Exploration of Aviation Climate Targets

Comparison of emission reduction targets and assessment of legal safeguards

CE Delft

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This report was prepared by:
Stefan Grebe, Merit Heijink, Christiaan Meijer, Jolien Meulenpas and Maarten de Vries

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Further information on this study can be obtained from the contact person Maarten de Vries (CE Delft)

Content

Summary

In 2020, the Ministry of Infrastructure and Water Management (I&W) has published the Aviation Policy Memorandum 'Verantwoord vliegen naar 2050 – Luchtvaartnota 2020-2050', which includes Dutch emission reduction targets for aviation. There are several pathways possible to safeguard these targets. One possibility, the introduction of a so-called 'CO_2-ceiling' for Dutch airports, has been extensively explored before. Another possibility, the inclusion of aviation into the Dutch Climate Law, was not investigated before and is the main focus of this study.

We have distinguished **several policy options for including the Dutch emission reduction targets for aviation into the Dutch Climate Law:**

1. Include aviation into the existing 2050 climate neutrality target of the Climate Law.
2. Create a distinct emission reduction target for aviation for 2050, where:
   a This target corresponds to the 2050 Aviation Policy Memorandum target.
   b This target is lower than the 2050 Aviation Policy Memorandum target, but not zero, or;
   c This target corresponds to climate neutrality for aviation (net-zero).

Inclusion of aviation in Climate Law should be complemented by mitigating measures

While the CO_2-ceiling approach does provide a mechanism for achieving the targets of the Aviation Policy Memorandum, by imposing emission ceilings to all Dutch airports, such a mechanism is lacking in all options that just enshrine these targets into law. From this, we conclude that **including the emission reduction targets for aviation into the Climate Law in itself is not sufficient to safeguard these targets, but should be complemented by other instruments to mitigate emissions**. Still, compared to the current situation where the targets are not legally enshrined, including them in the Climate Law offers the advantage that aviation would become an integral part of the climate policy cycle and hence would play a larger role in climate policy than is currently the case.

Especially with respect to aviation, with its increasing emissions and lack of options to realise carbon removals in-sector, **it is essential that policy instruments are in place that manage the still available carbon budgets and allocate scarce resources** across sectors (aviation and domestic sectors like industry, housing, mobility, agriculture), including resources related to carbon removal potential.

Consequences, opportunities and risks of the policy options

Overall, policy option 2a would provide the advantage of aviation being included in the climate policy cycle, while avoiding disadvantageous impacts on domestic sectors as well as complexities related to the accounting of carbon removals and uncertainties around their potential and costs.

In **policy option 1**, the climate neutrality target of the Climate Law applies to all sectors (aviation as well as the domestic sectors) together. The target also does not prescribe what level of residual emissions is still allowed and, as a consequence, how much carbon removals would be needed to achieve climate neutrality. In this option, the targets from the Aviation Policy Memorandum may be kept as well, but without being legally enshrined.

The main advantage of this option would be that all sectors are being treated equally. Also, this option would probably be the most acceptable to third countries, as it would not directly impact the number of flights. In contrast to other sectors, aviation emissions have increased significantly over the last decades, reaching a share of 8.1% of all CO_2 emissions in the Netherlands in 2023. The main risk of this policy option is therefore that it does not enough to curb the aviation emissions trend, other sectors have to reduce even more to achieve climate neutrality, and/or more carbon removals have to be realised. The latter bears a risk in itself, as technologies for (permanent) carbon removals are still under development and it is not clear what volumes of carbon removals will be available and at what price.

In **policy option 2**, a specific target for aviation is included in the Dutch Climate Law, next to the existing climate neutrality target. This can either be an in-sector reduction target equal to or lower than the 2050 target from the Aviation Policy Memorandum (2a and 2b) or a climate neutrality target just for the Dutch aviation sector (2c).

Policy option 2 has the advantage that it separates aviation from other, domestic sectors, which renders it more in line with UN practices. Policy option 2a in particular provides the opportunity to explicitly enshrine the reduction targets from the Aviation Policy Memorandum into law.

As this policy option involves a separate emission reduction target for Dutch aviation, especially options 2a and b will probably not attract much support from third countries as it may lead to a reduction in the number of flights, and the risk of countermeasures is relatively high here. At the same time, domestic stakeholders will probably oppose these policy options for another reason. For them, it may be hard to digest that aviation would still get room to have significant positive emissions in 2050, while domestic sectors have already decreased their emissions for decades and are subject to a variety of other policy instruments to decrease them even further. In policy option 2c, it would be allowed for the aviation sector to compensate residual emissions by purchasing carbon removal credits. However, for this a regulatory framework would need to be developed first.

LTAG and the Dutch emission reduction targets for aviation

In 2022, ICAO adopted its Long-Term Aspirational Goal (LTAG), involving a global net-zero carbon emissions target for international aviation by 2050 in support of the UNFCCC Paris Agreement's temperature goal. To put the Dutch emission reduction targets for aviation in the context of the international mitigation efforts in aviation, we assessed what the LTAG implies for the Dutch aviation sector. The LTAG does not involve national targets, so we used three scenarios on the deployment of various mitigation measures, as well as assumptions on the share of global aviation emissions to be allocated to the Netherlands, to arrive at a useful comparison of LTAG and the Dutch emission reduction targets for aviation. We conclude that the targets from the Aviation Policy Memorandum are largely comparable to the most ambitious scenario used. However, until 2050 the cumulative emissions that comply with the targets of the Aviation Policy Memorandum (281 Mt CO_2) are still 16% higher than the 243 Mt CO_2 allowed for in this scenario.

1 Introduction

1.1 Purpose and research questions

In 2020, the Ministry of Infrastructure and Water Management (I&W) has published the Aviation Policy Memorandum 'Verantwoord vliegen naar 2050 – Luchtvaartnota 2020-2050' (Ministerie van I&W, 2020). In this Memorandum, the emission reduction targets for the Dutch aviation sector, as formulated in the Sustainable Aviation Agreement (Duurzame Luchtvaarttafel, 2020), are being endorsed. These targets involve that the CO_2 emissions from flights departing from the Netherlands will be equal to 2005 levels by 2030, will be equal to half of 2005 levels by 2050, and will reach zero by 2070. Emission reductions need to be achieved in-sector, no compensation by reductions in other sectors or by carbon removals is allowed.

In 2022, the 41st ICAO Assembly adopted the so-called 'Long-Term Aspirational Goal' (LTAG) for international aviation. LTAG sets a global net-zero carbon emissions target for international aviation by 2050 in support of the UNFCCC Paris Agreement's temperature goal (ICAO, 2022b). Since it is currently not clear how the Dutch emission reduction targets for aviation exactly relate to the LTAG, this is the first research question we assess in this report.

There are several pathways to safeguard the Dutch emission reduction targets for aviation by including them into national legislation. The first one is to work through a legal standard for CO_2 emissions for the Dutch aviation sector. In the selected approach, a cap for CO_2 emissions is being imposed on each of the Dutch airports. This option has been investigated thoroughly in several reports on the so-called 'CO_2-ceiling' for Dutch airports (CE Delft, 2022a), (CE Delft, 2022b) and various legal assessments have been carried out. No political decisions have been taken on this approach so far.

Another key option is to integrate the emission reduction targets for aviation into the existing Dutch Climate Law. This option was not explored in detail before, which was the main reason for the Ministry of I&W to commission this study. Therefore, the second research question that is assessed in this report is on what alternative options for safeguarding the emission reduction targets for aviation, as established in the Aviation Policy Memorandum, are conceivable, with particular attention to the option of including these targets into the Climate Law and its implications. We also briefly explore whether there are still other ways of safeguarding the aviation targets, but these options are not assessed in detail.

1.2 Scope and approach

The first part of this study looks into the LTAG for international aviation. It should be noted that the LTAG does not attribute specific obligations or commitments in the form of emission reduction goals to individual states. Rather, states can establish by themselves how they will contribute to the LTAG in a way that suits their own circumstances (ICAO, ongoing-a). Therefore, to be able to compare LTAG with the Dutch national aviation targets, some kind of translation of LTAG to the Dutch aviation sector has to be performed. To do so, we make some explicit assumptions and deploy three different scenarios.

This enables us to provide a good impression of what the implications of LTAG for Dutch aviation may be, but of course it also means other assumptions and scenarios, which would lead to other outcomes, are excluded from the analysis.

For the second research question, on alternative options to safeguard the Dutch emission reduction targets for aviation, a policy analysis is carried out. The focus is on a discussion of the consequences, opportunities and risks of integrating the aviation sector into the Dutch Climate Law. A legal assessment is not part of this study. The options other than integration into the Climate Law are only discussed briefly, without dedicated sections on consequences, opportunities and risks.

The emissions reported in this study cover the departing flights from the Netherlands. Not considered are the emissions related to the Caribbean territories of the Kingdom of the Netherlands (Aruba, Curaçao, Sint Maarten, Bonaire, Sint Eustatius, Saba). In addition, this report focusses on the CO_2 emissions from aviation, although it is known that the non-CO_2 emissions from aviation are responsible for approximately two-thirds of the global climate impact of the sector (Lee et al., 2021).The reason for this limitation of the scope is that both the emission reduction targets for aviation as described in the Dutch Aviation Policy Memorandum and the LTAG mainly focus on CO_2. In addition, for the discussion on possibilities to safeguard the emission reduction targets for aviation, there is no fundamental difference whether this would include non-CO_2 emissions or not. Exactly quantifying, measuring and monitoring the climate impacts of non-CO_2 however is much more difficult than assessing the CO_2-related impacts. There is still a lot of scientific uncertainty about the exact effects. Climate impacts depend on the actual atmospheric conditions and show strong dependencies with the location and time of emission.

We would like to stress that making aviation climate neutral instead of CO_2 neutral, would make the challenge significantly more complex and would require additional efforts. Part of the climate impacts of non-CO_2 will also be reduced by measures that target CO_2, like Sustainable Aviation Fuel and aircraft technology developments. Operational measures, like flying different routes, could potentially also significantly reduce non-CO_2 effects. However, additional mitigation measures would very likely be necessary and these could require additional amounts of carbon dioxide removals for compensation.

1.3 Reading guide

An overview of relevant background information for the discussion of the research questions is provided in Chapter 2. This chapter includes a discussion of the development of CO_2 emissions from all sectors and aviation specifically for different geographical scales as well as a summary of relevant aviation policies. It shows that despite efforts in the past, emissions in aviation are still rising, whereas emissions in other sectors show a different trend or at least lower growth rates.

In Chapter 3, the first research question is being assessed: What is the relation between the Dutch emission reduction targets for aviation and the LTAG? In the analysis, the relations between the Dutch emission reduction targets for aviation and the international LTAG are examined to enable us to establish the implications of the LTAG for the Dutch context. We elaborate the differences in definitions, discuss the implications of in-sector and out-of-sector targets and the link to carbon removal technologies. By correcting for differences in definitions, a common ground is found for a fair comparison of the Dutch national goals and the LTAG.

Subject of Chapter 4 are the possibilities for legally safeguarding the Dutch emission reduction targets for aviation. The potential options are described with a detailed analysis of the option to include aviation into the Dutch Climate Law and the consequences, risks and opportunities this implies.

2 Background information

2.1 Urgency to reduce GHG emissions

Climate change, fuelled by global greenhouse gas (GHG) emissions[1], has an increasing impact on both humans and nature. To address climate change and mitigate its adverse effects, world leaders have agreed in the Paris Climate Agreement to limit global warming and keep global temperatures well below 2 °C, aiming for 1.5 °C (UN, 2015). As scientists have concluded global warming reached 1.26 ºC in 2022 and increased faster than ever before (0.2 ºC between 2013 and 2022), goals of limiting to 1.5 °C seem almost out of reach.

As global warming is driven by cumulative GHG emissions[2], not only reduction targets for specific years are relevant, but the path towards net zero is crucial in determining global temperature increase. IPCC has estimated remaining global carbon budgets to keep within specific global temperatures (with certain likelihoods) (IPCC, 2022). These carbon budgets have been translated into targets for specific years.

Although goals of limiting temperatures to 1.5 °C seem very ambitious, it has been recognised that negative effects of climate change will be even more severe when exceeding global temperatures of 2 °C. This is partially due to the fact that 1.5 °C is often put forward as the temperature threshold to observe to avoid crossing so called tipping points, leading to irreversible and severe impact. Widely known examples of tipping-points are melting of the polar ice sheets and destruction of the rainforest (UCAR, ongoing). To keep global temperatures within 1.5 °C or at least well below 2.0 °C, GHG reductions are needed at an extremely fast pace.

