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Control mechanisms and individual incentives

To reduce CO_2 emissions

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Report

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Executive Summary

The Ministry of Infrastructure and Water Management has requested To70 to identify and analyse potential control mechanisms and individual incentives for the CO_2 ceiling per airport. These control mechanisms and individual incentives should contribute to minimizing the weaknesses of the CO_2 ceiling per airport, which are a limited grip on emissions by airports and a weak incentive for airlines to reduce CO_2 emissions. The objective of the control mechanisms is to increase the grip by airports on emissions, the individual incentives aim to motivate airlines to reduce CO_2 emissions.

To70 has concluded that the possibilities for control mechanisms are limited, but there are opportunities (as shown in Table 1); including CO_2 limit as an environmental constraint in the capacity declaration for slot-coordinated airports, as part of the Slot allocation process. Including the CO_2 limit as environmental constraint in the capacity declaration is a highly effective mechanism, because airports have a high certainty that the CO_2 ceiling will not be exceeded. Moreover, the mechanism is easily enforceable. However, this control mechanism requires adjustments of IT-systems from the central stakeholders and is therefore not efficient. On top of that, the support from airlines is low, because it is seen as too strict and there is little room for interaction between the airports and between different seasons. For non-slot-coordinated airports, a similar mechanism can be designed, as a Movement allocation limit. This is not complex, easy to enforce, but has moderate support. The *use of individual incentives* is a third control mechanism, which has more support from stakeholders. The enforceability of this mechanism is low, because there is no steering in this mechanism.

Table 1 Assessment of steering mechanisms *(green is high, yellow is medium, orange is low)*

	Slot allocation process	Movement allocation limit	Use of incentives
Effectiveness	No exceedance of CO_2 limits	No exceedance of CO_2 limits.	Little to moderate grip on CO_2. Literature suggests that discouraging interventions have higher effectivity
Efficiency	IT and process for slot coordination needs to be adjusted	A simple tool should be created to register CO_2	Currently, incentives in place. No new system needed.
Equality	Historical rights for an airport slot imply also CO_2 rights	Number of aircraft movement could be reduced.	Use of incentives are equal for all airlines.
Enforceability	Easy to enforce, depends on monitoring and enforcement period	Easy to enforce. Enforcement creates necessity to shift to slot coordinated airport.	This mechanism contains no means to enforce
Support	Slot allocation is too strict (airlines)	Moderate support	Only with stimulation incentives.
Feasibility	Requires legislative investigation	Only small changes are needed, less strict than slot allocation process	Incentives already exist

To70 has also concluded that there are many individual incentives possible, of which three have been assessed as most promising, see Table 2. These include encouraging fuel-efficient aircraft types (combination of aircraft/engine type) via tariff differentiation in airport charges, a sustainable aviation fuels (SAF) incentive fund by airports and a ban on fuel-inefficient aircraft types. The SAF incentive fund already exists at some airports and there is support from the aviation sector for this incentive. The ban on fuel-inefficient aircraft types might be difficult to implement on a legal basis and there is less support for this. Both incentives are considered to be the most effective. The tariff differentiation in airport charges to encourage fuel-efficient aircraft types is expected to be less effective, but is easier to implement and is therefore still recommended. It is also recommended that another combination of *policy tools* (incentive fund, ban and tariff differentiation) and *targeted factors* (SAFs, fuel-(in)efficient aircraft) will be considered.

Table 2 Overview of individual incentives

Initiator	Encourage	Discourage
Airport	Discount on airport charges • Fuel-efficient aircraft • SAF	Surtax on airport charges • Fuel-efficient aircraft
Government		Ban • Fuel-efficient aircraft

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1 Introduction

In the Civil Aviation Policy Memorandum ("Luchtvaartnota"), the Ministry of Infrastructure and Water Management have set targets for reducing the CO_2 emissions of the Dutch aviation sector: reaching the level of 2005 in 2030, reducing by 50% in 2050 and to net zero in 2070.

In the letter to parliament of March 17th 2023, the principle decision by the Dutch government regarding the implementation and interpretation of a CO_2-ceiling is described. To gain control of the emissions and make the targets enforceable, the Ministry of Infrastructure and Water Management is implementing a CO_2-ceiling. The CO_2-ceiling will serve as a mechanism to assure the CO_2 emissions from departing international flights from the Netherlands will remain below a certain limit. In this way, the Ministry assures the aviation industry will achieve the national climate targets, and thereby contribute to the climate targets in the Paris agreement.

1.1 Problem statement

Following up previous research, the Ministry has decided to continue with a CO_2-ceiling per airport. This means that airports are given a CO_2-budget and are regulated based on this budget. This option has been chosen based on the research in the letter to the Parliament of January 17th 2023, which has concluded the airport option is considered to be the easiest to be implemented, has a relatively high level of enforceability and is expected to have a lower risk of international repercussions in comparison with the other variants. At the same time, the CO_2-ceiling per airport contains two important weaknesses.

First, airlines produce the CO_2 emissions, not airports. At the same time, the airport does not determine destinations, engine types, load factor and fuel type, but these factors do influence the CO_2 emissions considerably. As a result, the grip on emissions by airports is low.

Second, the airport option entails a collective system, where individual incentives for airlines are weak. When airlines collectively exceed the CO_2-ceiling, they have a collective incentive to reduce their emissions, for example by increasing the amount of sustainable aviation fuels (SAF) used, changing destinations or aircraft, or reducing the number of flights. While the reduction in emissions would benefit all airlines collectively, the costs of adjustment would be borne by each airline individually. Consequently, there is a weak incentive for airlines to reduce CO_2 emissions.

1.2 Objective

The main objective of this study is to identify and assess methods to resolve or reduce the weaknesses of the CO_2-ceiling per airport, which results in a twofold research objective.

The first objective is making an inventory of control mechanisms for airports to get a grip on the CO_2 emissions from airlines. In the current situation, the airport's grip on an airline's emissions is mainly limited to the outcomes of the implementation of the basic control mechanism, which is determining the capacity. This study aims to assess whether airports can expand this limited grip on airline emissions.

The following sub-questions have been formulated:

<u>Control mechanisms:</u>

- How can airports steer towards CO_2 reduction?
- What are the several potential control mechanisms?
- What are the advantages and disadvantages of each control mechanism?
- How can airports apply these control mechanisms?
- Which control mechanisms can be used to steer, and by whom and when should this be done?

The second objective is to make an inventory of opportunities for the airports and other involved stakeholders, such as the Airport Coordination Netherlands (ACNL) and the government to build in individual incentives for airlines to realise CO_2 reduction. The CO_2-ceiling per airport is characterised by a collective incentive, therefore it is important to explore strategies to incentivize individual airlines to reduce their CO_2 emissions.

The following sub-questions have been formulated:

<u>Individual incentives:</u>

- What are ways to realise CO_2 reduction?
- What are the several potential individual incentives?
- What are the advantages and disadvantages of each individual incentive?

1.3 Scope

This study assesses control mechanisms and individual incentives. It is essential to understand the definitions of these two items used throughout this report:

- <u>Control mechanism:</u> A means for an airport to get grip on airlines' CO_2 emissions, to reduce the risk of exceeding the CO_2-ceiling. It arises from the authority of the airport.
- <u>Individual incentive:</u> Something that encourages airlines to take specific actions or make certain decisions to reduce CO_2 emissions. Incentives can be both positive (e.g., subsidies, discounts and recognition) and negative (e.g., penalties and increased fees).

Table 3 provides a description of the two items.

Table 3 Descriptions control mechanisms and individual incentives

	Control mechanisms	Individual incentives
Definition	A means for an airport to get grip on airlines' CO_2 emissions, to reduce the risk of exceeding the CO_2-ceiling	A motivation for airlines to take specific actions or make certain decisions to reduce CO_2 emissions.
Regulating entity	Airport	Airport, government, air traffic control, slot coordinator, etc.
Implementation possibilities	Within current laws and regulation	Incentives which require adjustments to laws and regulations are within the scope of this study.

