# Effects of the Fit for 55 Package on the Dutch Aviation Sector

CE Delft

Committed to the Environment

# Effects of the Fit for 55 Package on the Dutch Aviation Sector


This report was written by:
Maarten de Vries, Emiel van den Toorn, Stefan Grebe



Delft, CE Delft, December 2021

Publication code: 21.210415.171

Aviation / Emissions / European Union / Government / Policy / Measures / Future / Effects / Analysis

Client: Ministerie van Infrastructuur en Waterstaat

Publications of CE Delft are available from www.cedelft.eu

Further information on this study can be obtained from the contact person Stefan Grebe (CE Delft)

# Content

# Summary

In this study we investigated the impacts of the European Commission's 'Fit for 55' legislative package on the Dutch aviation sector. This comprehensive package, presented in July 2021, is designed to implement the enhanced EU climate target of at least net 55% greenhouse gas emission reduction in 2030, relative to 1990 emission levels. In our assessment we focused on four proposals directly affecting the aviation sector:

- The revision of the **Emission Trading System (ETS)** for Aviation, including the introduction of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). The ETS for Aviation has been in place since 2012 for flights within the European Economic Area (EEA). The Commission proposes to phase out free allocation of allowances for aviation. For flights departing from the EEA to third countries ('extra-EEA flights') it is furthermore proposed to join the global mechanism of CORSIA. Under CORSIA airlines have to offset their emissions that exceed the baseline (currently 2019).
- The **ReFuelEU Aviation** regulation, which introduces a blending obligation for Sustainable Aviation Fuels (SAF). In 2030, at least 5% of aviation fuels provided at EU airports should consist of SAF, in 2050 63%.
- The revision of the **Renewable Energy Directive (RED)**, which stipulates a greenhouse gas intensity reduction target of 13% in 2030 for energy and fuels in the entire transport sector, including aviation.
- The recast of the **Energy Tax Directive (ETD)**, which extends the working of this directive to include the aviation sector. This means a minimum tax rate for kerosene will apply, phasing in over a period of ten years from 2023. From 2033 on also SAF are subject to a minimum tax rate.

## *Additional costs and their impact on demand*

Making use of the Impact Assessments accompanying the Fit for 55 proposals and other literature, we assessed the additional costs for airlines for each proposal individually in 2030 and 2050, expressed as an average ticket price increase. Next, we estimated the net ticket price increase rate for all proposals cumulatively, taking into account mutual interactions. The increase in ticket prices induces a decrease in demand, determined by the price elasticity. For 2050 we distinguished a low carbon price and a high carbon price variant due to uncertainties on the functioning of the ETS and CORSIA in 2050 and resulting market prices.

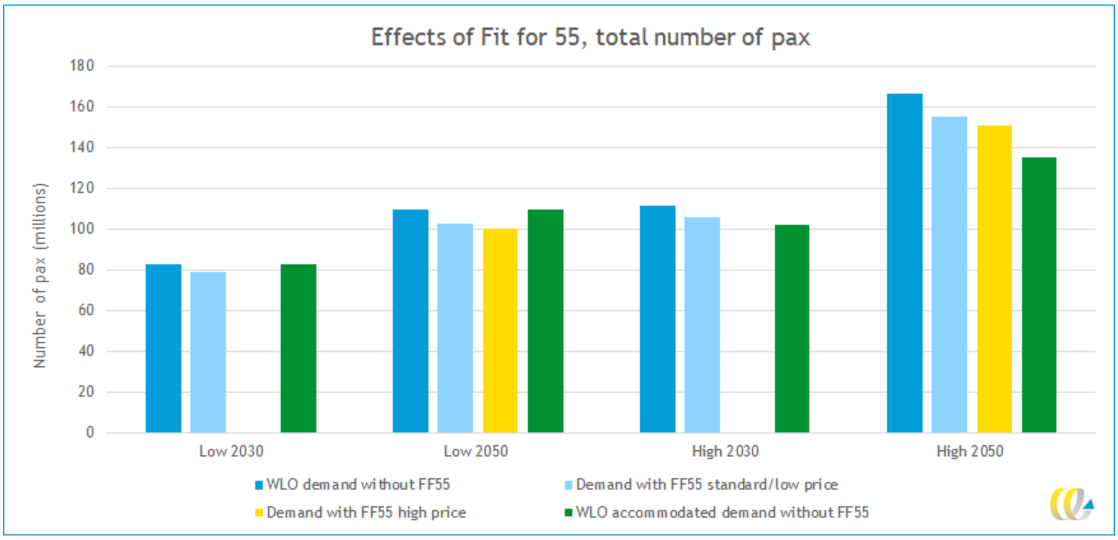
To estimate the effects on the Dutch aviation sector specifically, we made use of the Welvaart & Leefomgeving (WLO) scenarios for Dutch aviation[1]. The WLO presents two scenarios, Low and High, which project economic growth and technological developments and take into account the limited capacity of Dutch airports, distinguishing real demand and accommodated demand.