The EU has adopted a European Climate Law that defines the targets of at least 55% GHG emission reduction in 2030 compared to 1990 levels and of climate neutrality in 2050 as legal obligations (Council of the EU, 2023). At a national level, the Netherlands has adopted the Dutch Climate Law (‘Klimaatwet’), entailing both its climate goals, as well as the policy framework to reach these goals (Ministerie van EZK, 2019). The Dutch Climate Law follows similar GHG emission reduction targets for 2030 and 2050 as its European counterpart.

In the Paris agreement, aviation is not exempt but a proportionate and substantial contribution is required from the sector. Due to the international nature of aviation, a global approach was chosen. Therefore, the responsibility for international aviation is not assigned to individual member states but is placed with the International Civil Aviation Organization (ICAO) of the United Nations. This is similar to maritime shipping, where the International Maritim Organisation (IMO) is responsible for the reduction of GHG emissions. Hence, emissions from international aviation and maritime shipping are not part of the Dutch national GHG reduction targets and the climate law.

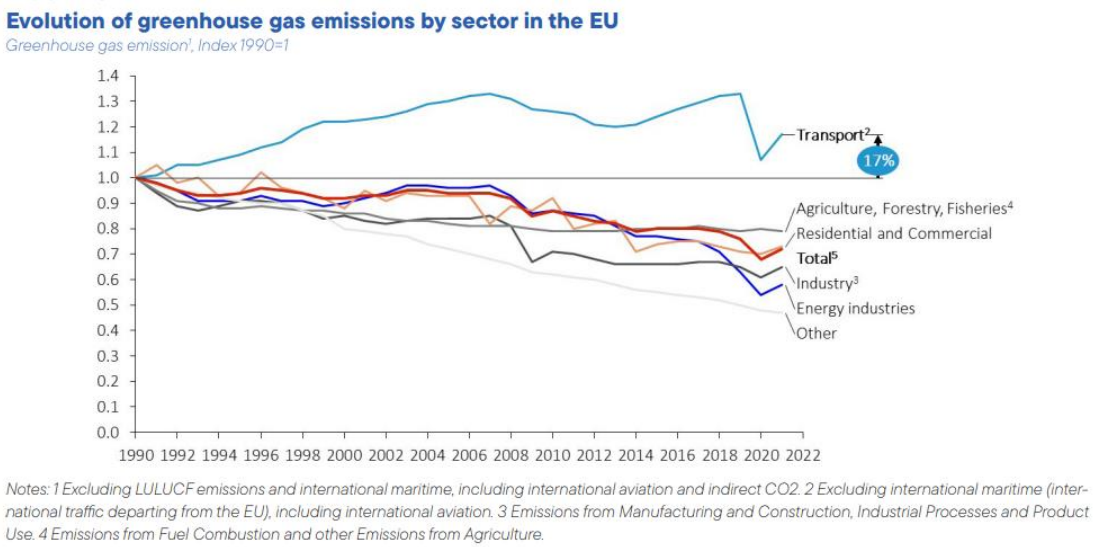
[1] Greenhouse gases constitute of different gases that contribute to climate change (such as carbon dioxide and methane). To compare them and assess their total contributions to global warming, greenhouse gases are regularly converted into CO_2 equivalents(Eurostat, 2023).

[2] This is especially relevant for CO_2 due to its long duration of stay in the atmosphere.

2.2 Historical development of emissions

When looking at a global scale, GHG emissions have been growing since the beginning of the industrialisation. In 2019, the growth rate was 1.1%, reaching 51.7 gigatonnes of CO_2 equivalent (PBL, 2020). Meanwhile, total GHG emissions in the EU have been decreasing by 26.1% in 2022 comparison to 1990 (Eurostat, 2024). This declining trend is observed in all sectors, with the exception of the transport sector, for which GHG emissions have increased by 17% in the same period (see Figure 1**Fout! Verwijzingsbron niet gevonden.**).

Figure 1 - Evolution of greenhouse gas emissions by sector in the EU (EC, 2024)

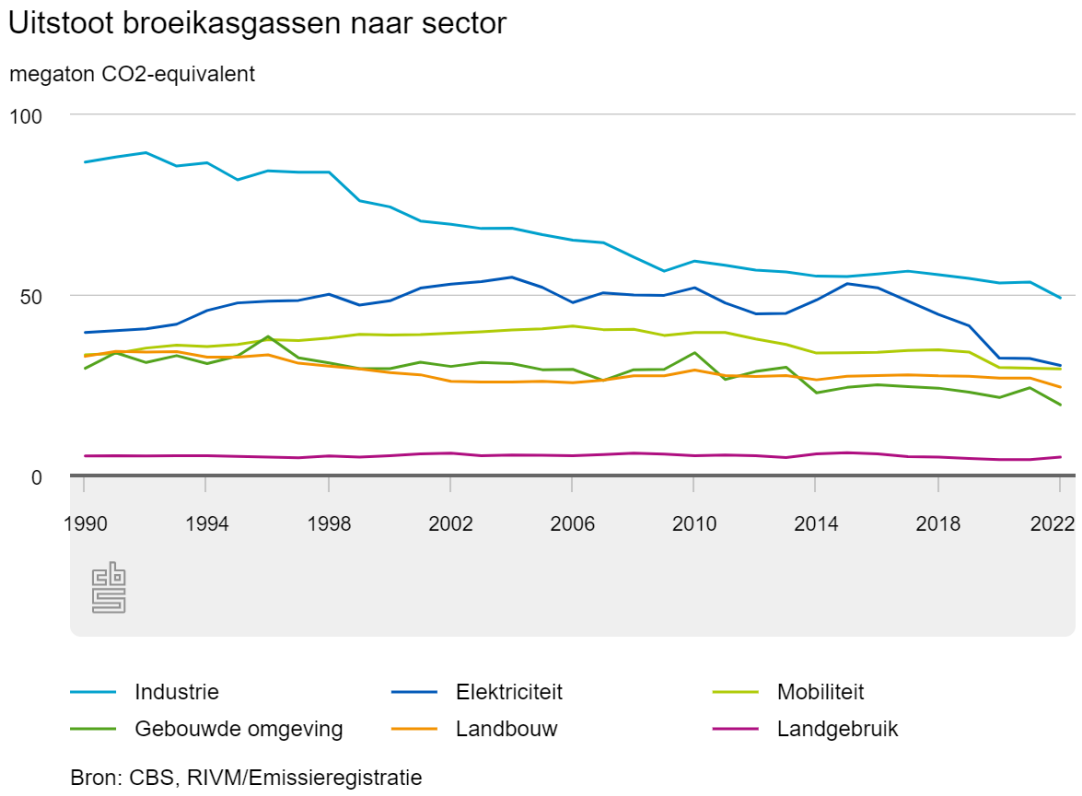


Notes: 1 Excluding LULUCF emissions and international maritime, including international aviation and indirect CO2. 2 Excluding international maritime (international traffic departing from the EU), including international aviation. 3 Emissions from Manufacturing and Construction, Industrial Processes and Product Use. 4 Emissions from Fuel Combustion and other Emissions from Agriculture.

Source: European Commission (EC, 2024).

In the Netherlands specifically, a similar downward trend can be seen in total GHG emissions in 2022, a 18.6% reduction compared to 1990. On a sector level a decline is observed for agriculture (-16.7%), the built environment (-22.2%), land-use (-13.0%) and for the industry (-37.1%). For two sectors emissions have increased: mobility (+2.4%) and electricity (+4.8%). It is important to notice however, that in the GHG emissions for mobility, international aviation and maritime shipment are not included, in both the European and national statistics.

Figure 2 - Evolution of greenhouse gas emissions by sector in the Netherlands (measured in Mt CO_2-eq.)



Source: (CBS, ongoing)

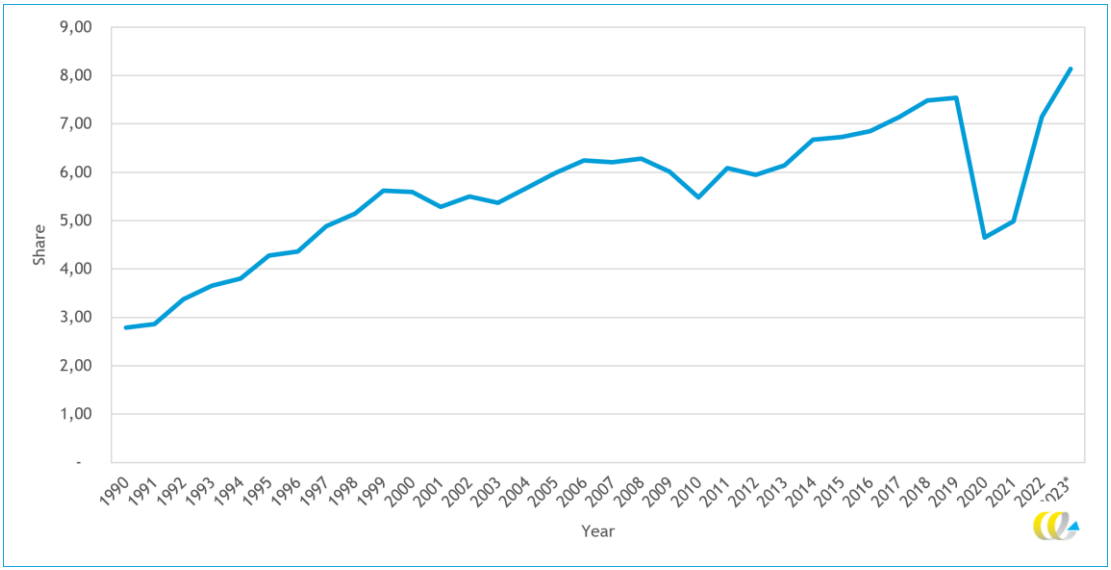
A comparison of total CO_2 emissions, as well as emissions specifically for the aviation sector for different geographical scales is provided in Table 1. The table shows that global CO_2 emissions have seen an upward trend (+67.8%) from 1990 to 2019, while European and Dutch CO_2 emissions have seen a downward trend (-23.7% and -4.3% respectively).
This trend is different for the aviation sector specifically, as it has seen an upward trend for all geographical scales. Global aviation almost doubled (+96.4%), European aviation more than doubled (+122.9%) and Dutch aviation had the highest growth in emissions of all geographical scopes assessed here, with +158.7%.

Table 1 - Comparison total/aviation emissions at different geographic scales, including domestic and international aviation, excluding emissions from LULUCF. For Europe and NL aviation, the share of European/Dutch aviation of global aviation is provided in between brackets. The scope of EU aviation emissions is all full-flight CO_2 emissions of all departures from EU27+EFTA. The scope for NL aviation emissions is all departing aircrafts at Dutch airports.

	1990 absolute emissions (Mt CO_2)	1990 share	2019 absolute emissions (Mt CO_2)	2019 share	Change absolute emissions between 1990 and 2019
Global (IEA-EDGAR, 2024)	22,680	100%	38,066	100%	+67.8%
Europe (EU27) (IEA-EDGAR, 2024)	3,810	16.8%	2,908	7.6%	-23.7%
NL (IEA-EDGAR, 2024)	165	0.7%	158	0.4%	-4.3%

	1990 absolute emissions (Mt CO_2)	1990 share	2019 absolute emissions (Mt CO_2)	2019 share	Change absolute emissions between 1990 and 2019
Global aviation (national + international) (IEA, 2023)	528	2.3%	1037[3]	2.7%	+96.4%
Europe aviation (EU27) (EASA, 2022)	66	0.3% (12.5%)	147	0.4% % (14%)	+122.9%
NL aviation (CBS, 2023)	5	0.02% (0.9%)	12	0.03% (1%)	+158.7%

Figure 3 - Share of Dutch aviation sector CO_2 emissions compared to total CO_2 emission in the Netherlands



When comparing the CO_2 emissions of all departing flights in the Netherlands with the total Dutch CO_2 emissions a clear trend can be observed. Between 1990 and 2019 the share of aviation has increased from 2.8% to 7.5% and, after a strong decline in aviation activities as a consequence of the Covid19 pandemic, this increase seems to continue with a share of 8.1% in 2023 (see

Figure 3).

2.3 Policy landscape of aviation in climate policies

International climate policy mainly refers to the temperature objectives as stated in the Paris Agreement (UN, 2015). As described in the first Article, all committed parties pursue efforts to limit global temperatures to well below 2 °C, aiming for 1.5 °C. This objective is directed at all causes of global warming, and in this way also includes aviation.