In this study, we only include control mechanisms which can be implemented by airports given the current laws and regulation. If the regulatory context changes, this could affect the available control mechanisms. However, the aim of this study is to assess how the airports can control the CO_2 emissions within the current context. Therefore, control mechanisms which require a change of legislation are excluded from this study.

There are multiple aspects on which control mechanisms and individual incentives differ from each other. However, an individual incentive can also be a control mechanism. By encouraging an airline to undertake an activity to reduce CO_2 by means of an imposed advantage or disadvantage, the airport can get a grip on the CO_2 emissions of airlines. The two categories of policy measures thus partly overlap each other.

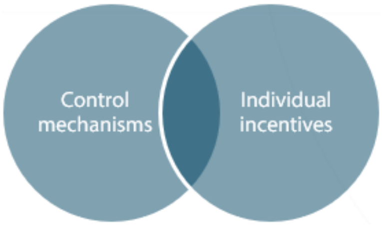

Figure 1 Overlap between control mechanisms and individual incentives

Besides the definitions, it is important to highlight the scope of this study regarding airports and flights:

- Airports: This study concerns all Dutch airports of national importance. This means that a combination of slot coordinated and non-slot coordinated airports are included. Schiphol Airport, Eindhoven Airport, Rotterdam Airport are slot-coordinated and Lelystad Airport is expected to be slot coordinated in the future. Groningen Airport Eelde and Maastricht Aachen Airport are not slot-coordinated.
- Flights: The CO_2-ceiling includes all CO_2 emissions of all international departing flights from the abovementioned airports. This concerns the emissions for the full length of the flight. Both passengers flights and cargo flights are included.

1.4 Methodology

The methodology used in this research is structured as follows. First, an inventory of industry example is created to identify potential examples of control mechanisms and individual incentives in the aviation industry and other industries, that could be applied in the context of the CO_2-ceiling for aviation as well. Second, both an internal stakeholder workshop with colleagues of To70, as well as an external session with representatives of selected industry stakeholders was organized. During these workshops, factors that influence CO_2 emissions were identified. These are the factors to must be targeted when determining policy tools for CO_2 reduction. Third, a list of control mechanisms and a list of individual incentives to steer the behaviour of airlines has been established. The lists of control mechanisms are assessed using a multi-criteria analyse and individual incentives are then filtered and selected using expert judgement and selection criteria. The expert judgement was expanded by organising sessions with airlines, airports and other sector parties to gather feedback regarding potential control mechanisms and individual incentives. This step resulted in a short list of control mechanisms and a short list of individual incentives.

1.5 Structure

This report starts with an overview of examples of control mechanisms and individual incentives from the aviation industry and other industries. Then, in chapter 3, several control mechanisms are described, including advantages and disadvantages. In chapter 4, individual incentives are described. This chapter starts with a long list of potential incentives, followed by a short list of incentives that are further explored. Based on the advantages and disadvantages of the incentives on the short list, a recommendation for potential individual incentives is given.

2 Industry examples

This chapter provides a brief overview of industry examples regarding the deployment of control mechanisms and individual incentives, both within the aviation industry as in other industries to gather inspiration for this research. These practices are used for inspiration for control mechanisms and individual incentives that may be used within the CO_2-ceiling. Table 4 provides an overview of control mechanisms and individual incentives described in this literature study.

Table 4 Overview of implemented control mechanism and individual incentives

Measure	Type	Industry	Intended effect	Applicable
Include CO_2 as environmental constraint in slot allocation process	Control mechanism	Aviation industry	To ensure the total amount of CO_2 produced by the all the flights combined stays below a certain limit.	Yes
Tariff differentiation in airport charges based on aircraft performance	Individual incentive	Aviation industry	Encourage the use of fuel-efficient aircraft, to reduce CO_2 emissions.	Yes
SAF incentive fund	Individual incentive	Aviation industry	Encourage the use of SAF, to reduce CO_2 emissions.	Yes
Aircraft noise as secondary allocation criterion	Individual incentive	Aviation industry	Encourage quieter aircraft, to reduce noise around airports	Yes
Tax on flights powered by fossil fuels	Individual incentive	Aviation industry	Discourage flights on fossil fuels.	Yes
Flight tax differentiation based on flight distance	Individual incentive	Aviation industry	Discourage long distance flights	Yes
Investment tax credit	Individual incentive	Solar energy industry	Push for market development.	No
Equal taxation on CO_2 emissions	Individual incentive	Greenhouse horticulture industry	Burden CO_2 emissions equally, to encourage CO_2 reduction.	Yes
Discounts on port dues, tonnage tax and fees	Individual incentive	Maritime transport industry	Accelerate the uptake of, and support investments in, the adoption of technologies.	Yes

2.1 Control mechanisms and individual incentives for airports

There are not many control mechanisms for airports. This is because the role of the airport is limited to facilitating the infrastructure for aircraft operators and the authority of the airport is based on fulfilling this role. Regulation is not the task of the airport, but of national or international governments. However, there are two ways for airports to influence the behaviour of aircraft operators: include coordination parameters in the capacity declaration and include tariff differentiation based on aircraft performance in airport charges.

Include coordination parameters in the capacity declaration

When demand for slots is higher than capacity, member states may decide to make an airport *slot coordinated*. This means that airports become subject to the EU Slot Regulation (95/93). According to this regulation, member states assign a competent authority. In The Netherlands, this is the Airport Coordination Netherlands (ACNL), which aims to distribute landing and take-off slots in an efficient, fair, non-discriminatory and transparent manner. This distribution is performed according to the available capacity that airports declare in a so-called capacity declaration. This document provides the competent authority with the number of movements that fit within the capacity of the airport, reflecting technical, operational and environmental limitations.

2.2 Individual incentives by governments

Because regulating is performed by national and international governments, there are more examples of individual incentives by governments than by airports. This includes incentives within the aviation industry and in other industries. This sub chapter describes several examples.

2.2.1 Within aviation

In the aviation industry, several individual incentives are installed. This sub chapter describes the following incentives:

- Tariff differentiation in airport charges based on aircraft performance (airport);
- SAF incentive fund (airport);
- Aircraft noise as secondary allocation criterion (airport slot coordinator);
- Tax on flights powered by fossil fuels (government); and
- Flight tax differentiation based on flight distance (government).

Tariff differentiation in airport charges based on aircraft performance

Initiator: airport

Airports with more than five million passenger movements are subject to the Airport Charges Directive (2009/12). According to this directive, the airport charges must be appropriate compared to the quality of the infrastructure and the service level offered by the airport. Aircraft operators must be consulted before the airport charges are installed. On top of that, this directive states airport charges shall be non-discriminatory, but charges may be modulated for issues of the general and public interest, and environmental interest. This modulation for the public interest is commonly practiced, because airports often receive many noise complaints. To reduce the noise for the surrounding communities, airports include lower rates for silent aircraft and higher rates for noisy aircraft in their airport charges.

SAF incentive fund

Initiator: airport

Several airports have introduced incentive programmes to stimulate the adoption of sustainable fuels (SAF) by airlines. One of these airports is Amsterdam Airport Schiphol. The airport stimulates airlines to make use of SAF by offering a financial contribution when they uplift SAF (Schiphol, 2021). Swedavia is another airport operator that introduced a SAF incentive programme. The incentive funds generally support up to 50 percent of the premium cost for neat SAF for approved applications. It is not publicly announced how the airports finance the incentive funds.