Figure 1 shows the impact of the Fit for 55 proposals on the total number of passengers travelling through Dutch airports. The dark blue and green bars represent WLO model output of real and accommodated demand, respectively. For 2030, the light blue bar represents the effects of the Fit for 55 package applied to real demand. For 2050, the light blue bar reflects the Fit for 55 effects on demand with the low carbon price assumed (ETS: € 88/tonne; CORSIA: € 30/tonne), the yellow bar reflects these effects with the high carbon price (ETS: € 315/tonne; CORSIA: € 160/tonne).

[1] By the Centraal Planbureau (CPB) and Planbureau voor de Leefomgeving (PBL).

It follows that in the WLO ‘Low’ scenario, reflecting low economic growth and moderate technological developments, demand does not surpass the capacity limits both for 2030 and 2050, so real demand is equal to accommodated demand. The total number of passengers will then decrease both in 2030 and 2050 due to the Fit for 55 proposals, resulting in financial effects for both airlines and airports. In the WLO ‘High’ scenario, characterised by high economic growth and fast technological developments, the price increase will also lead to lower demand, but demand still surpasses the capacity limits. Therefore, in this scenario the number of passengers or flights is not reduced due to the Fit for 55 package.

**Figure 1 – Effects of Fit for 55 (FF55) on total number of passengers (pax) travelling through Dutch airports in WLO Low and High scenario in 2030 and 2050. For 2050, two carbon price variants are distinguished**




Since the Fit for 55 package has an EU-wide scope, it will not directly affect competition between EU airports. Origin-Destination (OD) passengers departing from Dutch airports cannot avoid the ticket price increases by choosing a different airport. The effects on competitiveness for Amsterdam Airport as a transfer hub were assessed at aggregated route level between continents, since transfer passengers may choose alternative routes via non-EU hubs as a consequence of the ticket price increases. We found that around 22% of all transfer routes via Amsterdam face a high or medium risk of losing market share to another hub airport, e.g. London, Istanbul or Gulf State airports. This particularly holds for routes between Europe and Asia, accounting for 14.1% of transfers and 1.8 million passengers annually.

### *$CO_2$ emission reduction*

Lastly, the effects of the Fit for 55 proposals on $CO_2$ emission reduction at EU level and at national level for the Netherlands were estimated. We found that the proposals affecting aviation account for about 3% of the total EU reduction task induced by the 2030 target. At national level, in 2030 in both scenarios the proposals are not sufficient to realise the target of the Luchtvaartnota 2020-2050 (emissions at 2005 level), as shown in Table 1. In 2050, only in the WLO Low scenario emissions will drop below the target set in the Luchtvaartnota (50% of 2005 emissions).

**Table 1 - $CO_2$ emissions in Mt $CO_2$ in the Dutch aviation sector, baseline and effects of the Fit for 55 package. In brackets the change in emissions with respect to 2005 is shown**

| | 2005 | 2030 | 2050 | |
|---|---|---|---|---|
| | | | Low price variant | High price variant |
| Low scenario baseline | 10.9 | 14.2 (+30%) | 17.1 (+57%) | |
| Low scenario Fit for 55 | | 12.9 (+18%) | 5.3 (-51%) | 4.8 (-56%) |
| High scenario baseline | | 15.6 (+43%) | 15.3 (+40%) | |
| High scenario Fit for 55 | | 14.8 (+36%) | 5.7 (-48%) | 5.7 (-48%) |

# 1 Introduction

On July 14th, 2021, the European Commission presented a comprehensive package of legal proposals aimed at implementing the enhanced EU domestic net greenhouse gas emission reduction target of at least 55% in 2030 compared to 1990 levels and paving the way for the climate neutrality target in 2050. The package forms a central part of the European Green Deal, which, according to the Commission, has to deliver a transformational change of the European economy. To achieve the EU's ambitious climate targets, all economic sectors will have to contribute their share and reduce emissions.

This package, indicated by its working title 'Fit for 55'[2], includes several proposals that affect aviation. CE Delft was requested by the Ministry of Infrastructure and Water Management (I&W) to assess the impacts of these proposals on the Dutch aviation sector. This report presents the results of this study and answers the following research questions:
- What is the financial effect of the relevant Fit for 55 proposals, individually and cumulatively, on the Dutch aviation sector?
- What is the estimated effect of these proposals on the competitiveness of the Dutch aviation sector?
- What is the contribution of these proposals, individually and cumulatively, on the $CO_2$ emission reduction at EU level and on the national level of the Netherlands?

In order to answer these questions, we make use of the Commission's Impact Assessments and supporting studies to assess the individual effects of the relevant proposals in terms of additional costs, expressed as ticket price increase rates, and $CO_2$ emission reduction. Next, we account for the interactions between the various provisions to arrive at net, cumulative ticket price increase rates for different flight categories. We make use of the Welvaart en Leefomgeving (WLO) scenarios forecasting the development of the Dutch aviation sector in 2030 and 2050 (CPB & PBL, 2016) and apply the ticket price increase rates resulting from the Fit for 55 proposals to calculate the change in demand due to the provisions in these proposals. Finally, we use these results to estimate the effects of the Fit for 55 package on Dutch aviation in terms of financial impacts and $CO_2$ emission reduction and we assess possible effects on competitiveness.