[3] 61% (633 Mt CO_2) of the emissions is caused by international aviation and 39% (404 Mt CO_2) by national aviation.

However, the mandatory document (Nationally Determined Contributions) which has to be handed in by all committed parties only has to cover domestic aviation. International aviation emissions are to be addressed by the United Nations agency International Civil Aviation Organization (ICAO) and should be reported as a separate entity and not be included in the national totals, as confirmed at UNFCCC COP 24 in Katowice (Poland) (UNFCCC, 2019)[4]. ICAO has developed the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), which aims to stabilize CO_2 emissions from international aviation in the period until 2035 at the level of 85% of the emission level in 2019. In 2022, the Long-Term Global Aspirational Goal (LTAG) was agreed, which sets the target of net-zero carbon emissions by 2050 in support of the UNFCCC Paris Agreement's temperature goal.

At European level, the European Commission has adopted its Fit for 55 package in 2021 and almost all its proposals have been agreed on by the legislators by now. The package contains several legal instruments to achieve 55% GHG reduction in 2030, compared to 1990. Domestic aviation, which includes all aviation in the European Economic Area (EEA), is integrated into the EU's goal of net GHG emissions reduction and the climate neutrality target for 2050. The Fit for 55 measures aim to align aviation with the broader EU climate agenda without setting sectoral targets for the aviation sector or other sectors. Within the Fit for 55 package the relevant measures for aviation are the revision of the Emissions Trading System (ETS), the ReFuelEU Aviation blending obligations and the revision of the Renewable Energy Directive (RED).

In the Netherlands, overall climate action is covered by the Dutch climate Law (Ministerie van EZK, 2019). However, this law does not apply objectives specifically targeting aviation, as it refers to emissions within the Netherlands[5]. The Aviation Policy Memorandum has established Dutch emission reduction targets for aviation for 2030, 2050 and 2070, but these are not yet legally enshrined.

[4] It should be noted, however, that countries do have the liberty to design national climate laws as they wish; the agreement to exclude international aviation only applies to the Nationally Determined Contributions (NDCs) and national GHG inventories that countries have to submit to the UN.

[5] For the application of this law, greenhouse gas emissions are defined as the emissions of greenhouse gases within the Netherlands originating from sectors and sources, as well as removals by sinks, that are included in the national greenhouse gas inventories in accordance with Article 4, paragraph 1(a), of the United Nations Framework Convention on Climate Change (UNFCCC, 1992).

3 National reduction targets and LTAG

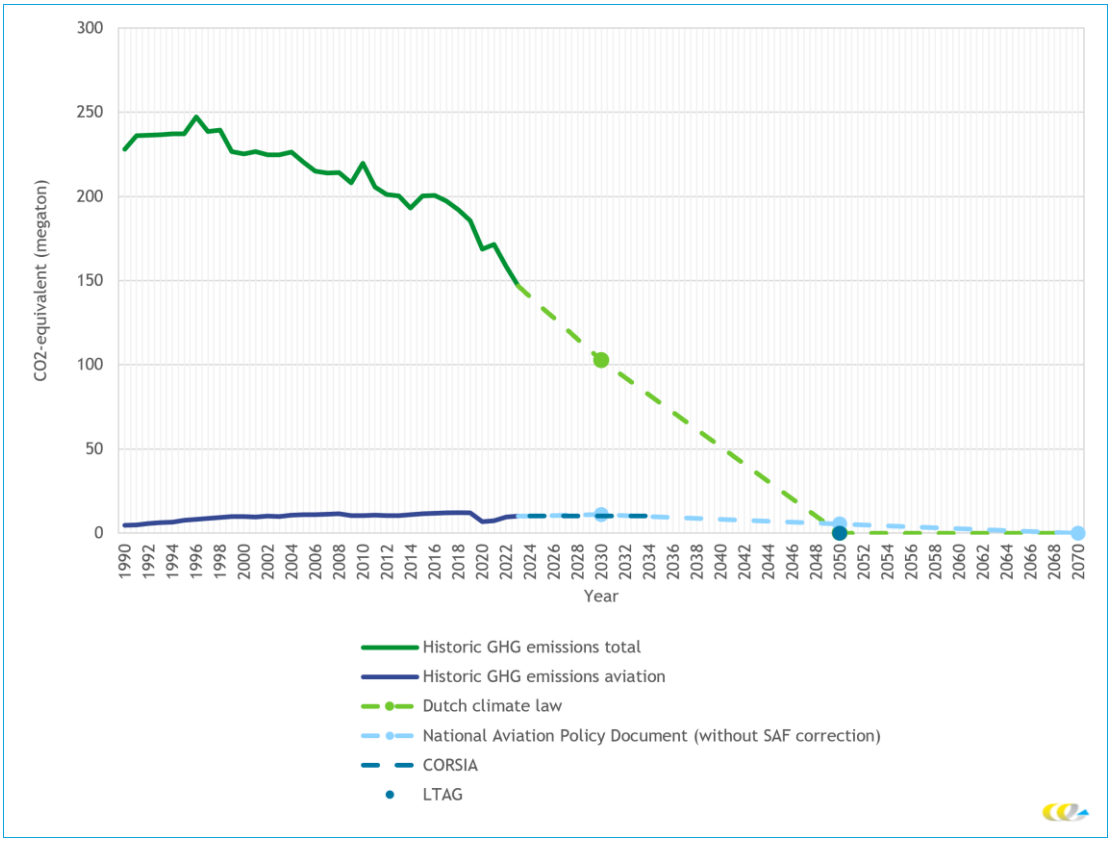
3.1 National emissions and reduction targets

In this section the link between the different emission reduction targets for aviation and overall emission reduction targets are discussed. We distinguish in-sector and out-of-sector reduction targets for the aviation industry. In-sector emission reduction can be achieved by aircraft technology developments, operational efficiency improvements, a shift to alternative fuels and demand management. For the out-of-sector reduction carbon removals technologies and offsets are the main options. For a more elaborate qualitative review of all the targets, we refer to Annex A.

In Figure 4, the historical emissions and reduction paths to meet emission reduction targets are shown for all Dutch GHG emissions and for international aviation departing from the Netherlands[6]. In 2023, a reduction of 36% compared to 1990 levels has been realised for the total of Dutch emissions. The target is climate neutrality in 2050, with an intermediate target of -55% emission reduction compared to 1990 levels in 2030. These overall targets do not imply that all sectors follow the same path and achieve carbon neutrality in 2050, but that these targets are met in total and that carbon removals compensate remaining emissions in 2050.

[6] Determined based on fuel uptake of flights departing at Dutch airports.

Figure 4 - Historical Dutch GHG emissions and emissions from departing flights at Dutch airports from 1990 to 2023 (solid lines). For the future years reduction paths that comply with the relevant climate policies and laws are shown as dashed lines.

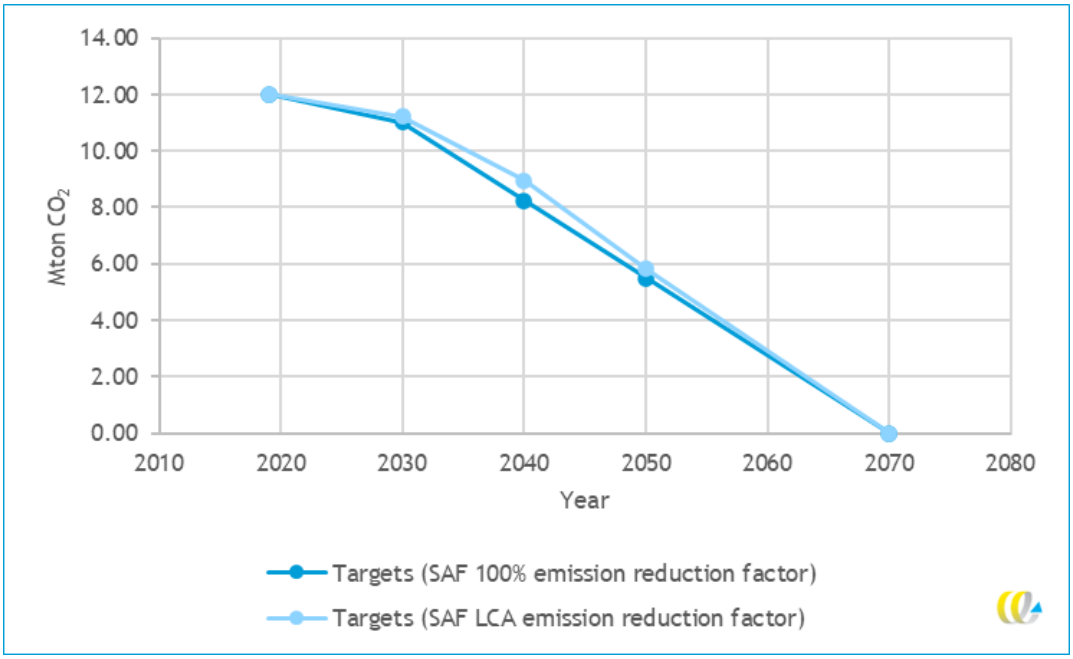


Emissions from aviation have evolved very differently compared to the total GHG emissions in the Netherlands. This is visualised in Figure 6, which is a normalised version of Figure 4. In the 29 years between 1990 and 2019 aviation emissions have increased by 120%. In the years after 2019, emissions from aviation have seen a steep drop as a consequence of COVID-19 restrictions. After restrictions were lifted, an fast recovery rate could be observed. Without additional policies, emissions from aviation are expected to exceed the 2019 level quite soon and to increase even further, leading to an even larger share of the total emissions.

Figure 6 also depicts the emission reduction targets for Dutch and international aviation. For the Netherlands, national emission reduction targets are defined in the Aviation Policy Memorandum:

- 2030: Reduce net CO_2 emissions from Dutch aviation to 2005 levels (~12.5 million tons of CO_2 equivalent);
- 2050: Emissions must be halved compared to 2005;
- 2070: flights departing from the Netherlands should no longer emit CO_2.

Figure 5 - Comparison of the emission reduction targets for Dutch aviation with administrative and realistic emission reduction factor for SAF



It should be noted that in the Aviation Policy Memorandum, targets are defined based on fossil fuel usage (Ministerie van I&W, 2020). This implies that SAF is accounted for with a 100% emissions reduction factor (as it is in the EU ETS directive), which does not take into account the life-cycle emissions of SAF. In order to make the national targets comparable to the international targets, the effect of this should be taken into account. With assumptions on the fuel blend (see Table 2) and emission reduction factors for SAF (see Table 3) the effect of the life-cycle emission reduction factor on the emission targets is estimated and shown in Figure 5. The effects are moderate, with the largest difference around 2040. In earlier years the differences are smaller since the SAF share is small and in later years the increasing emission reduction factors of SAF decrease the gap. In this comparative analysis, the targets from the ReFuelEU Aviation blending obligation are applied. In case additional policies or market incentives would lead to higher SAF shares, this would translate into higher differences in emissions measured according to the SAF 100% emission reduction factor and measured according to the SAF emission reduction factor based on a Life Cycle Assessment (LCA).