Aircraft noise as secondary slot allocation criterion

Initiator: airport slot coordinator

The slot-coordinator uses aircraft noise as secondary allocation criterion. This could be applied for CO_2 as well. Within the slot allocation process, the slot coordinator ACNL applies primary criteria to allocate slots. If slots cannot be allocated using the primary criteria, the slot coordinator should not simply allocate the remaining slots pro-rata among all requesting airlines (IATA, 2022), but should give consideration to the following factors (in no particular order) to determine which of the competing requests should be allocated a slot: *effective period of operation, operational factors, time spent on waitlist, type of consumer service and market, connectivity, competition, environment, local guidelines*. The slot coordinator in the Netherlands has defined a Policy Rule for Additional Allocation Criteria on how to allocate the remaining slots (Slot Coordination Netherlands, 2022). This policy rule contains environmental factors, such as noise, to give priority to airlines for slot allocation.

Tax on flights powered by fossil fuels

Initiator: government

An individual incentive that has already been implement within the aviation industry is the introduction of an incentive tax. The aim of this tax incentive is to incentivise people to take the most sustainable option, by decreasing the price gap between air travel and an alternative, more sustainable mode of transport, such as the train. Wild, Mathys and Wang (2021) state that this intended steering effect and its environmental impact are mainly dependent on the extent to which the flight ticket price can be manipulated, since a change in price should subsequently result in a change in demand.

Flight tax differentiation based on flight distance

Initiator: government

There are several examples of flight taxes that have been further elaborated in terms of differentiation based on flight distance. For instance, passengers departing from German airports are charged rates at €7.50, €22.43 and €42.18 for short, medium and long-distance flights respectively (Borbely, 2019). In the United Kingdom, the UK Air Passenger Duty (APD) is determined by four destination rate bands: a 'domestic' band, and three international bands. The aim of this differentiation based on flight difference is to discourage long-haul flights, because these flights are polluting the most. According to Eurocontrol (2020), only 9% of the flights is over 3,000 kilometres, but these account for 53% of the CO_2 emissions. In a report for the European Commission (2019), CE Delft and Seo state that a price incentive is an effective policy tool to influence CO_2 emissions. According to CE Delft and Seo, a 19% increase in ticket price will result in 19% less CO_2 emissions. Therefore, a flight tax differentiation based on flight distance is expected to be effective to reduce CO_2 emissions. However, it must be noted that this reduction in CO_2 emissions comes with severe side-effects. The 19% increase in ticket price will also result in 19% less connectivity, 20% less employment and 20% less value added within the aviation sector, according to CE Delft and CEO. The impact on other sectors is expected to be minimal.

2.2.2 In other industries

In other industries, there are several policy tools implemented which have been proven successful. This sub chapter describes three examples of successful policy tools in other industries:

- Investment tax credit (government);
- Equal taxation on CO2 emissions (government); and
- Discounts on port dues, tonnage tax and fees (port operator).

Investment tax credit

Initiatior: government

The solar energy industry in the United States has experienced one of the greatest successes of an investment tax credit specific to an industry, namely the so-called 'Solar ITC' (Allen, 2019). The investment tax credit (ITC) is a mechanism that is used to influence industry behaviour and drive change, as it allows relevant parties to deduct a certain percentage of investment related costs from their tax liability. The Solar ITC has been an important policy mechanism in driving solar industry growth in the United States with a 10,000% industry growth since the credit went into effect (Solar Energy Industries Association, 2023). The growth of the solar industry growth resulted in the creation of hundreds of thousands of jobs and in the generation of billions of dollars in the U.S. economy as a direct result, while simultaneously substantially reducing emissions impacts. Such an investment tax credit could be an interesting solution direction to further explore with the goal to incentivise airlines to make investments in green technologies and switch to the use of SAF. However, it is important to take the difference between the market in the U.S. and the market in the Netherlands into account: there are many national actors in the U.S., which means that national policies have a great deal of influence and that competition between them is not rapidly challenged. In the Netherlands it is different, as the Dutch market is much smaller. This means that the investments in sustainability have an impact on jobs, but it is uncertain whether the benefits of these investments relate to CO_2 emissions in the Netherlands (e.g. a SAF plant will produce SAF in the Netherlands, but the SAF can be exported or can be claimed by an airline for a flight abroad). The complex and dynamic nature of the Dutch aviation industry is necessary to consider when analysing such potential alternatives.

Equal taxation on CO_2 *emissions*

Initiator: government

In 2025, the Dutch government will introduce an equal taxation in the greenhouse horticulture industry to burden CO_2 emissions, which means that every tonne of CO_2 will be burdened equally instead of a rising tax or a tax from a certain amount of emissions (Bouwmeester, 2023). In the previous industry system, the incentive for the individual horticulturist to become more sustainable is limited, as the levy is not known in advance and depends on the performance of the entire sector. The new individual CO_2 system improves this as every greenhouse horticulture company is responsible for their own emissions and the associated costs, which will eventually incentivise each company to become more sustainable. Besides the introduction of this 'levelled levy', researchers also recommend letting the companies gain and maintain access to sustainable resources, as this is important to realise a successful system and a substantial environmental impact (GroentenNieuws, 2023).

Discounts on port dues, tonnage tax and fees

Initiator: port operator

Ports have been deploying incentive schemes, such as environmentally differentiated port fees, and grants in the battle towards decarbonisation of the maritime transport sector. The incentive schemes and grants are established to accelerate the uptake of and support investments in the adoption of technologies in ports, land transport and ship (Alamoush, Ölçer & Ballini, 2022). These incentives advance the implementation of CO_2 reducing strategies and technologies and internalise the socioenvironmental externalities (Gonzalez-Aregall, Bergqvist & Monios, 2019). The ports grant incentives to ships, which differentiate according to their type of size, as discounts on port dues, tonnage tax and registration fees. Within maritime transport there are several industry-initiated incentive schemes, such as the environmental ship index (ESI) and the clean shipping index (CSI), for which ports can register themselves as incentive providers to ships that have been certified by registering their fuel consumption and air emissions (ESI, 2023; CSI, 2023). Based on a ship's index score, the ports give incentives as percentage reductions in port dues. Government-led shipping incentive schemes are also being deployed within the maritime transport industry, of which several schemes led to a substantial reduction in CO_2 emissions by ships (Alamoush, Ölçer & Ballini, 2022).

2.3 Conclusion

The examples of control mechanisms within the aviation industry are limited, but there are many examples of individual incentives, both in the aviation industry and in other industries. Almost all the examples can be applied for achieving the goal of CO_2 reduction and are therefore selected for further exploration in Chapter 3 and Chapter 4. Only the investment tax credit is not applicable for aviation, because it is uncertain whether the benefits on the CO2 emissions within the Netherlands will have effect.

3 Control mechanisms

In the current situation, airport capacity management can be seen as the main control mechanism of the airport, as this mechanism helps to get grip on the CO_2 emissions and enables airports to steer airlines towards desired behaviour. Airport capacity management will be considered as the initial control mechanism in this study and will be briefly discussed in chapter 3.2. In addition, complementing control mechanisms will also be further explored. Chapter 3.3 describes the different types of control mechanisms and the assessment of these control mechanisms against the assessment criteria as mentioned in the previous chapter.

3.1 Assessment criteria

To have a comparison between the different control mechanisms, a multi criteria assessment (MCA) will be performed. For this MCA, the six criteria with which the potential control mechanisms will be assessed is inspired on Salamon's classification of policy tool assessment criteria (2000): Effectiveness, Efficiency, Equality, Enforceability, Support, and Feasibility. A short description of each criterion is provided.

Effectiveness - The effectiveness of the implementation of a control mechanism in this project's context is determined by the degree to which the control mechanism ensures grip for the airport on the (airlines') CO_2 emissions and makes sure that the CO_2-ceiling is not exceeded.

Efficiency - Efficiency is defined as the extent to which an airport's resources (e.g., time, money, labour or materials) are used optimally to realise more grip on the (airlines') CO_2 emissions, while not exceeding the CO_2-ceiling.

Equality - Equality can usually be subdivided into two sub-criteria: 1) equal treatment for all airlines, which entails same rules for all; 2) equal impact on all airlines, which implies that one airline must not be affected to a larger extent than the other airline. For this study, equality is defined as same procedures and same rules for all airlines.