## Scope of this study

Below we briefly define the scope of our assessment and explain the assumptions we made prior to our analysis. More specific assumptions are referred to where applicable later in this report.

We include in our analysis the following Fit for 55 proposals that contain provisions impacting the aviation sector:
- The revision of the ETS for Aviation including the introduction of CORSIA.
- The ReFuelEU Aviation regulation.
- The revision of the current Renewable Energy Directive (RED II).
- The recast of the Energy Tax Directive (ETD).

We briefly reflect on the revision of the Alternative Fuels Infrastructure Directive (AFID) as well. We consider the Fit for 55 proposals as they were presented on July 14th, 2021, as in

2 Presented as 'Delivering the European Green Deal', see https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en#documents

the current, early phase of the negotiations it is not possible to anticipate on their final outcome. Furthermore, we assume minimum compliance of the provisions in the proposals. For instance, we do not take into account the options to extend the fuel tax rate of the ETD revision to cargo flights or extra-EEA flights, nor the possibility of imposing a higher tax rate than the proposed minimum rate.

For the purposes of this study, we define the Dutch aviation sector to consist of the six civilian Dutch airports (Amsterdam (Schiphol) including Lelystad, Rotterdam-The Hague, Eindhoven, Groningen (Eelde) and Maastricht)), the Dutch airlines and foreign airlines as far as they operate flights to and from Dutch airports. Fuel suppliers that provide fuel to Dutch airports are included in our assessment as well where relevant. For the airports, we only take into account their main activities (directed at the facilitation of air operations) and no other economic activities such as parking or catering. Furthermore, we do not take into account possible national policies that could interfere with the effects of the European proposals, such as a higher share of Sustainable Aviation Fuels (SAF) than prescribed by the ReFuelEU Aviation regulation. This way, our results can be considered as representing the autonomous impacts of the Fit for 55 package, which can be seen as the baseline for possible additional national policy options.

## Reading guide

In the next chapter we present the individual Fit for 55 proposals that affect aviation. For each of them, we derive the additional costs and $CO_2$ emission reduction resulting from the proposal from the accompanying Impact Assessment and/or underlying studies. In Chapter 3, we outline our methodology, explaining how we apply the results from Chapter 2 to the Dutch WLO scenarios to obtain the impacts for the Dutch aviation sector. In Chapter 4 we present the results for the financial effects, in Chapter 5 the results of the competitiveness analysis and in Chapter 6 the results in terms of $CO_2$ emission reduction. Lastly, in Chapter 7 we will draw general conclusions and answer the research questions.

# 2 Fit for 55 proposals affecting aviation

## 2.1 Introduction

In this chapter, the proposals of the Fit for 55 package that are relevant for the aviation sector are presented, as well as their projected impact in terms of additional costs and $CO_2$ emission reduction. For this analysis, we make use of the Commission's Impact Assessments accompanying the proposals, supporting studies that are referred to in the Impact Assessments, and other existing studies.

For the purpose of this chapter, the proposals are treated individually, without taking into account interactions between their respective provisions, in line with the approach in the Impact Assessments. For instance, the projected additional costs emerging from the revision of the Energy Tax Directive assume kerosene-fuelled airplanes and do not take into account the blending obligation resulting from the ReFuelEU Aviation regulation, which would decrease the share of kerosene due to the mandatory blending of Sustainable Aviation Fuels (SAF). We include this type of interactions in our analysis of the cumulative effects of the proposals for the Dutch aviation sector, see Chapter 3.

As is customary in Impact Assessments of the Commission, all projections are expressed compared to a baseline scenario. This scenario assumes the continuation of existing policies, without the adoption of the Fit for 55 package. This is especially relevant for the case of the ETS, as this instrument already exists and its scope is not changed by the Fit for 55 revision proposal. Note that the baseline scenarios include generic developments such as increase of demand and ticket prices and technical improvements, which also take place without additional policies.

For each of the relevant proposals, a brief summary of its main provisions is presented. Next, the resulting additional costs for airlines are determined. As these costs are passed through to passengers either fully or to a large extent, the additional costs are expressed as a relative change in average ticket price, for both 2030 and 2050 and relative to the baseline. For each proposal also the projected change in $CO_2$ emissions is presented for both years. In each case, the main results concern the EU as a whole (or the EEA) as this is the scope of the Impact Assessments. We also briefly elaborate whether the projected impacts for the Netherlands are expected to be equal to the EU/EEA average or not and present disaggregated data for the Netherlands specifically if available.[3] Each paragraph ends with a tabled overview of the main results, for later reference.

Paragraph 2.2 treats the revision of the ETS Aviation and the introduction of CORSIA. Paragraph 2.3 is dedicated to the Fit for 55 proposals related to the use of SAF. These are mainly the ReFuelEU Aviation regulation and the revision of the current Renewable Energy Directive (RED II), but we briefly reflect on the revision of the Alternative Fuels

[3] Note that these data are also based on the Impact Assessments and/or other studies related to the *individual* proposals, similar to the rest of the chapter. Our own analysis concerns the *cumulative* effects of the proposals for the Dutch aviation sector.

