
11	De Brucker et al. 2011	Social-political acceptance, minimize investment risk, technical feasible	Implementations feasibility, cost efficiency and effectiveness
12	Bueno Cadena & Magro 2015	Investment costs, fuel consumption	Effective, cost efficiency
13	Milan et al. 2015	Viability of investment, Profitable operation, Employee satisfaction, network optimization and social-political acceptance	Effective, cost efficiency, stakeholder inclusiveness, scalable, implementation feasibility
14	Roukouni et al. 2018	Strategic goal, costs, risks, social equity, innovation, transparency	Effective, cost efficiency, stakeholder inclusiveness, scalable, implementation feasibility
15	Aljohani & Thompson 2018	Reduce cost, reduce negative impact, high return on investment, security, efficient integration, system integration, availability, harmonization	Effectiveness, cost efficiency, stakeholder inclusiveness, implementation feasibility EU harmonization can be directly linked to this

Appendix F – Matrix for MCA

Criteria	Weights	Blending Obligations	Direct investment support	Investment in infrastructure/feedstock	Contracts for difference	Carbon pricing/kerosene tax	Establishment of multi-stakeholder platforms
Effectiveness	-						
Cost Efficiency	-						
Implementation Feasibility	-						
Stakeholder Inclusiveness	-						
Flexibility/Scalability	-						
Weighted score							
Rank							