Enforceability - Enforceability is the degree to which airlines can be upheld or enforced by an authority. It is the quality of being legally binding and capable of being executed or implemented.

Support - Support is defined as the support from sector stakeholders (airports, airlines) for the control mechanism.

Feasibility - Possibility that a control mechanism can be implemented.

3.2 Airport capacity management as the initial control mechanism

Airport capacity management, which involves the planning, scheduling and utilisation of resources, ensures that an airport can meet the demand for air travel services. Capacity and demand are aligned as much as possible. Next to the infrastructural and operational constraints, also the environmental constraints must be considered. The increasing demand and the limited resources, due to the scarce availability of airport infrastructure and facilities, resulting in the necessity of efficient airport capacity management to avoid congestion, safety risks and delays. For congested airports, airports are slot coordinated as declared by the Ministry. The slot allocation process takes place twice a year; a winter season and a summer season. This applies to Schiphol, Rotterdam and Eindhoven (and Lelystad in the future). Maastricht and Groningen Eelde Airport are not slot coordinated. Currently, all airports have noise restrictions, which mean they have a limited number of aircraft movements due to noise.

3.3 Additional control mechanisms

In this chapter, the various types of additional control mechanisms are described.

3.3.1 Include CO_2 limit as environmental constraint in Capacity Declaration (Slot allocation process)

The control mechanism is to include the CO_2 limit as environmental constraint in the capacity declaration for every slot coordinated airport. The CO_2 limit could be described in a volume of CO_2 emissions rather than a calculation by the airport to translate a CO_2 limit into an amount of aircraft movements, as is done for the noise constraints. In this way, the slot coordinator must include CO_2 as a limit for all flights within the season, but also calculate the CO_2 emissions for every individual flight. An extra constraint for the slot coordinator means that the allocation of all aircraft movements must comply with the CO_2 limit.

This mechanism guarantees that the CO_2 emissions will not exceed the CO_2-ceiling for slot coordinated airports. When a slot change is requested, the slot coordinator can immediately check whether the change has an impact of CO_2 emissions. The grip on the CO_2 emissions is very strong. However, there is no flexibility when monitoring and enforcement exceed the period of one year or one season.

Within the current EU Slot Regulation, there is no direct connection between a slot and a noise quota or CO_2 volume. This steering mechanism creates this relationship. From a legislative perspective, this steering mechanism must be explored further. For Schiphol, there are also parameters that relate to capacity parameters, like wide body and narrow body aircraft. When a slot change is requested, also these parameters must be considered. For integrating the CO_2 quota in an airport decree, it is necessary to change the national regulation.

There is little room for interaction between the airports, as the capacity is determined for every single airport. Next to this, if the CO_2-ceiling will be monitored and enforced on a 3-year basis, the CO_2 limit - mentioned in the capacity declaration – should include some margin on a yearly basis to spread out the CO_2 between seasons. Adding a margin for environmental constraints is not favourable according to the Ministry.

Effectiveness - This mechanism is very effective, because the slot coordinator will not allocate slots where the sum of all flights exceeds the CO_2 limit per airport. Only when airlines fly with different aircraft than their slot should be used for the CO_2 limit could be exceeded.

Efficiency - In the current allocation process and IT-system of the slot coordinator there is no functionality yet to accommodate the constraint for CO_2. Adjustment of the IT-system will cost investment and time. An adjustment like this will easily take one year and need testing. For the calculations of the CO_2 emissions, a model must be determined. This model must be simple, in order to have the factors in line with the format of the slot requests (type of aircraft (in IATA code), destination). Also, it is recommended that the model is based on an industry standard (e.g. Small Emitters Tool from Eurocontrol).

Equality - At the moment, each slot consists of a combination of aircraft type, destination and number of passengers. A destination can be changed without regard[1], a destination has no impact on the coordination parameters. Including CO_2 as environmental constraint implies a CO_2 volume per flight. Historical rights for slots now include an historical right for CO_2, which is not part of the Slot Regulation nowadays. These types of historical rights have been applied in the past for wide body stands and the number of passengers. From a legal perspective, this must be investigated further.

Enforceability - The slot coordinator is responsible for allocation the slots within all limits. They cannot allocate slots where a limit is exceeded. Additional enforceability is not necessary.

Support - There is no support from airlines and some support from airports for this mechanism as this mechanism is too strict. Steering on the CO_2 limit immediately means enforcement on the CO_2 limit and the flexibility is low when changing flights. This occurs when flights will be cancelled later in the season and some CO2 emissions will become available that could have been used earlier in the season.

Feasibility - For integrating the CO_2 quota in an airport decree, it is necessary to change the national regulation. From a legal perspective, this must be investigated further, which makes it uncertain regarding feasibility. And there is limited support for this mechanism. It is therefore understood that the feasibility is not so high.

3.3.2 Include CO_2 capacity when requesting aircraft movements (movement allocation limit)

This mechanism is the equivalent of the previous mechanism, but only for non-slot coordinated airports. Since aircraft movements do not have historical right and the movements are not requested at the same time as for slot coordinated airports, airports can take the CO_2 limit into account when facilitating the aircraft movements.

This mechanism is not as strict as the previous mechanism, and therefore it is possible to include the CO_2 limit over a period of longer than one year. But, when scarcity is expected for these non-slot coordinated airports, a capacity and demand assessment should be performed to determine whether an airport should be slot coordinated.

The previous two mechanisms contain a system, where it is possible for airports to steering during a season (or more seasons) and have grip on the aircraft movements and their CO_2 emissions. Both contain a monitoring aspect and to determine whether steering is necessary.

Effectivity - This system is very effective, because airports can determine during the season whether the CO_2 emissions will exceed the CO_2 limit or not. The airport can determine whether new aircraft movements are allowed within the limits. It is however possible to compensate between the different seasons and years for the total CO_2 emissions.

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[1] Except for new entrants, see European Commission (1993) article 8a

Efficiency - This system requires a tool to administer the CO_2 emissions. This can be simple document of spreadsheet. For the calculations of the CO_2 emissions, a model must be determined. This model could be a simple model, but it is recommended that the model is based on an industry standard (e.g. Small Emitters Tool from Eurocontrol).

Equality - As no historical rights exist for non-slot coordinated airports, this mechanism is equal for all airlines.

Enforceability - The airport can intervene during the season and no additional enforceability is necessary.

Support - There is moderate support from airlines and airports for this mechanism.

Feasibility - The feasibility of this mechanism is high, as there are no changes needed for the slot coordinator, nor for regulation.

3.3.3 Use of incentives

This steering mechanism contains the individual incentives, as described in the next chapter. The use of individual incentives will stimulate interventions for reducing CO_2 or discourage interventions that do not reduce CO_2. These incentives are facilitated and coordinated by airports. The next chapter describes all types of individual incentives. Within this chapter, the use of incentives - as a steering mechanism - will be assessed. It includes all types of incentives. This steering mechanism can be used in parallel to the first and second steering mechanism.

Effectivity - An incentive is a one-way mechanism, which does not compare the outcome with the results. It is up to the airlines whether they make use of incentives. The effectivity of the use of incentives is limited.

Efficiency - At the moment, there are already incentives in place (e.g., for SAF subsidy). No additional system or procedure must be implemented. However, almost all incentives require an administration for the use of incentives.

Equality - This is dependent on the factors that will be targeted by the incentive. In chapter 3.3.4, the assessment of incentives against equality is done.

Enforceability - This mechanism includes no enforceability. An additional procedure or article in the legislation needs to be implemented.

Support - There is support from airlines for the use of incentives, especially when using positive incentives. There is support from airports for this, especially when the incentives are positive.

Feasibility - The feasibility is this mechanism is high, because these incentives already exist and there is support from the aviation sector.

3.3.4 Assessment of criteria

The criteria assessment from the previous chapter is shown in Table 3 below.