Infrastructure Directive (AFID) as well. Lastly, Paragraph 2.4 deals with the recast of the Energy Tax Directive.

## 2.2 Revision of the European Emission Trading System (ETS) for Aviation & CORSIA

### 2.2.1 Summary of the proposal

Since 2012 intra-EU aviation has been part of the EU's Emission Trade System (ETS). The Fit for 55 proposal concerning ETS Aviation (EC, 2021a) introduces a number of amendments to the existing directive, aligning its ambition level with the enhanced overall EU greenhouse gas emission reduction target of at least 55% in 2030 and preparing the application of ICAO's Carbon Offsetting Scheme for International Aviation (CORSIA) for flights to and from destinations outside the European Economic Area (EEA)[4].

Firstly, the Commission proposes to consolidate the number of ETS allowances available for aviation, by basing the allocation for 2024 and onwards on the emissions in 2023, reduced by the annual linear reduction factor of the cap that applies to the entire ETS. This reduction factor is increased from 2.2 to 4.2% and is applied retroactively from 2021, to induce a one-off downward adjustment of the cap.

Secondly, the allocation of allowances is amended in order to phase out free allocation from the current 82% to zero in 2027. A transition period applies from 2024, with the amount of allowances that is freely allocated decreasing linearly towards full auctioning in 2027.

Thirdly, the scope of the ETS is maintained to include flights within the EEA and flights to airports in Switzerland and the UK, also after 2023[5]. All flights to and from third countries and flights operated by EU airlines between third countries will be subject to the CORSIA provisions, obliging airlines to provide credits to compensate all emissions from these flights that surpass the baseline (currently at 2019 emissions). To ensure equal treatment for airlines on the same routes, up to 2027 flights to or from countries that do not apply CORSIA are exempt from the CORSIA (and ETS) obligations. After 2027, this still holds for the countries that belong to a category that is exempted from CORSIA also after its full entry into force, such as the Least Developed Countries (LDCs) and the Small Island Developing States (SIDS).

### 2.2.2 Additional costs

*ETS*

As the ETS for intra-EEA aviation is already in place and the current proposal does not change its scope, costs incurred by airlines to comply with the ETS are only additional as far as they result from the amendments mentioned above. For instance, the costs resulting

[4] The European Economic Area includes the EU-27, Norway, Iceland and Liechtenstein. The latter does not dispose of an international airport. Flights from EEA airports to UK and Switzerland also fall under the scope of the ETS.

[5] Following international resistance to the initial scope of the ETS Aviation, including flights to and from third countries, the EU decided in 2014 to temporarily limit its scope to intra-EEA flights ('Stop the Clock'). In response to a 2016 Resolution by the ICAO Assembly on a global measure for reducing aviation emissions, the EU decided to maintain this limitation from 2016 until the end of 2023.

from the rising ETS price are only considered additional to the extent that the price increases *more* than it would do without the Fit for 55 package. It actually seems probable that the ETS carbon price will indeed surpass the baseline projections, as is illustrated by the fact that the announcement of the Climate Target Plan in September 2020 spurred a steep increase of the price[6], leaving it at about € 60 at the time of writing, while the carbon prices applied in the baseline scenario of the Impact Assessment are € 26.50 in 2020, € 27.50 in 2025 and € 32/tonne in 2030 (2020 price level).

The first amendment, the enhanced linear reduction factor, causes the supply of ETS allowances to decrease stronger than under existing policies. This in turn leads to higher carbon prices, as long as demand remains at the same level or increases. The second amendment, directed at phasing out free allocation in 2027, seems to force up the carbon price as well, as airlines will eventually have to buy all the allowances they need, instead of receiving the majority for free as is currently the case. However, according to economic theory, the allocation method should not matter in the determination of the carbon price. This is because allowances that are obtained for free also reflect their market value, as not selling them would incur opportunity costs (CE Delft, 2021). In practice, full auctioning can still contribute to the price signal of the ETS, as companies do not always act fully according to rational principles and may be more triggered to realise emission reductions in case the majority of allowances is auctioned.

**Text box 1 - How do we interpret the ETS Aviation Impact Assessment?**

In the Impact Assessment accompanying the ETS Aviation revision proposal (EC, 2021b), several possible combinations of scopes for the ETS and CORSIA are investigated. The policy option that turns out to be the preferred one and is reflected in the ETS revision proposal (C3CLEAN), includes maintaining the ETS scope as it is (i.e. intra-EEA flights and flights from EEA airports to the UK and Switzerland). Therefore, as far as the ETS is concerned, in the Commission's analysis this option is equal to the baseline. The linear reduction factor is not treated as a variable that changes with the policy option[7], so the Impact Assessment provides little information on its effects on the ETS carbon price or the amount of $CO_2$ emission reduction that results from it.