Table 2 - Assumed share of fuels according to the ReFuelEU Aviation blending obligation for aircraft departing at Dutch airports

Fuel type	2019	2030	2040	2050
Fossil kerosene	100%	94%	66%	30%
Biofuels	0%	5%	15%	35%
Synthetic fuels	0%	1%	19%	35%

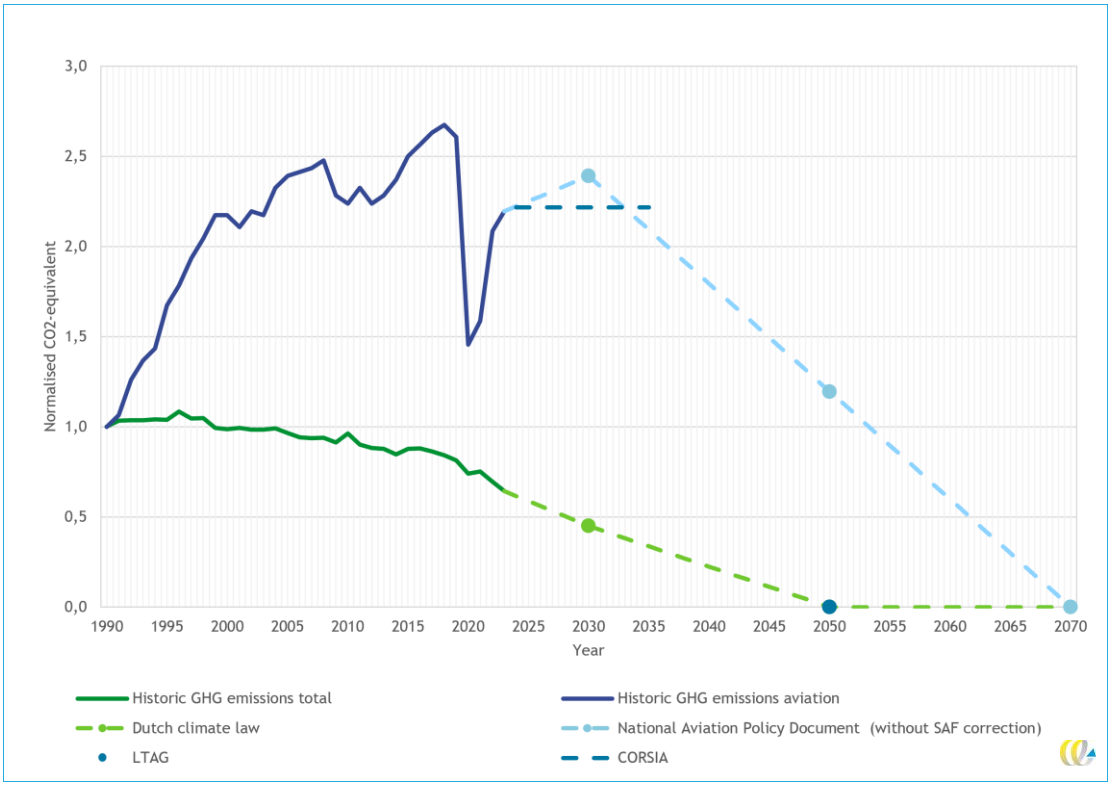
Table 3 - Assumed emission reduction factors for SAF

Fuel type	2019	2030	2040	2050
Biofuels	65%	65%	75%	95%
Synthetic fuels	85%	85%	90%	100%

Since the EU has not set a specific target for emission reduction of European aviation, no EU targets are shown in Figure 6. At international level we distinguish CORSIA with short term targets until 2035 and the Long Term Aspirational Goal (LTAG) which sets a net-zero target for 2050. Both targets/measures were developed by The International Civil Aviation Organisation (ICAO).

CORSIA defines a baseline of 85% compared to 2019 emission[7]. All remaining emissions above the baseline have to be compensated by offsets in other sectors. The LTAG goal of net zero emissions in 2050 is based on in-sector reduction measures, but in all scenarios a residual amount of CO_2 remains. This requires out-of-sector measures, such as offsets like under CORSIA. How the ICAO targets and the national emission reduction targets for aviation compare, will be discussed in Section **Fout! Verwijzingsbron niet gevonden.**.

Figure 6 - Historical Dutch GHG emissions and emissions from departing flights at Dutch airports from 1990 to 2023 (solid lines, normalised to 1990 emissions for total emissions and aviation). For the future years reduction paths that comply with the relevant climate policies and laws are shown in dashed lines.



[7] CORSIA covers the emissions of flights from Dutch airports to extra-EEA destinations. Since emissions subject to CORSIA and the EU ETS are not distinguished, the line indicates the 85% of the total emissions of departing flights from the Netherlands.

3.2 ICAO's long-term aspirational goal (LTAG)

At the 41st ICAO assembly in 2022, the LTAG for international aviation[8] to reach net-zero carbon emissions by 2050 was adopted. The goal of the LTAG is to support the Paris agreement. However, the LTAG does not set specific targets to countries, while under the Paris agreement states make pledges on their national contributions.

"The LTAG does not attribute specific obligations or commitments in the form of emissions reduction goals to individual States. Instead, it recognizes that each State's special circumstances and respective capabilities (e.g., the level of development, maturity of aviation markets, sustainable growth of its international aviation, just transition, and national priorities of air transport development) will inform the ability of each State to contribute to the LTAG within its own national timeframe. Each State will contribute to achieving the goal in a socially, economically and environmentally sustainable manner and in accordance with its national circumstances (ICAO, ongoing-a)."

To compare the targets of the LTAG with national targets we have translated the global emission reduction targets to the emission reduction targets of the Netherlands.
We describe the assumptions made for this translation, but wish to emphasise that this is not an advice, neither for the Dutch authorities nor for ICAO, about which national emission reduction target should be defined for the Netherlands based on the LTAG.

Three scenarios were developed by ICAO to explore the feasibility of an LTAG. They are based on combining increasing levels of ambition and decreasing levels of readiness and attainability for reduction measures/technology improvements in technology, operations and fuels:

- IS1: the first scenario represents the current expectations with relatively low ambition levels and high levels of readiness and attainability;
- IS2: Scenario 2 is defined to approximate the mid-point between IS1 and IS3;
- IS3: Scenario 3 (IS3) reflects high levels of aspiration, but lower levels of readiness and attainability.

All three scenarios are placed in the context of a baseline scenario, integrated scenario 0 (IS0). This scenario represents emission reduction through fleet evolution alone based on frozen aircraft technology at 2018 level and without additional improvements in operations and fuel.
The focus of the LTAG scenarios is on net-zero emissions. To achieve net-zero, the scenarios focus on in-sector reduction measures. Market-based measures to reduce CO_2 emissions like CORSIA are outside the scope of LTAG and thus excluded from the scenarios. Residual emissions must be offset or compensated via carbon removal or offsetting projects. For the global growth in demand, annual growth rates around 3.5% are assumed according to the ICAO mid scenario traffic growth forecast, see Table 4 (ICAO, ongoing-b). Demand measures are not taken into account.

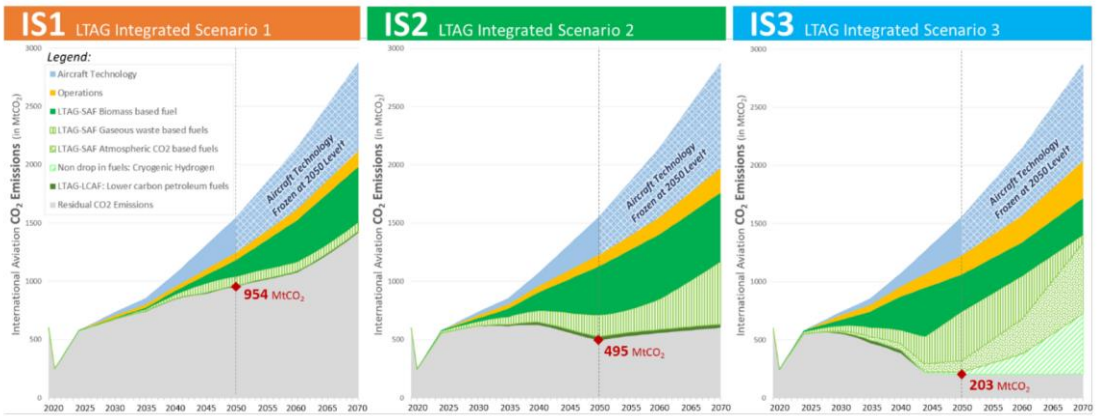
Table 4 - Traffic growth forecast used in the LTAG scenario's.

	2018-2050	2018-2070
Annual growth rate revenue passenger kilometre (RPK)	3.6%	3.4%
Annual growth rate freight tonne kilometre (FTK)	3.5%	3.3%

[8] Note that in 2019 international aviation was responsible for 61% of global aviation emissions. The remaining 39% are caused by domestic flights, for which ICAO is not responsible. Emissions of domestic aviation are part of the national obligations. There is no domestic aviation in the Netherlands, otherwise the emissions would be subject to the Dutch climate law.

displays the emission development of the three scenarios compared to the baseline scenario. The corresponding numbers for 2050 are summarized in Table 5. In all three scenarios a residual amount of emissions occurs. These emissions have to be offset or compensated in order to reach net-zero. This can be done using different mitigation measures, such as market based measures or carbon removals. The amount of residual emissions varies per scenario between 959 Mt CO_2 in IS1, which is 160% of global aviation emission in 2019, and 203 Mt CO_2 in IS3, which corresponds to 34% of the 2019 level.

Figure 7 - Overview of effects of emission reduction measures and residual in-sector emissions for aviation in the LTAG scenarios (REF)



Source: (ICAO, 2022a)

Table 5 – Emission reduction and residual emissions in 2050 for the three LTAG scenarios

	IS1	IS2	IS3
Aviation emissions in 2019 (Mt CO_2)	600	600	600
Residual emissions in 2050 (Mt CO_2)	954	495	203
Emission change in 2050 compared to 2019	+59%	-18%	-66%
Emission change in 2050 compared to baseline scenario	-39%	-68%	-87%
Aircraft technology	*-20%*	*-21%*	*-21%*
Operations	*-4%*	*-6%*	*-11%*
Fuels	*-15%*	*-41%*	*-55%*

The in-sector emission reductions in the scenarios are achieved with measures that can be divided into three categories (see Table 5). The main difference between the scenarios is caused by replacing kerosine by advanced fuels, which lead to an emission reduction between 15% in IS1 and 55% in IS3. For operations differences between 4 and 11% are estimated, whereas for aircraft technology similar effects around -21% are assumed in all scenarios. We discuss the differences for these categories briefly.

Aircraft technology

Aircraft technology developments are divided into Advanced Tube and Wing (ATW) and Advanced Concept Aircraft (ACA). Three aircraft technology scenarios are developed where for five aircraft types an energy intensity reduction factor is determined for different future years. The scenarios differ in market shares for new entry and replacement of the five different aircraft types and in the energy intensity reduction factor. These aircraft technology developments reduce 2050 emissions in each scenario with around 20% compared to the baseline scenario.

Operations

Three operations scenarios were developed, a conservative, medium and aggressive one, that align with the integrated scenarios IS1, IS2 and IS3. These scenarios differ in the implementation rate of five operational efficiency categories. To illustrate what this entails, for instance for the innovative flight efficiency category, formation flying saves 3.3 to 7.1% fuel per flight and is applied to 15% of all flights in 2050. We consider these reduction percentages and scope to be very optimistic. The categories and their deployment rate are listed in Table 6. Operations reduce emissions in 2050 between 4 to 11% depending on the scenario compared to the baseline.

Table 6 - Summary of the operation scenarios and the implementation rate of operational measure categories

Measure category	O1 (IS1)	O2 (IS2)	O3 (IS3)
Horizontal Flight Efficiency (HEF)	Low	Medium	High
Vertical Flight Efficiency (VFE)	Low	Medium	High
Ground Flight Efficiency (GFE)		Medium	High
Innovative Flight Efficiency (IFE)		Low	Medium
Advanced Flight Efficiency (AFE)		Low	Medium

Fuels

The main difference in emission reduction between the scenarios is caused by replacing fossil fuel by more environmental friendly aviation fuels. LTAG distinguishes five fuel types:

- SAF-FTG: SAF made from biomass and solid/liquid waste.
- SAF-CO_2: SAF made from waste CO_2.
- SAF-DAC: SAF made by using direct air capture (DAC).
- LCAF: low carbon aviation fuel, with an emission reduction factor of 10% compared to fossil jet fuel.
- LH_2: cryogenic hydrogen. This is a non-drop in fuel, meaning the conventional drop-in jet fuel is replaced by LH_2 used in a dedicated aircraft.

Figure 8 shows the amount of fuel required for each LTAG scenario by fuel type. IS1 requires the most fuel, due to less aircraft technology and operational efficiency improvements. The shares per fuel type required under each scenario are summarised in Table 7. For instance, IS1 assumes that 73% of the fuel used for international aviation globally has a fossil origin, 19% of the fuels have a bio-origin and 8% is synthetic fuel in 2050. In contrast, IS3 relies for 96% on bio-SAF and e-fuels in 2050. The remaining 4% is hydrogen demand. In 2050, no fossil fuel is used in IS2 and IS3. Sufficient biomass, clean energy and production capacity is required to accommodate this, which will be challenging.

It is furthermore worth mentioning that the global sustainable fuel shares in IS1 are lower than the target for departing European flights mandated by the ReFuelEU Aviation blending obligation.