Table 3 Assessment of steering mechanisms *(green is high, yellow is medium, orange is low)*

	Slot allocation process	Movement allocation limit	Use of incentives
Effectiveness	No exceedance of CO_2 limits	No exceedance of CO_2 limits	Little to moderate grip on CO_2. Literature suggests that discouraging interventions have higher effectivity
Efficiency	IT and process for slot coordination needs to be adjusted	A simple tool should be created to register CO_2	Currently, incentives in place. No new system needed.
Equality	Historical rights for an airport slot imply also CO_2 rights	Number of aircraft movement could be reduced.	Use of incentives are equal for all airlines.
Enforceability	Easy to enforce, depends on monitoring and enforcement period	Easy to enforce	This mechanism contains no means to enforce
Support	Slot allocation is too strict (airlines)	Moderate support	Only with stimulation incentives. But also depends on the type of incentive, where one airline benefits more than another.
Feasibility	Requires legislative investigation	Only small changes are needed, less strict than slot allocation process	Incentives already exist

3.4 Conclusion

During the study, three steering mechanisms have been identified. For slot coordinated airports, the CO_2 limit can be included in the capacity declaration. While this mechanism is very effective, it is not very efficient and there is very limited support from the sector parties for this mechanism, because it is seen as too strict in comparison with the other steering mechanisms. For non-slot coordinated airports, a movement allocation limit can be applied. This mechanism is also very effective, and the effort needed to implement this mechanism is minimal. There is moderate support for this mechanism.

Next to the first and second mechanism, there is a third mechanism that can be applied in combination with the first ones. The use of incentives has limited effectivity, but it is positive for efficiency and equality. This mechanism needs an enforcement procedure when only this mechanism is put in place. There is support from the sector parties, as long as this is a positive incentive.

In the comparison between the control mechanisms, the legislative aspect was not taken into account, and should be investigated further.

4 Individual incentives

The second weakness of the CO_2-ceiling per airport is the low pressure for airlines to invest in CO_2 reduction strategies by themselves. A classis game theory scenario, the prisoner's dilemma, arises. In this dilemma, multiple rational players may choose actions that benefit themselves individually but this leads to a suboptimal outcome for both when considered together. In the context of carbon emissions and the aviation industry, this means airlines might hesitate to reduce emissions voluntarily, fearing that their competitors will not do the same, giving them a competitive advantage. A way to overcome the prisoners' dilemma between airlines and to collectively reduce carbon emissions within the aviation industry, is to provide individual incentives for the airlines, which may result in investing in CO_2 reduction strategies.

An incentive consist of two elements, namely a policy tool and the targeted factor the policy tool intends to influence. The policy tool is described as the way to stimulate desired behaviour, the targeted factor is described as the behaviour that is desired.

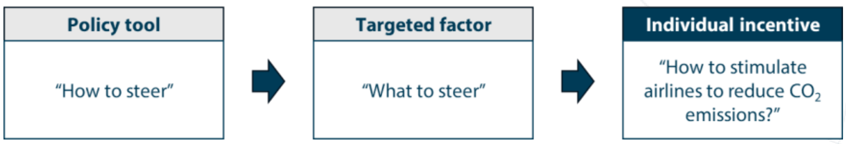

Figure 2 An individual incentive consists of a policy tool and a targeted factor

This chapter describes how the long list of incentives has been established, including policy tools and targeted factors, and how this has been reduced to a short list of individual incentives.

4.1 Long list of individual incentives

Policy tools

The policy tool consists of three elements: the category, the initiator and the approach. The policy tool can be financial, regulating or a service. Financial policy tools aim to motivate airlines with a financial reward or punishment, regulating policy tools aim to achieve CO_2-reduction by setting a norm and service policy tools aim to motivate airlines by offering a service benefit or constraint. These policy tools can be initiated and implemented by either the airport, government or slot coordinator, and the approach may be encouraging or discouraging. Combinations of these three elements result in potential policy tools as displayed in table 3.

Table 4 Potential policy tools

Category	Initiator	Encourage	Discourage
Financial	Airport	Discount on airport charges	Surtax on airport charges
	Government	*Subsidy*	*Flight tax*
Regulating	Government	*Mandate*	Ban
Service	*Airport*	*Benefit*	*Constraint*
	Slot coordinator	*High priority*	*Low priority*

Targeted factors

The targeted factors are identified during workshops with aviation experts. The long list of targeted factors can be found in the Appendix A, including the reason why (not) to include these targeted factors. The targeted factors that will be further explored are aircraft type, flight distance, engine type and use of SAF. These are targeted factors that are within the influence of the airlines and are available in the future. Aircraft type and engine type will be considered as one targeted factor, called *fuel efficient aircraft*. Table 4 shows the influence of the targeted factors on the CO_2 emissions.

Table 5 Targeted factors that influence the CO_2 emissions

<table>
<tr><th>Targeted factor</th><th>Influence on CO_2 emissions</th><th></th></tr>
<tr><td>Aircraft type</td><td>The design and efficiency of the aircraft play a significant role in determining CO_2 emissions. Newer aircraft models are generally more fuel-efficient and produce fewer emissions compared to older ones.</td><td rowspan="2">Fuel efficiency of aircraft</td></tr>
<tr><td>Engine type</td><td>Newer engine types are usually more fuel efficient than older ones. When newer engines are installed on a relatively old aircraft, this could make a large difference. This also includes new propulsion types, such as electric and hydrogen aircraft.</td></tr>
<tr><td>Flight distance</td><td>Longer flights generally result in higher CO_2 emissions due to the increased fuel consumption required to cover the distance.</td><td></td></tr>
<tr><td>Use of SAF</td><td>The proportion of sustainable aviation fuels used in an aircraft's fuel blend can significantly impact its carbon footprint. SAFs have the potential to reduce CO_2 emissions compared to conventional fossil-based jet fuels.</td><td></td></tr>
</table>

Individual incentives

The combinations of the policy tools and targeted factors result in a long list of potential individual incentives. Every policy tool may be applicable to every targeted factor, resulting in 10 x 4 individual incentives. However, a large share of the incentives has not been selected for further research for several reasons. This selection has been performed based on expert judgement and is arbitrary, but it must be emphasized that the short list is not exclusive:

- <u>Government subsidies:</u> Financial stimulation is an effective policy tool for reducing CO_2 emissions and is supported by stakeholders. However, a government subsidy is considered to be an inefficient policy tool for achieving CO_2 reduction, because the costs are high. Therefore, preference is given to financial stimulation by airports, instead of by governments. This financial stimulation by airports can be combined with a surtax for undesired behaviour, resulting in a zero-sum game and no additional costs for airports.
- <u>Government flight taxes:</u> A government flight tax is a price incentive, aimed at increasing the flight ticket price and reducing demand for certain flights, fuels or aircraft types. Due to the negative character, where airlines are penalized for undesired behaviour and not rewarded for desired behaviour, this policy tool has low support from the sector. However, a price incentive has proven to be effective, so it is recommended to implement this mechanism, but operated by the airport and including rewards for desired behaviour. This can be done via tariff differentiation in airport charges.