However, the Impact Assessment does refer to a high carbon price variant (€ 84.50/tonne in 2030, 2020 prices) in the supporting study of ICF Consulting et al. (2020) that is useful for our purposes. We assume that this price level is a better reflection of the impact of the increased linear reduction factor. Note that this price level falls within the range for 2030 projections indicated in the Impact Assessment of the revision of the ETS Directive (EC, 2021c, p.35). In this scenario, based on a carbon costs pass through rate of 74%, ticket fares would rise by about € 7 or 4.7% between 2015 and 2030 (compared to ca. € 5 or 3.2% in the baseline). As explained above, for our analysis of additional costs we need to focus on the difference between the projected ETS carbon price and the price in the baseline scenario. This leads to an increase in the one-way intra-EEA ticket price of € 2.10 or 1.4%.

6 https://sandbag.be/index.php/carbon-price-viewer/

7 The Impact Assessment does consider different options for phasing in full auctioning, though. It concludes that there is a small risk of carbon leakage for higher auctioning percentages, but the costs associated with the change in auctioning remain well within the normal range of cost variability. Also, aviation demand for ETS allowances is only weakly affected by the pace of phasing in full auctioning.

## *CORSIA*

The price of offset credits needed to comply with CORSIA for extra-EEA flights is of a different order than the ETS carbon price. In its analysis of the preferred policy option the Commission assumes a price of € 1/tonne for CORSIA credits in 2030, which produces very small shares of carbon costs in fuel costs (0.06%) and operational costs (0.01%). In the baseline scenario CORSIA is only applied to flights between participating non-EEA countries, not to flights to and from the EEA or within the EEA. Therefore, the costs for airlines due to the proposed CORSIA implementation to flights to and from the EEA, albeit small, are additional. Assuming a cost pass through of 75-82% for extra-EEA flights, they induce an average one-way ticket price increase of only € 0.03, which is negligible. In the high price scenario, ICF Consulting et al. (2020) assumed a credit price of € 13.20/tonne. This would lead to a slightly higher price increase of € 0.24, still even less than 0.1%. The resulting demand for extra-EEA flights is projected to decrease from 276.9 to 276.5 trillion RTK, corresponding to -0.1%.

**Text box 2 - How do we treat uncertainties in 2050?**

In the previous paragraphs we only discussed additional costs and emission reductions up to 2030. It is quite challenging to draw conclusions about the impacts of ETS and CORSIA in 2050, as it is not clear how both instruments will function by then. The enhanced reduction factor of the ETS results in the cap reaching zero around 2040, leaving uncertainty about the existence and working principles of the mechanism after that. CORSIA's second phase ends in 2035, and a decision about what comes next will be made in due time. The Commission's Impact Assessments do not provide any projection of the carbon price within ETS or CORSIA in 2050.

To be able to take ETS and CORSIA into account in our calculations in this study for 2050, we need to make some assumptions about their status in 2050. The Destination 2050 report of the European aviation sector (NLR & SEO, 2021) suggests that in 2050 ETS allowances and/or carbon credits will still be available to enable airlines to compensate for hard-to-abate emissions by removing carbon from the atmosphere. The price of those allowances would be equal to the costs of removing 1 tonne of $CO_2$. For Europe, this is estimated to be € 315/t$CO_2$ in 2050. Outside Europe, the carbon removal costs are estimated to be lower, around € 160/t$CO_2$[8]. Thus, identifying the removal credits within Europe with the ETS allowances and outside Europe with CORSIA credits, we can consider those numbers as indicative for the ETS price and CORSIA credit price in 2050, respectively.

Naturally, there is a high level of uncertainty whether this scenario will indeed materialize. Until now there is no provision within the ETS Directive to account for removal credits or other types of negative $CO_2$ emissions. As an alternative option, Ricardo, GWS & Ipsos (2021, p.103) make assumptions for the baseline ETS carbon price up to 2050, extrapolating the Commission's baseline scenario to € 88 in 2050 (2015 price level). As noted above, we consider the baseline scenario as not taking into account the enhanced linear reduction factor sufficiently, but we can use it as a lower limit for the 2050 price projections. For CORSIA, we can use estimations from IETA (2020) to derive a corresponding lower limit for the international carbon credit price in 2050.

To account for the high degree of uncertainty with regard to the ETS and CORSIA in 2050, we present our results both for a low price variant and a high price variant for 2050 (see Chapter 4), based on the references

8 This cost difference arises from the different potential for certain methods of carbon removal within and outside Europe. For carbon removal within Europe, it is assumed that Direct Air Capture (DAC), which is relatively expensive, will be the most used method, as afforestation/reforestation and Bioenergy with Carbon Capture and Storage (BECCS) require vast amounts of land which might not be available in Europe. For the literature on which this assessment was based, see NLR & SEO (2021, p. 119).

mentioned above. Although both have their limitations, these two variants reflect a low- and high-end estimation of the 2050 carbon price, respectively, and enable us to take into account the price effects of the two market mechanisms in 2050 in a transparent way.