Figure 8 - LTAG scenarios required amount of fuel per type

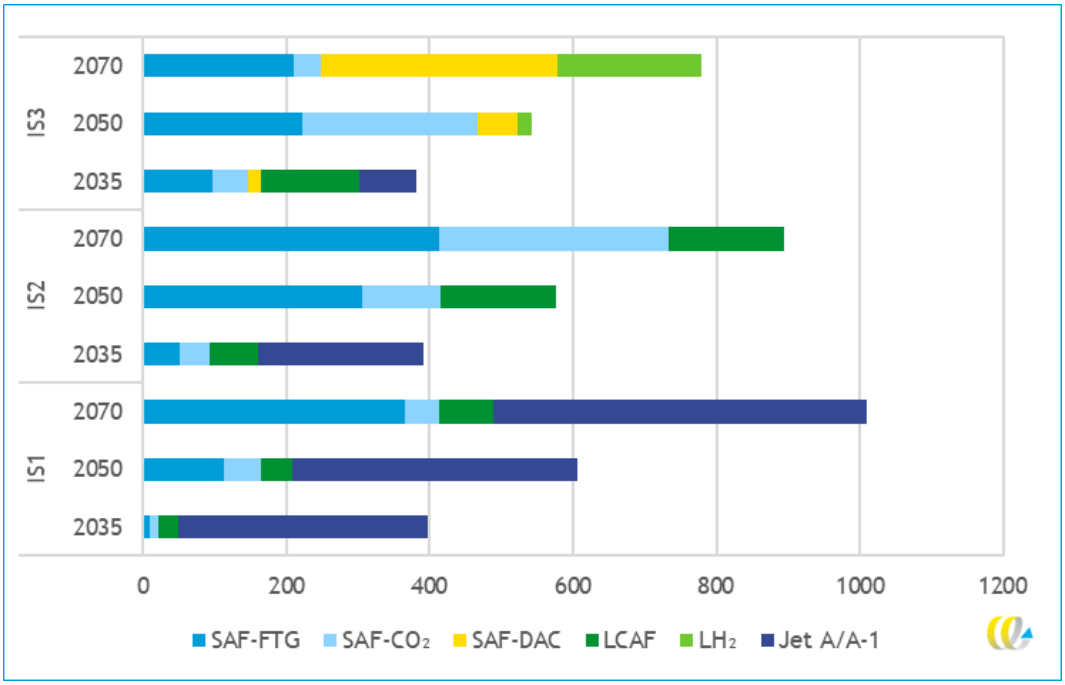


Table 7 - Share of different fuel type in 2050 in the three LTAG scenarios

Aviation fuel type	IS1	IS2	IS3
Jet A/A-1 kerosene and LCAF	73%	28%	0%
Bio-SAF	19%	53%	41%
E-fuels	8%	19%	55%
LH_2	0%	0%	4%

3.3 Comparison of LTAG with national emission reduction targets

As mentioned in Section **Fout! Verwijzingsbron niet gevonden.**, LTAG does not attribute specific emissions reduction goals to individual States. However, to be able to compare the LTAG goals with the national emission reduction targets of the Netherlands, a translation of what the LTAG would mean in the context of the Dutch aviation sector is necessary. The allocation of global emissions to individual countries is a political decision and could be based on different ethical frames, for instance:

- per capita (share of the country of the world population);
- based on an economic measure, like the GDP;
- based on the size of the aviation sector in a country;
- based on historical emissions (in a specific reference year).

In 2019, flights departing from the Netherlands had a share of 1.16% of global aviation. For the future allocation between Dutch and global aviation, potential options are (CE Delft, 2024):

- Maintaining the share of 1.16%, which continues the disproportional high emissions of Dutch citizens.
- Distributing the budget to countries by shares of the world population, this leads to a Dutch share of 0.21%.
- Applying socio-economic forecasts on the current market share leads to a share of 1.05%. The Dutch share decreases slightly since the population and economy grows faster in other parts of the world.

In this study, the share of 1.05% is used for the allocation of global emissions in LTAG to the Netherlands. The same allocation method has also been applied in a recent Carbon Budget study (CE Delft, 2024). Note that this approach uses the historic high (per capita) aviation emissions of the Netherlands as a starting point. An approach that would require more efforts by developed countries than by developing countries would lead to a lower carbon budget for Dutch aviation.

Note that with this allocation we also make the implicit assumption that the in-sector reductions based on aircraft technology, operations and fuels have the same speed in the Netherlands as in the rest of the world. One might argue that the speed should be higher in developed countries than in developing countries since their higher welfare allows them to invest more in aircraft technology, advanced fuels and operations. These considerations are additional arguments why these translation of the global LTAG scenarios to the Netherlands should be interpreted as upper boundaries in terms of the carbon budget for aviation. However, growing economies with a growing aviation sector often own only a small number of old less-efficient aircraft and extent their fleet by new fuel efficient aircraft. Due to their geographical location, some also have advantages for the production of SAF, since renewable energy can be produced for lower costs. Hence, the investments in fleet renewal by airlines and the upscale of SAF is based on a large number of factors and not necessarily linked to the GDP of the state of registration.

In Figure 9, the three LTAG scenarios IS1, IS2 and IS3 are shown and compared to the emission reduction targets of the Aviation Policy Memorandum[9]. The Dutch national emission reduction targets are in between the IS2 and IS3 scenarios until 2055.
The fact that the Dutch targets seem to be stricter than IS3 after 2055 is mainly caused by our assumption that the life-cycle reduction of SAF reaches almost 100% after 2050, which is more optimistic than the assumption within ICAO. For the period 2050-2070, ICAO applied a high level of uncertainty considering emissions reduction and specifically with respect to global fleet renewal. However, for the period 2025 to 2055 the IS3 scenario is more stringent than the Dutch national targets. Therefore, if the Netherlands would follow the IS3 scenario as implementation mode of the LTAG, the Dutch emission reduction targets would have to be adjusted to be in line with this.

[9] Since ICAO takes into account the life-cycle emissions of SAF and the Dutch targets in the Aviation Policy Memorandum are based on fossil fuel usage (counting SAF as zero emissions), they are corrected for a fair comparison (see Section 3.1 and Figure 5).

Before, we compared the LTAG scenarios to the Dutch emission reduction targets for aviation. Now we proceed to compare these to the carbon budget that is still available for the Dutch aviation sector. In recent studies, the Netherlands Aerospace Centre (NLR, 2024) and CE Delft (2024) have determined remaining carbon budgets for Dutch aviation based on international remaining carbon budgets estimated by the International Panel on Climate Change (IPCC, 2022).

The comparison of cumulative emissions in periods of ten years is depicted in Figure 10. Since global warming is driven by cumulative emissions and not by targets in specific years, we can conclude that the climate impact of CO_2 emissions in IS1 is much higher than in IS3. Over the entire period the difference is a factor 2.6 (830 Mt CO_2 in IS1 compared to 318 Mt CO_2 in IS3), mainly caused by the large difference in the decades after 2050. For the period until 2050 the difference is a factor 1.6 (404 Mt CO_2 in IS1 compared to 243 Mt CO_2 in IS3). The targets in the Aviation Policy Memorandum are comparable to IS3 when considering all emissions until 2070. However, until 2050 the cumulative emissions that comply with the targets of the Aviation Policy Memorandum (281 Mt CO_2) are 16% higher than (the 243 Mt CO_2) in IS3.

Figure 9 - Comparison of the LTAG scenarios translated to the Netherlands with the Dutch national emission reduction targets for aviation

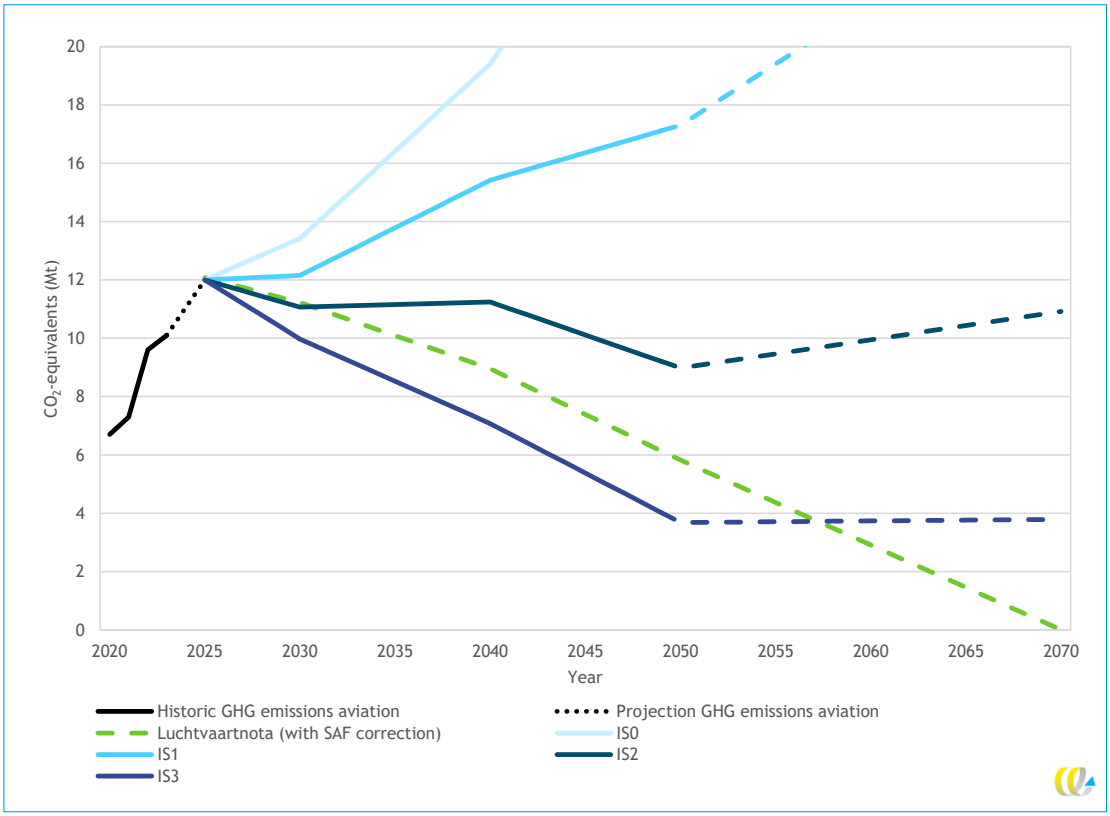
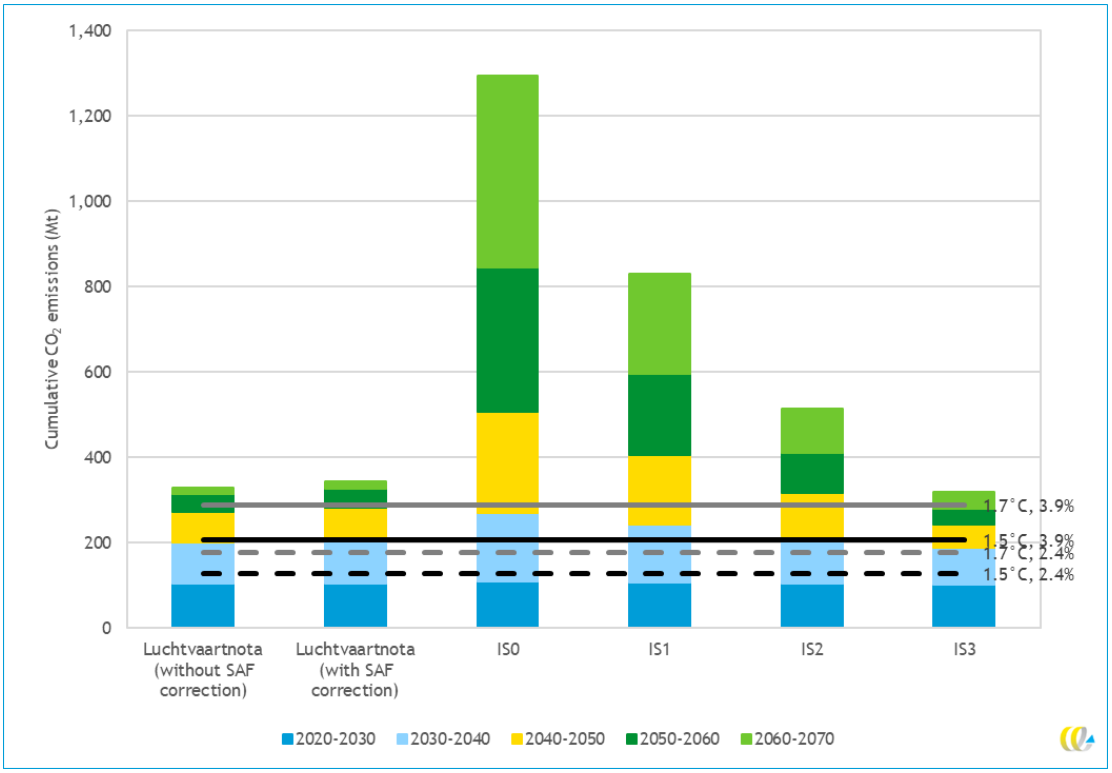


Figure 10 - Cumulative CO_2 emissions for 2020 and beyond associated to the emission reduction targets from the Aviation Policy Memorandum and the translated LTAG scenarios compared to derived remaining carbon budgets for Dutch aviation (CE Delft, 2024). The carbon budgets are derived for global warming of 1.5 °C and 1.7 °C and two aviation shares in global emissions, a constant share of 2.4% and an increased share (3.9%).