- Government mandates: This is often difficult, due to legal constraints. A national mandate on SAF is not allowed within the ReFuelEU regulations, and for mandating short-haul flights, a procedure by the European Commission must be followed. A mandate on fuel-efficient aircraft types would be possible, but a ban fuel-inefficient aircraft is chosen because it is in line with proposed measures to reduce noise around airports.
- Service benefit by the airport: These are not considered to be viable by airports and airlines, because not all airports can offer equal service benefits and constraints. An example of a service benefit is preferred gate allocation. Having priority access to specific gates allows airlines to plan their flight schedules more effectively, reducing the time that aircraft spend on the ground. However, most airports only have remote stands. In addition, the reduced amount of CO_2 cannot be expressed in a service benefit. An airline will have a service benefit or not, while there may be great variations in the amount of reduced CO_2 by airlines.
- Service benefit by the slot coordinator: It can be a benefit for airlines when flying fuel efficient aircraft is an additional slot allocation criterion, which gives this slot request priority over other slot requests. This will only occur if there are slots left after allocating the historical slots and if this additional slot allocation criterion is the only additional slot allocation. Now, slots will be given priority using six additional slot allocation criteria. So, the effectivity of this service benefit is very low and not be analysed further in this study.
- Incentives aimed at discouraging long distance flights: This can be an effective policy tool to reduce CO_2 emissions but it comes with significant side-effects, such as job losses in de aviation industry and loss of connectivity. On top of that, it will likely result in a shift of passengers to foreign airports, so CO_2 emissions are rather displaced than reduced. Finally, the support from the sector is very low, due to the large impact on the business models and strategies of the base carriers, resulting in a disruption of the level playing field.
- Incentives aimed at encouraging short distance flights: At the same time, encouraging short distance flights will be in conflict with the ambition to select the most sustainable travel mode for every route. At short distances, there are more sustainable alternatives, such as the high-speed train.

Table 6 Overview of remaining individual incentives

Initiator	Encourage	Discourage
Airport	Discount on airport charges • Fuel efficient aircraft • SAF	Surtax on airport charges • Fuel efficient aircraft
Government		Ban • Fuel inefficient aircraft

4.2 Short list

The individual incentives that have been selected for further evaluation are:

- Encouraging fuel-efficient aircraft types via airport charges;
- SAF incentive fund; and
- Banning aircraft types based on environmental performance.

For each of these individual incentives, the following paragraphs describe the mechanism of how the incentive will lead to less CO_2 emissions, the strategy of implementing the incentive, advantages and disadvantages.

4.2.1 Encouraging fuel-efficient aircraft via airport charges

The deployment of fuel-efficient aircraft types by the airlines has several benefits in comparison with the use of more fuel-consuming aircraft types. The fuel-efficient aircraft are generally the more modern aircraft types with new engine types. Generally, more modern aircraft types go paired with a wide range of technological advancements. They often incorporate the latest technological innovations, aerodynamics improvements and engineering advancements, which can lead to improvements in fuel efficiency. The same goes for engine types. As the aircraft technologies evolve, modern aircraft types can outperform and replace older, less efficient models. In terms of environmental considerations, the designs of modern aircraft types focus on fuel efficiency and emissions reduction, which could help the airlines to meet environmental regulations and lowers their overall CO_2 production. Besides the benefits in fuel use, modern aircraft also require less maintenance in comparison with older models. These benefits can result in long-term cost savings for airlines, as the operations become more economically sustainable as well.

Airport charges can play a significant role in steering airlines towards the replacement of their fuel-inefficient aircraft with new, more fuel-efficient and environmentally friendly aircraft. Airports can provide airlines that operate cleaner aircraft with discounts on the landing fees. This strategy, based on discounted charges for airlines operating more fuel-efficient aircraft, can be implemented as follows:

1. <u>Define criteria for eligibility:</u> The airport must define criteria for aircraft to be considered as 'fuel-efficient' or 'fuel-consuming'. For this, it is wishful to use internationally accepted standards. Therefore, it is recommended to use the ICAO Aircraft Engine Emissions Databank, which is based on the ICAO Annex 16, volume 2 about aircraft engine emissions. Using the Emissions Databank, the airport may categorize aircraft types, ranging from very fuel-efficient to very fuel inefficient. Within these categories, there should also be a place for zero-emission aircraft, such as hydrogen and electric aircraft. These aircraft technologies are still in development but are expected to fly by the time the CO_2-ceiling is implemented.
2. <u>Determine airport charges:</u> Different airport charges based on the airlines' compliance with eligibility criteria should be established: airlines with the most fuel-efficient aircraft could pay lower airport charges than those with fuel-consuming aircraft. To realize a zero-sum game, the airport may choose to combine a discount for fuel-efficient aircraft with a charge for fuel-consuming aircraft. With this 'polluter pays principle', the fuel-consuming aircraft will contribute to the discount for fuel-efficient aircraft.

3. Formalize agreements: Formal agreements between the airport and the airlines that outline the terms of the discounted charges program should be created. The agreement should specify the airport charges, the duration of the program, and any other relevant conditions.
4. Communicate the benefits: The benefits of the discount program (potential cost savings, improved brand image, and enhanced competitiveness) should be highlighted to airlines. Airlines need to take advantage of the incentives to upgrade their fleet and contribute to sustainability efforts.
5. Review and update: The airport charges should be periodically evaluated to assess its effectiveness and make any necessary adjustments. This could involve revising the eligibility criteria, adjusting airport charges, or extending the duration of the program based on the progress made in fleet modernization and environmental goals.

Differentiating airport charges based on environmental performance of aircraft offers several benefits.

1. Polluter pays principle: When lower airport charges for fuel-efficient aircraft are combined with higher charges for fuel-inefficient aircraft, this means that the polluter pays for the benefit of airlines that operate with fuel-efficient aircraft. The airport should establish the airport charges in such a way that there is a balance between fuel-efficient aircraft and fuel-inefficient aircraft, resulting in a zero-sum game.
2. No financial burden on airports in case of a zero-sum game: When the airport establishes airport charges based on a zero-sum game, this means that the airport is not required to subsidize fuel-efficient aircraft from own financial sources. This makes the incentive highly efficient for airports.
3. Avoids strategic behaviour from foreign airlines: It prevents against strategic behaviour from these foreign airlines. When there is no incentive to use more fuel-efficient aircraft to Dutch airports, but there is a CO_2-ceiling, foreign airlines would have a competitive reason to use their most polluting aircraft at Dutch airports, because this will mean that the CO_2 budget is used up more quickly. The airlines most affected by this are the home carriers. Stimulates foreign airlines to use their most fuel-efficient aircraft at Dutch airports will benefit the Dutch airports, and therefore helps the airports to stay within their CO_2-budget. Therefore, encouraging efficient aircraft types is considered highly effective to reduce CO_2 emissions.
4. In line with noise reduction strategies: Differentiation in airport charges for noisy aircraft is a common practice at airports. Aircraft that produce high noise levels face higher airport charges than silent aircraft. Therefore, airports are familiar with differentiation in airport charges. On top of that, the noise levels of aircraft are usually related to the aircraft generation. Typically, older aircraft make more noise. At the same time, these are also the types of aircraft that generally produce more CO_2.

Despite its intended benefits, the implementation of this strategy could also have some potential disadvantages and challenges.

1. Uneven playing field: Fleet renewal is usually connected to bigger and newer airlines, whereas smaller or older airlines might not afford to update their fleets. The discounts could therefore result in potential market distortions and reduced competition.

2. Displacement of CO_2 emissions: Airlines with a diverse fleet may choose to use their newer aircraft at Dutch airports and older aircraft at airports that do not have such charges. In this case, CO_2 emissions will be moved instead of reduced. This will be beneficial for the Dutch climate goals but will not help solve the global climate problem.
3. Additional emission of nitrogen: New aircraft typically emit more nitrogen. This local problem is of big relevance in the Netherlands.

4.2.2 SAF incentive fund

SAF is a critical component in the decarbonization of the aviation industry due to its potential to significantly reduce greenhouse gas emissions. Conventional jet fuels are derived from fossil fuels and contribute to the industry's carbon footprint. SAF, on the other hand, is produced from renewable or sustainable feedstocks, such as agricultural residues, waste oils, or algae, resulting in considerably fewer CO_2 emissions over the full lifecycle. Depending on the feedstock, SAF offers CO_2 reductions between 60 and 80 percent, which can increase to up to 99% with new technologies. The biggest advantage of SAF is that it enables airlines to mitigate their environmental impact without requiring significant modifications to existing aircraft or infrastructure. This drop-in capability makes SAF a viable and scalable solution to reduce CO_2 emissions.