To arrive at the ticket price increase rates in 2050, we extrapolate the baseline ticket prices from the Impact Assessment (EC, 2021b) and calculate the contribution of the carbon costs on top of the baseline. As auctioning will be 100% in 2050, allowances will have to be bought for full emissions. We use an emission rate per passenger per kilometre of 80 g $CO_2$ (CE Delft, 2019)[9] and the same cost pass through rates as for 2030. See Table 2 at the end of this section for the resulting ticket price increase rates.

*Impacts for the Dutch aviation sector*

Both the ETS and CORSIA are market-based mechanisms, which means the carbon prices associated with ETS allowances and CORSIA offsetting credits are established by market forces and are the same to all participants. Therefore, there is no difference in additional costs related to ETS and CORSIA between the Dutch aviation sector and other parties participating in ETS/CORSIA. In theory, Dutch airlines could apply a different carbon costs pass through rate than the EEA average, which would lead to a different ticket price increase rate. Since it is not probable that Dutch airlines are in the position to apply carbon costs pass through rates that differ significantly from their competitors', we assume this would be a very small effect that we will not take into account any further.

### 2.2.3 Effects on $CO_2$ emission reduction

Although the ETS for aviation includes a cap on the total number of allowances made available each year, and this cap decreases annually, the current design of the system does not guarantee emission reduction in the aviation sector itself. This is because the aviation sector is a hard-to-abate sector, with high costs associated with emission reduction measures, and the high degree of interlinkage between the aviation pillar of the ETS and the main (stationary) ETS for industry and electricity production. Airlines are allowed to surrender allowances from the main ETS (EUAs) alongside the allowances for aviation (AEUAs), and for the current trading period (since 2021) the allowances from both pillars have been made interchangeable. In the current revision, the Commission proposes to maintain this interconnection and merge the two types of allowances. Therefore, emission reduction takes place where the related marginal costs are lowest, which is typically not in the aviation sector. Indeed, over the period 2013-2019, verified emissions in intra-EU aviation have increased by 27%[10]. In theory, this situation could change in the period up to 2050, if technological breakthroughs would enable the aviation sector to reduce emissions at much lower costs (relative to other sectors). We assess the probability of this scenario as low, however, as technological developments will take place in all sectors and aviation emissions remain fundamentally harder to abate. Thus, we assume that direct emission reductions as a result of the ETS will be realised in other sectors also in the future. Other (indirect) emission routes, e.g. through behavioural effects, are of course still possible.

As regards extra-EEA flights, CORSIA is actually designed to realise emission reductions outside the aviation sector through offsetting. So, both market-based mechanisms do not guarantee a gross reduction of aviation emissions, but induce net reductions in other sectors. The most straightforward way to quantify this indirect emission reductions is to look at the absolute emissions projected to be offset under both instruments. In 2030,

9 Assuming an intra-EEA average flight distance of 970 km (Ricardo et al., 2021) and an extra-EEA average flight distance of 6,000 km (estimation CE Delft).

10 https://www.eea.europa.eu/data-and-maps/dashboards/emissions-trading-viewer-1

according to the Impact Assessment accompanying this proposal, the EU ETS will lead to reductions in other sectors that add up to ca. 25.5 Mt, compared to a total intra-EEA aviation emission of 52.5 Mt. In the same year, CORSIA will offset 20 Mt for flights to and from the EEA at total emission levels of 174 Mt. It is assumed that CORSIA offsetting credits are of high quality and fully additional.

As with the assessment of additional costs, we have to take into account that the Commission treats the amended ETS as being equivalent to the baseline scenario. For intra-EEA flights, the share of emissions reduced in other sectors in 2030 (25.5 Mt on 52.5 Mt) corresponds to 49%, which seems very significant, but is not additional, as it is a consequence of the existing ETS scope. It is explicitly stated in the Impact Assessment that in 2030 the demand for ETS allowances from aviation by other sectors under the ETS is about 25 million, so there are no in-sector emission reductions expected as a consequence of the ETS in the baseline scenario. The Impact Assessment does not provide an estimate of the amount of emission reduction, inside or outside aviation, at an enhanced ETS carbon price level. As we have not identified any studies that elaborated on this question in more detail, we will assume that also at a higher carbon price (of about € 84.50) airlines will realise emission reductions in other sectors by buying extra allowances, as the higher price level is insufficient to spark in-sector reductions.[11] This also means that the volume of reduction in other sectors does not change with the ETS carbon price, as this volume only depends on the aviation emission level in 2030.

The offsetting under CORSIA for flights to and from the EEA is smaller in terms of the share of emissions that is being offset, but it does count as additional for a large part. In the baseline scenario, emissions from flights to and from the EEA amount to 170 Mt in 2030. With CORSIA being applied to this category, the net emission level is 154 Mt, so 16 Mt of emission reduction in other sectors can be assigned to CORSIA. This corresponds to an additional offset of 9.4% of direct emissions.

As indicated above, apart from the emission reduction achieved from compliance with the ETS and CORSIA, albeit de facto in other sectors, emission reductions can also take place through volume reductions as a result of lower demand due to ticket price increases. The Impact Assessment estimates this effect to be unsignificant in 2030 due to the low price increase rates. However, we will not ignore it, as in this study we will combine the price effects of all relevant proposals to estimate their cumulative impact on the Dutch aviation sector.