4 Possibilities for legally binding aviation targets

4.1 Introduction

As discussed before, the Dutch aviation targets from the Aviation Policy Memorandum have not been legally enshrined so far. In this chapter we look into policy options for establishing a legal basis for these targets, in order to safeguard the achievement of the targets. The first option to do so is to introduce a so-called CO_2 ceiling for Dutch airports. This options has been studied extensively by CE Delft (CE Delft, 2021b, 2022a, 2022b), therefore in this study we limit ourselves to referring to the outcomes of the existing studies.

The second option, which will be investigated in depth in this chapter, is to explicitly include the aviation sector in the Dutch Climate Law. Currently, this law only applies to domestic emissions, in line with the standing UN guidelines on national GHG inventories, which exclude emissions from international shipping and aviation.

Lastly, we will assess briefly whether still other options to safeguard the Aviation Policy Memorandum targets are, at least theoretically, possible.

4.2 CO_2 ceiling for aviation

In order to safeguard that the emission reduction targets of the Aviation Policy Memorandum will be met, the implementation of a so-called CO_2 emissions ceiling for the international aviation sector has been investigated in detail. The aim of this CO_2 ceiling is to turn the CO_2 targets into enforceable targets that have to be reached by the aviation sector. Implementation of the CO_2 ceiling would shift the responsibility of reaching the targets from the government to the sector. The three main policy framework options that have been investigated are:

- **Airport option**: A national CO_2 ceiling divided over airports and embedded in airport permits, comparable to standards for airports with regard to noise and local air quality.
- **Fuel supplier option**: A fossil fuel ceiling, which limits the amount of fossil fuels which fuel suppliers are allowed to supply to aircraft by auctioning permits.
- **Airline option**: A national Emissions Trading Scheme, which establishes a closed ETS for airlines departing from Dutch airports.

In an impact assessment 54 scenarios were defined which cover a wide range of possibilities in the capacity of Dutch airports, European measures from the European Fit for 55 proposals, national climate policy and socio-economic development. Impacts were assessed for Dutch aviation, the economy and the environment (CE Delft, 2022a). Due to changes in national aviation policies an update of the study has been carried out, which assessed the same types of effects(CE Delft, 2022b).

The legal assessment considers the airport option to be the most legally viable option. The Fuel supplier option could negatively interfere with the objectives of ReFuelEU Aviation, which aims to ensure a level playing field and harmonisation for SAF usage in Europe.

For the ETS variant, there is a significant risk that the beneficial effect of the EU ETS would be undermined, rendering this variant incompatible with the ETS Directive. Both ReFuelEU and EU ETS appear to leave no room for more ambitious national measures (Ministerie van I&W, 2023).

In March 2023, the Minister of Infrastructure and Water Management has informed the House of Representatives about the cabinet's decision in principle regarding the introduction and design of a CO_2 ceiling for aviation (Minister van I&W, 2023).

The Dutch CO_2 ceiling would limit the total CO_2 emissions from the aviation sector operating within the Netherlands. This cap establishes a maximum allowable level of CO_2 emissions, ensuring that the emission reduction targets of the Aviation Policy Memorandum are met. Afterwards preparations have started for embedding the CO_2 ceiling in national legislation, ensuring enforceability and compliance.

In June 2024, the Minister of Infrastructure and Water Management informed the House of Representatives about the publication of a study on a distribution key that allocates the CO_2 budget under the CO_2 ceiling amongst airports. In the accompanying letter, it was stated that next steps regarding the implementation of a CO_2 ceiling will be taken by the new government (Ministerie van I&W, 2024). In the beginning of July 2024, the new Schoof government was installed. In October 2024, during a Parliamentary debate on aviation, the Minister of Infrastructure and Water Management announced that he will inform the Parliament before the summer of 2025 about the next steps regarding the CO_2 ceiling (Tweede Kamer der Staten Generaal, 2024).

4.3 Including aviation in the Dutch Climate Law

In this section, we discuss the consequences, opportunities and risks of integrating the aviation sector into the Dutch Climate Law. It is important to note for the reader that opportunities and risks are often two sides of the same coin. Also, an opportunity for one stakeholder may pose a risk from the perspective of another. When describing opportunities of policy options, we indicate the advantages that may be experienced from the policy options by the various stakeholders. We do acknowledge that these advantages can turn into disadvantages when seen from another perspective, and we attempt to cover this as completely as possible in the section on risks. Before proceeding, however, we need to establish how we envisage an inclusion of aviation into the Climate Law in a concrete manner.

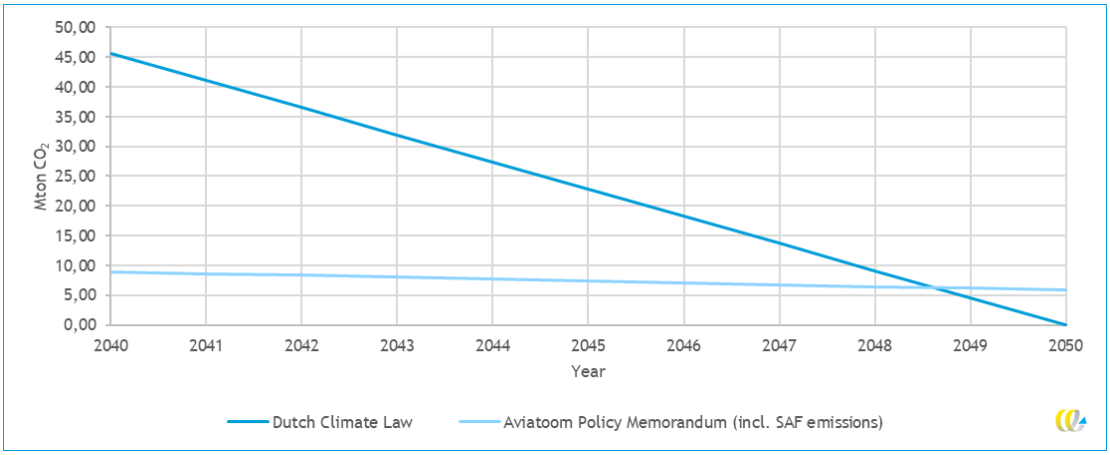
4.3.1 Options to include aviation in the Dutch Climate Law

The Dutch Climate Law (Ministerie van EZK, 2019) offers a framework for policy development, directed at a gradual and irreversible reduction of the emission of greenhouse gases in the Netherlands, aiming at limiting global warming and climate change (Art. 2.1). In line with the European Climate Law, the Dutch Law establishes that the Netherlands will reduce its net greenhouse gas emissions to zero in 2050 at the latest and strive for negative emissions thereafter.

In order to achieve the net-zero target in 2050, the Dutch Climate Law also includes a non-binding target of at least 55% emission reduction in 2030 compared to 1990 (Art. 2.2). However, as it is considered not feasible to include aviation into the Dutch Climate Law with regard to the 2030 targets due to the short timeframe, we will disregard the 2030 target in the remainder of this study.

Currently, the scope of the Dutch Climate Law is restricted to emissions and sinks of greenhouse gases as defined in the national greenhouse gas inventories under the UNFCCC, which don't include international shipping and aviation (Art. 2.3). Indeed, one way of integrating aviation into the Climate Law is simply by extending its scope to include aviation[10]. The climate neutrality target in 2050 would then apply to all domestic emissions as well as those from flights departing from Dutch airports. All these emissions together should be net-zero in 2050, so any remaining emissions from aviation in 2050 should be compensated by an equivalent amount of carbon removals, which would be additional to the carbon removals needed to comply to the target with its current scope.[11] Figure 11 indicates the additional reduction requirements from aviation for the period 2040 to 2050, assuming the targets from the Aviation Policy Memorandum are met. To achieve net-zero, these emission reduction targets would translate into a demand of carbon removals of 5.8 Mt CO_2 in 2050.

Figure 11 - Emission reduction paths for the period 2040 to 2050 for the sectors covered by the Dutch Climate Law and for aviation as described in the Aviation Policy Memorandum. The aviation target is 5.8 Mt CO_2 in 2050, taking into account the emissions from SAF (see Figure 5).



The Aviation Policy Memorandum targets apply to the tanked fossil aviation fuel in the Netherlands. As mentioned in the Introduction, reductions need to be achieved in-sector. See Textbox 1 for some general considerations in-sector and climate neutrality targets and the need for complementary policy instruments for emission reduction. It could be decided that, even if aviation is included in the overarching climate neutrality target, the emission reduction targets from the Aviation Policy Memorandum would still apply at the same time. This would imply that not all aviation emissions could be compensated for, but only the residual emissions that are allowed for under these targets.

[10] Conceptually, it would make sense to treat international aviation and international shipping equally, as these sectors have the same (exceptional) position in the current climate policy framework. Thus, if aviation would be included in the Climate Law, it would be logical to include shipping in the same way and, in this example, extent the scope of the Climate Law also to international shipping. However, since this study focuses on the aviation sector, we will not revert to this issue in the remainder of this study and only discuss aviation.

[11] To be sure, also without being included in the Dutch Climate Law the aviation sector would need carbon removals to compensate for its residual emissions, but what is meant here is that an additional amount of carbon removals would be needed to comply with the Climate Law including aviation compared to the Climate Law excluding aviation, since it is virtually certain that the aviation sector will have residual emissions by 2050.

Another way of integrating aviation into the Climate Law would be by including it into the scope of the law (Art. 2.3), but not into the overall 2050 climate neutrality target (Art. 2.1). Instead, a distinct target could be formulated specifically for the aviation sector. This offers the possibility to directly enshrine the targets of the Aviation Policy Memorandum into the Climate Law. The 2050 target of the Aviation Policy Memorandum is that emissions from flights departing from the Netherlands should not surpass 50% of the emissions level in 2005.

Textbox 1 - In-sector and climate neutrality targets and the need for complementary policy instruments

By exploring the possibilities of including the Aviation Policy Memorandum target into the Dutch Climate Law, we are in fact trying to **reconcile two basically different types of emission reduction targets**. As a background to the remainder of this section, we present some general considerations on the nature of these targets.

As mentioned in the main text, the Aviation Policy Memorandum target applies on the amount of fossil fuel tanked for flights leaving Dutch airports. How this target could be met is open: for instance through the application of SAF, operational efficiency improvements, more efficient aircraft or reducing the number of flights. The target itself does not provide a mechanism through which it can be achieved, nor a reduction pathway towards the target year. Compensating emissions by carbon removal credits is not an option to achieve this target.

Climate neutrality targets, on the other hand, **explicitly allow for carbon removals to compensate for residual emissions.** By themselves, they do not limit the amount of residual emissions, and therefore the amount of carbon removals necessary. **Other policy instruments are always needed to actually reduce the emissions.** If this does not happen sufficiently, demand for carbon removals may surpass supply and/or their price will increase strongly. See also Textbox 3 on carbon removals.

If several sectors are brought under a single climate neutrality target, as is the case in the Dutch Climate Law (with or without adding the aviation sector to it), an additional issue is that **no allocation of the available carbon budget over the various sectors is made.** If it is not clear how much each sector can still emit, and how it will reduce its emissions. **Hence, sectors will compete over scarce resources.** For instance, many sectors trust on biomass for providing sustainable fuels or raw materials, but sustainable biomass will probably become scarce. Also the supply of (affordable) carbon removals can be considered a scarce good. A target will by itself not solve this allocation issue, with the risk that the various sectors will face a prisoner's dilemma and just try to meet their own interests, without taking into account the common goal.

In the case of aviation being included in a climate neutrality target, a particular challenge is that aviation emissions are projected to continue increasing over the next decades, while other sectors have stabilised or decreased their emissions. This implies that **aviation may force other sectors to reduce even more than initially foreseen.** If other sectors have no more options to reduce their residual emissions further, the only way to meet the climate neutrality target is to realise even more carbon removals, which comes with its own price and risks (see Textbox 3)

From the above, we conclude that both types of targets need to be complemented with other policy instruments, which can offer concrete reduction mechanisms, set out sectoral reduction pathways and allocate carbon budgets and scarce resources. **Setting targets alone is always insufficient if emission reductions need to be safeguarded**, and in this sense a mechanism such as offered by the CO_2 ceiling for aviation has clear advantages over all policy options discussed in this section. This should be taken into account when discussing the consequences, opportunities and risks of the options, and we will come back to the considerations in this textbox where applicable in the remainder of this section.