Airports can stimulate the consumption of SAF by airlines through different methods. Of these methods, financial support has been proven successful at other airports, such as Schiphol Airport, London Heathrow and Swedish airports. Stimulating SAF via operational benefits is considered to be less viable, because the operational benefits cannot be adjusted according to the environmental benefit. For example, if airlines receive priority gate allocation when they fly on SAF, this benefit is the same for an airline that flies on 2% SAF as for an airline that has 40% of SAF in its tanks. Mandating SAF on a national level is not viable, because it will conflict with the upcoming Refuel EU regulations.

SAF is currently more expensive than conventional jet fuel due to limited production volumes and absence of economies of scale. The price difference makes it a financially less attractive option for airlines, especially in an industry with narrow profit margins. To stimulate airlines, airports can set up an incentive fund. This is a financial mechanism designed to encourage and support the adoption of SAF by airlines. The fund provides financial incentives to airlines to help offset the higher cost of SAF compared to conventional jet fuels, making it more economically viable for carriers to use sustainable alternatives. A SAF incentive fund typically works as visualized in figure 3.

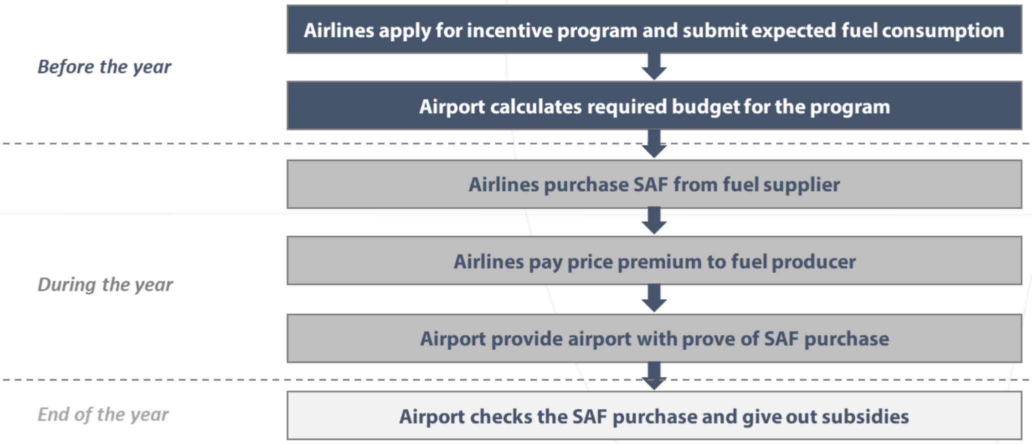

Figure 3 SAF incentive fund

A SAF incentive fund offers several benefits for both airlines and airports:

1. Acceleration of SAF adoption: The financial incentives from the fund encourage airlines to use SAF, leading to faster adoption and increased demand for sustainable fuels. This will encourage SAF producers to invest in production capacity and cost reduction measures, eventually leading to lower prices for SAF.
2. Alignment with airline strategies: The SAF incentive fund gives airlines the opportunity to make their operation more sustainable for a share of the related costs. Therefore, incentive funds are sometimes incorporated in the sustainable strategies of airlines, who will start uplifting SAF first on airports with an incentive fund. For these airports, this is beneficial, because it will reduce their emissions.

While a SAF incentive fund for airlines can be an effective policy tool to promote the adoption of sustainable fuels, there are some concerns and challenges that need to be considered. These concerns include:

1. Potential legal complications: In the first stage of the upcoming Refuel EU regulations, which will be implemented on January 1st, 2025, fuel producers are required to have an average blend of at least 6% SAF supplied over all EU airports in 2030. Governments are not allowed to top up this mandate, but according to EU Guidelines on State Aid to Airports and Airlines, they are also not allowed to incentivize additional uplift. It is unclear whether airports are also limited by European regulations and if they may stimulate additional uplift above the mandate. It is also unclear what is allowed for airports that are (partly) state-owned.
2. Financial sustainability: The long-term financial sustainability of the incentive fund is a concern. The fund relies on financial resources, and if funding sources are not stable or sufficient, it may be challenging to sustain the incentives over time.
3. Budget limitations: Limited funding availability may restrict the number of airlines that can benefit from the incentives.

4. Long-term commitment: The effectiveness of the fund depends on sustained commitment from governments, industry stakeholders, and funding sources. A lack of long-term commitment may result in reduced incentives or even discontinuation of the fund, affecting airlines' SAF investment plans.
5. Potential market distortion: If the fund provides significant financial incentives, it may distort market dynamics, leading to over-reliance on incentives rather than genuine market demand for SAF.
6. Project scalability: The fund's ability to scale up to meet increasing SAF demand is essential as the industry strives to achieve larger emission reduction targets in the future.
7. SAF availability: An airport ideally offers the physical SAF. When this is not the case, a book-and-claim system can be the solution, but it must be noted that this may prevent the airport from investing in SAF infrastructure in the near future. .

To address these concerns, a well-designed SAF incentive fund should have clear and transparent criteria for eligibility, robust monitoring and verification mechanisms, long-term funding commitments, and effective collaboration between industry stakeholders. Balancing financial support with market-driven demand and carefully addressing potential challenges can maximize the fund's positive impact on SAF adoption and emissions reduction in the aviation industry.

4.2.3 Banning aircraft based on environmental performance

As described in detail in section 4.2.1, more fuel-efficient aircraft offer several operational and environmental benefits in comparison with less fuel-efficient aircraft models. Instead of encouraging airlines to use their most-efficient aircraft at Dutch airports, governments could impose a ban on fuel-inefficient aircraft. This is standard-setting measure is in line with the CO_2-ceiling, which also creates a norm that sector parties must meet.

The ban on fuel-inefficient aircraft types can be implemented as follows:

1. Determine emission standards: To establish a ban on fuel-inefficient aircraft, specific criteria that determine when an aircraft is considered "inefficient" or unfit for continued operation must be defined. For this, it is recommended to align with internationally accepted standards, such as the ICAO Annex 16, volume 3. This ICAO document describes standards for aircraft CO_2 emissions. Based on these standards, aircraft types that do not meet the requirements could be banned.
2. Determine a reduction path: The ban could be implemented in the same way as the CO_2-ceiling, which means a gradually decreasing limit, requiring airlines to operate with increasingly fuel-efficient aircraft over time.
3. Communicate the reduction path: It is important to clearly communicate the reduction path far in advance, so airlines and aircraft manufacturers have time to anticipate on the regulations.

There are several reasons to choose for a ban over a subsidy:

1. Effectivity: According to Vollenbergh en Rozendaal (2022), a ban is more effective than a subsidy. They state that organisations are more pushed towards innovation when there is a strict norm than when there is a subsidy. This can be concluded from developments in the automotive

industry. Apparently, an ambitious norm required companies to innovate to meet the norm, while there was only a small change in behaviour visible in case of a subsidy.

2. Efficiency: A norm is free of costs for the regulating party. This is in contrast with subsidies, since the government or airport will financially support the industry. Therefore, the efficiency of a norm is higher.