### *2050*

As explained in the previous section, the Impact Assessment does not include 2050 as a projection year as it is unsure what both the ETS and CORSIA will look like by then. Based on literature, we constructed a high price scenario based on the expectation that carbon removal will be central to both mechanisms and a low price scenario based on the current ETS Directive. Combined with our assumption on the marginal costs of emission reduction in aviation remaining high compared to other sectors, this means that also in 2050, direct emission reduction induced by the ETS and CORSIA will not be achieved in-sector. To what extent aviation emission reductions will be realised in other sectors by these mechanisms in 2050 is very hard to estimate with some degree of accuracy and would require a separate study outside the scope of this report.

[11] E.g. this in-sector reduction could be achieved by using (more) SAF, but at the given price level SAF is still more expensive than buying more allowances: according to NLR & SEO (2021), abatement costs based on SAF usage are at least € 280/tonne in 2030.

*Impacts for the Dutch aviation sector*

As the ETS works at EEA level and does not allocate certain budgets or targets to Member States, the associated $CO_2$ emission reduction cannot be assigned to the Netherlands or another Member State. The same holds for CORSIA, which is a global mechanism.

### 2.2.4 Overview

See Table 2 for the main figures presented in this section, which we will use for later analysis. Note that all figures are relative to the baseline, which includes the current ETS scope but not the application of CORSIA to extra-EEA flights. For 2030 we will disregard the baseline scenario as this does not take into account the amendments to the ETS Aviation directive sufficiently[12].

**Table 2 - Main figures for ETS revision & CORSIA: ticket price increase and $CO_2$ reduction compared to baseline**

| | **2030 high price**<br>ETS: € 84.50<br>CORSIA: € 13.20 | **2050 low price**<br>ETS: € 88<br>CORSIA: € 30 | **2050 high price**<br>ETS: € 315<br>CORSIA: € 160 |
|---|---|---|---|
| Ticket price increase ETS (Intra-EEA) | 1.4% | 0,0% (baseline) | 8.4% |
| Ticket price increase CORSIA (Extra-EEA) | 0.1% | 3.2% | 16.9% |
| $CO_2$ emission offset in other sectors by ETS (Intra-EEA) | 0.0% | N/A | N/A |
| $CO_2$ emission offset in other sectors by CORSIA (Extra-EEA) | 9.4% | N/A | N/A |

## 2.3 ReFuelEU Aviation & Revision of RED II

### 2.3.1 Summary of the proposals

*Relationship between ReFuelEU Aviation and the RED II revision*

The ReFuelEU Aviation proposal and the revision of the RED II will be treated here in conjunction as they both concern the use of sustainable aviation fuels (SAF). The Commission clearly considers the ReFuelEU Aviation initiative, creating a SAF blending obligation to fuel suppliers, to be a special case of the RED legislation, dedicated to the aviation sector. This is demonstrated, for example, by the remark in the explanatory memorandum of the ReFuelEU Aviation regulation that it 'constitutes a lex specialis' of the RED (EC, 2021f). Also, in the recitals of the RED II revision (EC, 2021d), the Commission explicitly states that dedicated obligations on aviation fuel suppliers should be set only pursuant to the ReFuelEU Aviation regulation.

However, the revision of the RED II includes an extension of the overall renewable energy target for the transport sector (now defined as a greenhouse gas emission intensity target)

[12] For the estimate of $CO_2$ emissions offset in 2030 we use the figure of 9.4% derived from the Impact Assessment for the high price scenario as this amount of offsetting seems unrealistic at a carbon price of € 1.

to cover the aviation and maritime sectors as well. It is not expected that complying with the blending obligation will be sufficient to meet the aviation's share in this transport target. Therefore, fuel suppliers will suffer additional costs by providing more advanced sustainable fuels than necessary under the blending obligation. Even though it is possible to actually provide these fuels to other transport sectors than aviation, the additional costs will probably partly be passed through to the aviation sector.

### *Renewable Energy Directive revision*

The overall objectives of the proposal to revise the Renewable Energy Directive (RED) (EC, 2021d) are to increase the amount of renewable energy used in the Union, to improve energy system integration and to align the directive to the updated European climate and environmental policies, including the preservation of biodiversity. In the revision, several existing targets are strengthened and new targets are proposed to enhance the Directive's contribution to the EU's 2030 greenhouse gas emission reduction target of at least 55%. The overarching target for renewable energy production at Union level is increased from 32% to 40% in 2030. Furthermore, various sectoral targets — indicative or binding — are defined to support the realisation of the overarching target.

For the transport sector, a main revision concerns the obligation for fuel producers to reduce the greenhouse gas emission intensity of all transport fuels. This intensity must be lowered by at least 13% in 2030 by enhancing the use of renewable energy. This target applies to the entire transport sector, including aviation and waterborne navigation.
In addition to these changes in the overarching sectoral target, the revision includes an increased volume-based sub-target for physical use of advanced biofuels (Part A of Annex IX) in the transport sector of 0.2% in 2022, 0.5% in 2025 and 2.2% in 2030 as well as a separate target for Renewable Fuels of Non-Biological Origin (RFNBOs) of 2.6% in 2030.