We also take into account some variations on the option mentioned before, to include the Aviation Policy Memorandum target separately into the Climate Law. One alternative sub-option could be to include such a distinct target in the Climate Law but lower it compared to the targets in the Aviation Policy Memorandum, however still allowing for positive net emissions[12]. Lastly, a separate climate neutrality target for aviation may be included in the Climate Law, which would make the aviation target more comparable to the overall Climate Law target, but would leave aviation outside the target for the domestic sectors.

This way, we arrive at the following policy options for integrating aviation into the Dutch Climate Law:

- **Policy Option 1**: Extend the scope of the Climate Law to include aviation and include aviation into the 2050 climate neutrality target. The targets from the Aviation Policy Memorandum may still apply, but are not included in the law in this option.
- **Policy Option 2**: Extend the scope of the Climate Law to include aviation and create a distinct emission reduction target for aviation for 2050:
  - **Sub-Option 2A**: corresponding to the target in the Aviation Policy Memorandum[13];
  - **Sub-Option 2B**: lower than the target in the Aviation Policy Memorandum, but not zero;
  - **Sub-Option 2C**: corresponding to climate neutrality for aviation (net-zero).

Hereafter, we discuss the consequences, opportunities and risks of these four policy options, respectively.

4.3.2 Consequences

In this section we present the expected consequences of the policy options, without adding an appreciation. In the next sections we discuss opportunities and risks, from the viewpoint of the Ministry's policy objectives.

In **Policy Option 1**, the 2050 climate neutrality target would apply to aviation and all emissions from the domestic sectors, such as industry, housing and non-aviation mobility, together. All residual emissions from these sectors should be compensated by an equivalent amount of carbon removals. Because the target applies to the total emissions of all sectors within scope, it does not imply climate neutrality for any of the sectors separately.
Also, the target in itself does not prescribe how much residual emissions are still allowed, and by consequence neither how much carbon removals are needed to achieve the target. If the Aviation Policy Memorandum targets still apply at the same time, only the residual emission from aviation could be compensated for, but this would not be legally enshrined in this policy option.

In **Policy Option 2**, the aviation target is not linked to the current climate neutrality target of the sectors covered by the current version of the Climate Law and the latter would not be affected. The Climate Law just serves as the vehicle to enshrine the emission reduction targets for aviation.

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[12] We don't consider the option of lowering the Aviation Policy Memorandum target all the way to gross zero emissions, which we consider not realistic as it would mean no fossil kerosene could be tanked for Dutch aviation in 2050 anymore and that SAF would have zero GHG emissions over the entire lifecycle. Note, that the climate impact of aviation in 2050 is bigger than the CO_2 emissions due to the non-CO_2 effects of aviation, which are out of scope of this study.

[13] The Aviation Policy Memorandum includes targets for 2030, 2050 and 2070, but we focus on the 2050 target in the remainder of the discussion to be able to compare with the climate neutrality target in the current Dutch Climate Law.

The added value of including these targets in the Climate Law in contrast to creating a separate law, is that the Climate Law includes several provisions to guarantee a policy cycle aimed at monitoring progress and involving stakeholders. In this policy option, aviation would be part of this policy cycle. Important elements of this policy cycle are the Climate Plan (Art. 3-5) and the annual policy evaluation report[14] by the PBL Netherlands Environmental Assessment Agency (Art. 6-7). If the annual report shows that emission reductions are lagging behind compared to the targets, this can create pressure from Parliament to take more measures or be a reason for the Ministry to engage with stakeholders from the respective sectors and discuss the possibilities to enhance actions.[15]

In **Sub-options 2A and 2B**, the aviation sector would have to achieve an in-sector emission reduction target that is equal or lower to the current Aviation Policy Memorandum targets, respectively, which are expressed with reference to 2005 emissions of the Dutch aviation sector. The reduction has to be achieved by lowering tanked fossil aviation fuels, for instance by using SAF (which counts as 100% reduction in the context of the Aviation Policy Memorandum targets), flying more efficiently of flying less. Carbon removals play no role in the achievement of the target, and the total amount of carbon removals needed for compliance with the Climate Law as a whole would not change compared to the current situation.

In **Sub-option 2C**, aviation has its own distinct target, but this is equal to the current target of the Climate Law for the domestic sectors: reaching climate neutrality by 2050. This means no cap is set on the emissions as such, as long as they are compensated by carbon removals. Hence, no direct relationship with the Aviation Policy Memorandum targets can be established[16]. The total amount of carbon removals necessary for compliance with the Climate Law as a whole would be the same as in Policy Option 1, but in this case the aviation sector would reach climate neutrality by itself. An important issue here is that this would imply a new framework on how aviation would be allowed to compensate its residual emissions. Indeed, for the climate neutrality target in the current Climate Law, compensating residual emissions by purchasing carbon removal credits is not allowed. Climate neutrality must be achieved by balancing emissions and sinks/carbon removals on Dutch territory. In this sub-option, this approach would not work as aviation cannot create carbon removals in-sector. Therefore, this sub-option would imply the development of a mechanism allowing aviation to purchase carbon removals elsewhere, while guaranteeing that double-counting is avoided.

4.3.3 Opportunities

In this section we identify the opportunities, in the Ministry's perspective, of the various policy options. We look at advantages of the options, both related to the substance and to the political context. Where applicable, we also mention expected views of other stakeholders.

The main advantage of **Policy Option 1** is that all sectors under the Climate Law would be treated equally: together they have to achieve climate neutrality, and no sector is singled out. This could be a political advantage, both domestically and internationally.

[14] Klimaat- en Energieverkenning (KEV).

[15] To be sure, aviation is already included in the KEV, but less prominently than other sectors, see also Section 4.4. The point being made here is that including aviation into the Climate Law would make it a more central part of the policy cycle underpinning this law.

[16] Unless an additional condition is set, such as reaching climate neutrality but with a maximum amount of emissions. This would in fact result in another sub-option that we don't further elaborate on here.

By including aviation into the Climate Law, its anomalous position in national climate policies would end, and it would not get a distinct emission target while other sectors would not. Overall, the policy framework would be clear and simple, with a strong legal signal that emissions should be reduced, albeit without sectoral targets. As mentioned before, it is possible to still commit to the targets from the Aviation Policy Memorandum in this option, but without enshrining them into law, as is currently the case. This would be comparable to other, domestic sectors having ambitions or projected reduction pathways as indicated in the Climate Agreement (Rijksoverheid, 2019), but without a binding, legal status.

As for the aviation sector, both in the Netherlands and internationally, this policy option would probably be the most acceptable to third countries and other stakeholders, as it would not necessarily imply a significant reduction of in-sector aviation emissions, hence number of flights. Therefore, the risk of countermeasures would be limited. See further in Textbox 2 on a brief overview of third countries' policies and the interactions between Dutch policies and those of the EU and third countries.

Textbox 2 - Interactions with EU and third countries' policies

The European Climate Law, which includes a domestic net-zero greenhouse gas emission reduction target for 2050, is directly applicable in all EU Member States, since it is a Regulation. Member States are not obliged to achieve net-zero also on their own territories. Even so, the Netherlands are not the only Member State to have adopted a national Climate Law on top of the European one. According to a 2023 report (Ecologic Institute, 2023), which was an update of an earlier study (Ecologic Institute, 2020). 22 governments from the EEA+UK area have adopted some form of a national climate law, albeit only fifteen of these include objectives beyond a time horizon for 2030. However, from this reports it does not become clear whether aviation is included in the scope of these climate laws. In 2021, the UK has set its 6th UK Carbon Budget into law (Gov.uk, 2021). The budget incorporates the UK's share of international aviation and shipping (IAS) emissions for the first time, aligning with its commitment to achieving net-zero greenhouse gas emissions by 2050.

Apart from national climate laws, several Member States do have national policies on emission reduction from aviation, on top of EU level policies. France, for instance, has prohibited certain short domestic flights and Germany and Sweden apply a landing charge that is dependent on emissions. Norway, which is not an EU Member State but does belong to the EEA, applies CO_2, NO_x and SO_x taxes on domestic flights (CE Delft, 2021a). In Denmark, there are plans to create a 100% green domestic flight route (State of Green, 2022).

At EU-level, there is no specific emission reduction target for aviation. The EU regulates aviation emissions mainly through the ETS and the ReFuelEU Aviation Regulation, which sets targets for the use of Sustainable Aviation Fuels (SAF). These instruments work by definition, and on purpose, at EU level, to guarantee a level playing field. By setting a national target for aviation in the Netherlands, there is a chance that this will lead to evasion of passengers and freight, thereby causing carbon leakage, but only if the aviation target does lead to additional cost increases that do not apply in the neighbouring countries. Given the fact that all policy options assessed in this section only involve targets for 2050, and no mechanisms to realise emission reductions or to establish a certain reduction pathway (see also **Fout! Verwijzingsbron niet gevonden.**), it is implausible that adopting any of the policy options in itself would lead to a ticket price increase, and hence carbon leakage, on the short term.

Policy Option 2 has the advantage that it separates aviation from other, domestic sectors, which renders it more in line with UN practices. Furthermore, as mentioned before, the Climate Law includes a number of provisions on a policy cycle aimed at monitoring progress towards the Law's targets. A clear advantage of including a separate target for aviation in the Climate Law, which could in principle also be done by creating a new law, is that the aviation sector would be included in the relevant policy cycles of climate

mitigation policies. Furthermore, creating a separate target for aviation could increase political and societal pressure to reduce aviation emissions.
Policy Option 2A would be the most direct way of legally enshrining the target(s) from the Aviation Policy Memorandum. Identifying options for doing so is one of the key objectives of this study, so in that sense this option is attractive from a policy view. Until now, the Aviation Policy Memorandum's targets are not enforceable, and this policy option would change that.

Policy Option 2B would have a comparable advantage, and additionally it would partly counter criticism that aviation would still be allowed to have positive emissions in 2050, while other sectors try to liquidate all their remaining emissions. This might be an advantage from the perspective of climate policies, but of course it would increase resistance from the aviation sector itself compared to Option 2A.

In contrast to Option 2A and 2B, **Policy Option 2C** would not legally enshrine the Aviation Policy Memorandum target for aviation, or an even stricter target. Instead, it would legally enshrine the target of climate neutrality for aviation. Compared to Option 1, the advantage from a policy perspective could be that in this case there would be a separate target for aviation, which means aviation would not interact with other sectors' path towards climate neutrality. For the aviation sector, this option would be attractive compared to Option 2A and 2B, because there would be no in-sector target related to fossil fuel use, but rather the possibility to compensate emissions with carbon removals (for which, as mentioned above, a new regulatory framework would be necessary). Also, by achieving this target, the Dutch sector would automatically comply with LTAG (see Section 3.3).

4.3.4 Risks

After having discussed consequences and opportunities of the various policy options, in this section we assess the risks associated to them. Before turning towards the separate policy options, we point at a **generic risk that applies to all policy options considered**, which was already touched upon in Textbox 1. All policy options relate to inserting aviation into the climate law and thus legally enshrining some kind of emission reduction target for the aviation sector. The CO_2 ceiling approach (see Section 4.2), on the other hand, does more than that: it provides a mechanism through which the desired emission reductions are actually achieved, namely by imposing emission ceilings on each airport. Of course, these emission ceilings still have to be implemented themselves, but the CO_2 ceiling policy instrument provides some way of safeguarding that the emission reduction targets are met.

This aspect is lacking in all policy options for including aviation in the Dutch Climate Law. All options provide a legal obligation to reduce emissions, but no mechanism or instrument to actually realise the emission reductions. In particular, setting a reduction target for 2050 does nothing to enforce a certain reduction *pathway* between now and 2050. Also the monitoring provisions included in the Climate Law, such as the Climate Plan and the KEV, do not establish such a reduction pathway and are insufficient to safeguard the achievement of the targets. This means there is a significant risk that emissions will stay at a high level for too long and reductions will not take place sufficiently and/or not in time. This could lead to higher cumulative emissions than remaining carbon budgets that are in line with the goals of the Paris agreement.