However, a ban on fuel-inefficient aircraft also entails potential challenges:

1. Responsiveness of manufacturers: The idea is that airlines are forced to operate with more fuel-efficient aircraft. Aircraft manufacturers are supposed to respond to this need from airlines and produce more fuel-efficient aircraft. Developments in the automotive industry have shown that this strategy is effective. When certain types of cars were not allowed in city centres anymore, it became unattractive to purchase these cars and therefore it became unattractive to produce these cars. However, the level of competition in the automotive industry is larger than in the aviation industry, because there are more car producers than aircraft manufacturers. Therefore, it is not sure how the aircraft producers will respond, especially when this ban is only implemented at Dutch airports and not at other airports.
2. Not within control of airlines: Current delivery times of aircraft are very long, as well as waiting lists. Even if airlines would want to renew the fleet as soon as possible, it might take years before the new aircraft arrive. Therefore, renewing the fleet is not always in the control of the airline.
3. Financial burden on airlines: Less fuel-efficient planes may still be functional and economically viable for some airlines, and the cost of replacing them with newer models can be substantial. When airlines are forced to retire older aircraft prematurely, this may result in a financial burden on airlines.
4. Displacement of CO_2 emissions: There is the risk that aircraft will be sold to airlines in other parts of the world, resulting in a displacement of CO_2 emissions instead of a reduction. In case the aircraft is taken out of service, it is the question whether this is sustainable, because the materials from the aircraft might not serve their full lifespan.
5. Legal concerns: It is not clear whether airports or governments have the authority to ban certain aircraft types based on CO_2 emission levels. When airports of governments want to take measures to reduce noise, the Balanced Approach procedure must be conducted. This is a procedure that includes consultation with stakeholders and approval by the European Commission. Since there is no procedure yet for CO_2 reduction, further investigation - in consultation with the European Commission - is needed for airports or governments to ban certain aircraft types.

4.3 Conclusion

All the incentives have their specific benefits and concerns. A SAF incentive fund has been proven to be effective at other airports, as it shows that airlines are uplifting more SAF due to the incentive fund. Therefore, this incentive fund is considered to be highly impactful, since SAF has the potential to reduce more emissions than for example fleet renewal. However, there might be legal complications regarding the upcoming ReFuelEU regulations.

Differentiation in airport charges based on environmental performance of aircraft is considered to be a feasible incentive, since it is already practiced for other reasons, such as noise and capacity. On top of that, it is considered to be easy to implement by airports, because it does not impact the finances. Moreover, it is perceived as a fair solution, since the polluters pay more, and the sustainable airlines pay less. And finally, it avoids strategic behavior from foreign airlines. Nevertheless, there are concerns about the level playing field, the displacement of CO_2 emissions and additional nitrogen.

An alternative to differentiation in airport charges is banning aircraft based on environmental performance. This is an example of the stick instead of the carrot. Compared to differentiation in airport charges, a ban is considered to be more effective and more efficient. Nonetheless, it brings several concerns, including the level of control by airlines, responsiveness of manufacturers and the legal feasibility.

To conclude, of the three incentives that have been further explored, two of the incentives are considered to be highly effective but face legal concerns. These legal concerns should be examined further. This is the case for the SAF incentive fund and the ban of aircraft types based on environmental performance. The other incentive, the differentiation in airport charges based on environmental performance, is less effective, but is easy to implement and it is therefore recommended.

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A Appendix A – Targeted factors that influence CO_2 emissions

To steer on CO_2 emissions, it is necessary to know to steer on which factors. During the workshops with aviation experts, numerous targeted factors that influence the levels of CO_2 emissions have been identified. These were assessed on effectiveness for CO_2 reductions and whether and airlines can control that factor.

Targeted factor	Description	Include/exclude in study
Aircraft type	The design and efficiency of the aircraft play a significant role in determining CO_2 emissions. Newer aircraft models are generally more fuel-efficient and produce fewer emissions compared to older ones.	Include
Engine type	Newer engine types are usually more fuel efficient than older ones. This also includes new propulsion types, such as electric and hydrogen aircraft.	Include
Flight distance	Longer flights generally result in higher CO_2 emissions due to the increased fuel consumption required to cover the distance.	Include
Payload	The payload includes the weight of the passengers, cargo and fuel on the flight and therefore impacts fuel consumption and CO_2 emissions. The higher the payload of the aircraft, the more fuel is consumed, and the more CO_2 is emitted.	Exclude, the effectivity of the payload is low compared to the weight of the aircraft.
Flight altitude and speed	Flying at higher altitudes can be more fuel-efficient, as it reduces air resistance and allows the aircraft to operate at optimal efficiency. However, flying at high altitudes also leads to the release of other greenhouse gases, such as nitrogen oxides (NOx), which can have a complex impact on the overall climate.	Exclude, airline is not in control
Weather conditions	Wind patterns, temperature, and other weather factors can influence flight efficiency and fuel consumption. Tailwinds can reduce fuel consumption, while headwinds can increase it.	Exclude, airline is not in control
Direct routes	Efficient air traffic control and management systems can help optimize flight paths, reducing the time spent in the air and consequently lowering fuel consumption and CO_2 emissions.	Exclude, airline is not in control
Use of sustainable aviation fuels (SAFs)	The proportion of sustainable aviation fuels used in an aircraft's fuel blend can significantly impact its carbon footprint. SAFs have the potential to reduce	Include

Targeted factor	Description	Include/exclude in study
	CO_2 emissions compared to conventional fossil-based jet fuels.	
Ground operations	CO_2 emissions are not limited to the flight itself; ground operations such as taxiing, boarding, and auxiliary power unit (APU) usage also contribute to the overall emissions	Exclude, airline is not in control
Airline operational practices	Airlines can implement various operational practices, such as single-engine taxiing, optimized climb and descent profiles, avoid tankering and efficient ground handling, to reduce their carbon footprint.	Exclude, effectivity is low compared to the entire flight

B Appendix B – Long list of individual incentives for airports

Initiator	Individual incentive	Reason for go/no go
Airport	**Discount on airport charges for the use of SAF (SAF incentive fund)**	• **Acceleration of SAF adoption.** • **Alignment with airline strategies.**
	Discount on airport charges for short distance departing flights	• For short distances, there are more sustainable alternatives, such as the high speed train.
	Discount on airport charges for fuel efficient aircraft types	• **Considered as fair by sector stakeholders.** • **No financial burden on airports in case of zero-sum game.** • **Avoids strategic behaviour from foreign airlines.** • **In line with noise reduction strategies at airports.**
	Surtax on airport charges for aircraft not using SAF	• Inappropriate, since SAF is not (sufficiently) available at every airport.
	Surtax on airport charges for long distance departing flights	• Discouraging long distance flights will reduce the emitted CO_2, but it brings side-effects that are considered to be too significant.
	Surtax on airport charges for fuel inefficient aircraft types	• **Will be combined with a discount on airport charges for fuel efficient aircraft types.**
	Service benefit	• Not all airports are able to offer service benefits • The amount of reduced CO2 cannot be expressed in a service benefit.
	Service constraint	• Not all airports are able to offer service constraints. • The amount of reduced CO2 cannot be expressed in a service benefit.
Government	Subsidy for the use of SAF (SAF incentive fund)	• Government subsidies are considered to be an inefficient policy tool for achieving a certain goal. • Effectivity of a ban or mandate is higher. • Will be considered as state aid.
	Subsidy for short distance departing flights	• For short distances, there are more sustainable alternatives, such as the high speed train.
	Subsidy for fuel efficient aircraft types	• Government subsidies are considered to be an inefficient policy tool for achieving a certain goal. • Effectivity of a ban or mandate is higher.

Initiator	Individual incentive	Reason for go/no go
	Flight tax for long distance departing flights	• Discouraging long distance flights will reduce the emitted CO_2, but it brings side-effects that are considered to be too significant. • Low support from sector.
	Flight tax for fuel inefficient aircraft types	• Low support from sector. • Tariff differentiation in airport charges considered to be a more suitable alternative.
Government	Mandate the use of SAF	• Already included in the ReFuelEU. • National top-up is not allowed.
	Mandate short distance departing flights	• For short distances, there are more sustainable alternatives, such as the high speed train.
	Mandate fuel efficient aircraft types	• Legally difficult. • Preference for a ban on inefficient aircraft types.
	Ban of long distance departing flights	• Discouraging long distance flights will reduce the emitted CO_2, but it brings side-effects that are considered to be too significant. • Discouraging long distance flights is in conflict with Dutch policy about connectivity.
	Ban of fuel inefficient aircraft types	• **Higher effectivity than a subsidy.** • **Higher efficiency than a subsidy.**
Slot coordinator	High priority is slot allocation process	• Low effectivity
	Low priority in slot allocation process	• Low effectivity