From this, we conclude that including the emission reduction targets for aviation into the Climate Law in itself is not sufficient to safeguard these targets, but should be complemented by other instruments to mitigate emissions. Still, compared to the current situation where the targets are not legally enshrined, including them in the Climate Law

offers the advantage that aviation would become an integral part of the climate policy cycle and hence would play a larger role in climate policy than is currently the case. Looking into more detail of the different policy options, we note that risks and opportunities are often two sides of the same coin, as was mentioned above. For **Policy Option 1**, the advantage of all sectors being treated equally also bears a risk, as aviation is quite different from other sectors in its emissions trend. This risk was also discussed briefly in Textbox 1. Where most other sectors have already reduced their emissions over the last decades (with the exception of agriculture), aviation emissions are expected to continue increasing. Given the fact that Policy Option 1 does not limit the emissions of any sector in particular, and residual emissions are still allowed as long as they are compensated for, this policy option is not able to set a break on this emissions trend by itself. Keeping the targets from the Aviation Policy Memorandum at the same time is a possibility, but in this policy option these targets are not legally enshrined, so it is unclear how they should be enforced. If no other policy instruments reduce aviation emissions significantly, these will continue to grow or decrease too slowly, and other sectors either have to reduce even more than in the current situation (with aviation excluded from the Climate Law) and/or the total amount of carbon removals needed for compliance with the climate neutrality target will increase. The latter bears a risk in itself, as technologies for (permanent) carbon removals are still under development and it is not clear what volumes of carbon removals will be available and at what price. See Textbox 3 on a brief discussion of the main features and challenges of carbon removals.

Textbox 3 - Main features and challenges of carbon removals

It is now broadly acknowledged that removing CO_2 from the atmosphere (carbon dioxide removal – CDR) is necessary in order to achieve the temperature targets from the Paris Agreement. For scenarios in which the global temperature rise stays below 2 degrees, it is estimated that between 2020 and the moment climate neutrality is reached, 170-260 $GtCO_2$ must be removed cumulatively (Smith et al., 2024). Carbon removals can be used to compensate for current emissions, to compensate for residual emissions when climate neutrality should be reached in 2050, and to revert a potential temperature overshoot afterwards. At the moment, there is still a significant gap between what countries are proposing in terms of CDR and what is needed to achieve the Paris temperature goal (Smith et al., 2024).

Several methods or technologies exist for CDR. Their main distinctive feature is whether they provide permanent carbon removals (with permanent meaning at least several centuries) or non-permanent removals. Permanent removals can be achieved for instance by capturing carbon directly from the air or from the combustion of bio-based carbon, and store the captured carbon dioxide underground. Also the deployment of biochar, a particular form of carbon produced through pyrolysis, can provide permanent carbon removal. More nature-based solutions, such as afforestation or carbon sequestrating in arable lands, are easier and cheaper to realise, but do not lead to permanent carbon removals.

To genuinely compensate for residual emissions, permanent carbon removals are needed (CE Delft, 2023). However, many challenges remain in upscaling the available technologies. Direct Air Carbon Capture and Storage (DACCS), for instance, has still high costs and energy needs associated with it. For Bio Energy with Carbon Capture and Storage (BECCS), the availability of sustainable biomass may pose a challenge for scaling up the volume of CDR. For both technologies, the availability of storage capacity is also key. This can become increasingly scarce when CDR is being scaled up. When looking at the Netherlands for example, DACCS and BECCS will require storage capacity in depleted gas fields under the North Sea. The more carbon removals are necessary, the more far-away gas fields will have to be deployed, with higher costs involved accordingly (CE Delft, 2023).

Apart from technological and financial challenges, **CDR policies also still need to be developed for a large part.** Currently, there is only a voluntary market for carbon removal certificates. The creation of a mandatory market seems essential to develop stable business cases, as well as flanking measures. In the Netherlands, the government is advised to focus on permanent carbon removals, to stimulate those through the creation of a public purchasing programme, and to initiate further policy development in the EU (WKR, 2024).

When considering the aviation sector, it is crucial to note that CDR is not possible within the aviation sector. Therefore, **when aviation has to compensate for residual emissions, it needs to purchase carbon removal certificates elsewhere**, thus pushing up the prices and making it harder for other sectors to compensate for their residual emissions. As was mentioned in the main text, organising this in the Dutch context would require the development of a regulatory framework.

A risk related to the international context is that, while aviation may be treated more equally in this option from a domestic point of view, it is still no common practice to include international aviation in overarching emission reduction targets because of UN agreements. It should be noted, however, that countries do have the liberty to design national climate laws as they wish; the agreement to exclude international aviation only applies to the Nationally Determined Contributions (NDCs) and national GHG inventories that countries have to submit to the UN. Nevertheless, deviating from the norm here may still lead to a lack of understanding by international stakeholders or the idea that the Netherlands is frustrating attempts to regulate international aviation through ICAO regulation, as is the internationally agreed approach. To be sure, this reasoning also holds for other unilateral measures to reduce aviation emissions, such as a CO_2 ceiling.

In a similar vein, the advantage of **Policy Option 2** of establishing a separate target for aviation, thus avoiding the above mentioned risks, at the same time leads to another risk, namely that this option is less attractive to both the Dutch aviation sector and international stakeholders. This is because aviation has a separate target here, which may lead to direct consequences for the number of flights from the Netherlands. The probability of countermeasures from third countries is therefore higher for this policy option.

Policy Options 2A and, to a lesser extent, 2B have another risk that relates more to domestic politics. Even though these options establish a legally enshrined emission reduction target for aviation, which currently does not exist, the fact that this target explicitly allows aviation to have residual emissions in 2050 may lead to concerns in other sectors. Although the Climate Law's climate neutrality target does not require them to achieve (close to) zero residual emissions, other policy instruments are in place to reduce these residual emissions as much as possible. At the same time, emissions in most other sectors have been decreasing already for some decades, while aviation emissions continue to grow, mainly driven by increased demand (see Section 2.2) . All this would challenge the acceptability of these policy options among other Dutch stakeholders and/or risk that other sectors will ask for more room for residual emissions themselves. In fact, as described under Section 4.3.3 on the opportunities, the main rationale for Option 2B would be to partly mitigate this same risk by allowing less emissions for aviation in 2050 than in Option 2A.

This risk can also be expressed at a more conceptual level. Although there may be arguments (by stakeholders) for giving more room to aviation in terms of residual emissions, such as the projected growth of the sector or the technological challenges to reduce emissions (hard-to-abate), this does not change the reality that the space for manoeuvre for achieving the targets of the Paris Agreement is shrinking rapidly. In other words, this policy option may not require all aviation emissions to be compensated by carbon removals in

2050, but in the end the actual state of the atmosphere and the remaining carbon budget may require this anyway.
Lastly, even though the aviation sector and other stakeholders may favour **Option 2C** over 2A and 2B, the fact that Option 2C would lead to a separate target for aviation may still cause significantly more resistance than what could be expected from Policy Option 1. Furthermore, the risk, identified for Option 1, that aviation emissions are actually not reduced sufficiently and carbon removals are overly counted upon, naturally also applies to Option 2C.

4.4 Other options to safeguard reduction targets for aviation

Next to the options of a CO_2 ceiling (Section 4.2) and including aviation in the Dutch Climate Law (Section 0), other options are possible to enshrine the emission reduction targets of the Aviation Policy Memorandum. In this section, a brief overview of alternatives is given, without investigating the options in detail. None of the options safeguards by itself that the emission reduction targets are met, but support the decrease in emissions or creates awareness by monitoring the development of emissions. We briefly discuss:
- annual monitoring;
- dialogue-based processes;
- other governmental influence.

Annual monitoring: Aviation is part of the annual Climate and Energy Outlook (KEV)[17] of PBL Netherlands Environmental Assessment Agency (PBL, 2024). The emissions of the sector are monitored base on sold bunker fuels and estimations for future years are provided. In line with the Climate Law, emissions from international aviation and shipping are not being calculated into the national emission total. The emissions and progress of aviation are also monitored through the Climate Plan (Ministerie van KGG, 2024), but not included in the climate dashboard[18].
Strengthening the monitoring of aviation emissions and explicitly raise attention for the progress towards the targets for aviation in Parliament would raise awareness and may form a first step towards legally safeguarding emission reduction targets for aviation.

Dialogue-based processes: The monitoring could be combined with cyclical dialogue-based processes among different stakeholders from the aviation industry. An existing example is the Sustainable Aviation Table (DLT), with independent chairman Lodewijk Asscher.
The DLT brings together airports, airlines, knowledge institutions, fuel producers, the manufacturing industry and policy makers, who can in principle together suggest or prepare measures to reach the emission reduction targets of the Aviation Policy Memorandum. Partners from industry could also reach bilateral or multilateral agreements in order to achieve their own sustainability targets that contribute to the overall targets of the Netherlands.

Other governmental influence: Even without legal enforcement for limiting emissions to a specific emission level, the government maintains influence on aviation emissions with other aviation policies and decisions. Possibilities are for instance the regulatory flexibility within the airport traffic decrees, decision making about airport expansions and openings (like Lelystad Airport), stimulation of SAF and implementation or adjustment of pricing mechanisms, like the national ticket tax for departing passengers. This shows that even in the absence of legal anchoring, the government has fallback measures to manage and

[17] Klimaat- en Energieverkenning.
[18] www.dashboardklimaatbeleid.nl/

influence CO_2 emissions from aviation. These options do rely, though, on a certain level of (societal) pressure and accountability within the sector.

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A Annex A

Table 1 - Overview of relevant climate agreements and policy instruments for the decarbonisation of aviation

	Targets 2030	Targets 2040	Targets 2050	Targets 2070	Overall target	Scope	Remarks	Implications	Legal status/actors
Global level									
Paris agreement					Long-term temperature goal (2, preferably 1,5 °C global warming).	All emissions.	All aviation included in target, but mandatory NDCs only have to cover domestic aviation. International aviation covered by ICAO.		Binding for all parties to the Agreement.
CORSIA					Carbon neutral growth from 2020. Baseline: 85% GHG emissions, compared to 2019 (from 2024 until end of scheme 2035).	All aviation emissions covered by CORSIA above CORSIA baseline.	Based on offsetting of emissions (not CDR). Instrument ends in 2035.		Mandatory until 2027, binding for non-exempted Member States from 2027 onwards.
LTAG			Net-zero carbon emissions (ICAO, 2022b)			All aviation emissions.	Has to be worked out in detail, agreements have to be made during next ICAO assemblies.		Non-binding.

European level									
EU climate law	55% GHG emission reduction.		Climate neutrality in 2050.			All domestic EU emissions, also departing flights are included.	Targets do not apply at national level but all Member States should contribute their fair share.		Binding at EU level.
ETS Aviation Directive		ETS cap will reach zero around 2040.			No (only in combination with stationary ETS).	Intra-EEA aviation.	Reductions can also be realised in other sectors as ETS allowances are interchangeable.	Decreasing cap of the ETS for aviation does not automatically lead to a reduction in emissions from intra-EEA aviation (the aviation sector buys allowances from other sectors) (CE Delft, 2024).	Binding for airlines.
RED3	Transport target in 2030; RFNBO/advanced biofuels subtarget (5.5% of which 1% RFNBOs) in 2030.					All transport fuels used in EU.	For the transport target, Member States can choose between 14.5% GHG intensity reduction or 29% renewables. Member States can decide on the contribution of aviation to these targets.		Binding for Member States.
ReFuelEU Aviation Regulation	SAF blending obligation of 6%.	SAF blending obligation of 34%.	SAF blending obligation of 70%.			Aviation fuel uptake in EU, some exemptions.			Binding for Member States/fuel suppliers.
Energy Tax Directive (ETD) proposal						All energy products. For aviation fuel: mandatory for intra-EU passenger flights, optional for cargo and extra-EU flights.	In proposal phase, no agreement yet (and not expected in the short term). If adopted, Member States are required to apply a minimum tax rate on aviation fuel for intra-EU passenger flights.		Binding for Member States (when implemented).

National level									
Dutch Climate Law	55% GHG emission reduction compared to 1990.		Net-zero GHG emissions, 100% renewable electricity produced.	After 2050 negative GHG emissions.		All NL emissions (according to the national inventory for the UNFCCC, thus excluding international aviation).	States that aviation targets need to be achieved at international level.		Binding at national level.
Aviation Policy Memorandum	Emissions equal 2005 emissions.		Emissions equal half of 2005 emissions.	Emissions are zero.		Departing flights from Dutch airports.	Policy ambition, but not enshrined in law.		Non-binding.
CO_2 ceiling					No concrete ceilings yet.	Departing flights from Dutch airports.	Not yet translated into concrete emission ceilings for Dutch airports; only then the instrument would become legally binding. Offsetting is not possible.		Binding at national level (when implemented).