For bio-based fuels, the revision proposal strengthens the criteria for them to be counted as sustainable. Regarding RFNBOs, the revision stipulates that they can only count towards the targets set in the Directive as long as their use yields a greenhouse gas emission reduction of at least 70%. For recycled carbon fuels, this applies only to the 13% emission intensity reduction target for the transport sector.

In the Commission's proposal the current option to apply multipliers to certain renewable fuels and renewable electricity used in transport will cease to exist, since the Commission considers them less apt when expressing the sectoral target in terms of greenhouse gas emission intensity. To promote the use of sustainable fuels in the aviation and the maritime sectors, however, an exception applies to those sectors. In the calculation of the specific targets for advanced biofuels, biogas and RFNBOs in the aviation and the maritime modes, their share shall be considered 1.2 times their energy content.

### *ReFuelEU Aviation regulation*

In contrast to the RED II revision, the ReFuelEU Aviation initiative (EC, 2021f) is, as the name suggests, fully focused on the aviation sector. Its main provision concerns a blending obligation for sustainable aviation fuels (SAFs), imposed on fuel providers. This blending obligation is volume-based, stipulating a minimum share of SAFs in the fuel that is made available to aircraft operators at each Union airport that processes more than 1 million passengers or 100,000 tons of cargo annually[13]. Furthermore, airlines will be obliged, on an

[13] Under current policies, Amsterdam Airport (AMS), Rotterdam-The Hague Airport (RTM) and Eindhoven Airport (EIN) will remain above the limit of 1 million passengers annually. Also Lelystad Airport would attract more

annual basis, to take in at least 90% of the fuel they need for intra-EU flights at the Union airport of departure, to prevent tankering. Taken together, these provisions will, according to the Commission, both significantly reduce the greenhouse gas emissions of the aviation sector and stimulate the production and development of SAFs.

For the purpose of this proposal, SAFs can be both synthetic or bio-based (Part A and B of Annex IX). Feed and food crop-based fuels are not eligible. Apart from the general blending obligation, the Commission introduces a sub-target for synthetic sustainable fuels, to provide a specific stimulus for this more expensive type of SAF. For the definitions and sustainability criteria of the different types of fuel, the regulation refers to the relevant provisions in the RED. Recycled Carbon Fuels (RCF) do not comply with the criteria for synthetic fuels and therefore cannot contribute to the blending obligation. See Table 3 for the detailed obligations for the different target years.

**Table 3 - Blending obligations for different target years according to the ReFuelEU Aviation proposal**

| Type of fuel | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|
| All SAF | 2% | 5% | 20% | 32% | 38% | 63% |
| Synthetic fuels | - | 0.7% | 5% | 8% | 11% | 28% |

For both fuel suppliers and airlines, reporting obligations are introduced for monitoring and verification purposes. Airlines can claim the $CO_2$ emission reduction following from the SAF they have used to be accounted for under the ETS or CORSIA (see above). A transition phase is proposed for five years (2025-2029), during which each fuel supplier may supply the minimum share of SAF as a weighted average over all the fuel it supplied to Union airports. From 2030 on, the obligation will apply at airport level.

### *Revision of the Alternative Fuels Infrastructure Directive (AFID)*

As part of the Fit for 55 package, the Commission has revised the AFID (EC, 2021h) to adjust it to the enhanced climate ambitions of the EU. The current AFID (2014/94/EU) sets out a framework for the deployment of infrastructure for alternative fuels, but the Commission concluded that Member States' infrastructure planning falls short in terms of ambition, consistency and coherence. The aim of the revision proposal is to ensure the availability and usability of a dense, widespread network of alternative fuels infrastructure throughout the EU. Part of the revision entails changing the AFID into a Regulation to enable a more detailed prescription of measures.

As regards aviation, in general existing fuelling infrastructure is suited for SAF and there is no need for extensive adjustments. Infrastructure to supply electricity to stationary aircraft, however, is not widespread yet and needs more investments. To spur this development, the Commission proposes that at all main airports[14] ensure the provision of electricity supply to all gates from 2025 and all outfield posts from 2030. The Impact Assessment accompanying the AFID revision (EC, 2021i) estimates the total, EU-wide investment costs needed to comply with this provision at € 949 million over the time period

than 1 million passengers in case the airport would be opened for commercial flights. Maastricht Airport (MST) and Groningen Airport Eelde (GRQ) are forecast to receive significantly less than 1 million passengers annually until 2050. Cargo transit at MST accounts for about 100 kton annually, which would mean it would be covered by the ReFuelEU Aviation regulation as well (Significance & TO70, 2019). In conclusion, almost all flights from Dutch airports would fall under the regulation.

14 I.e. airports part of the TEN-T core network and 'comprehensive network' airports.

2021-2050. We include this type of investments in our general assessment of costs related to the Fit for 55 package (Chapter 4), but we assume they are not passed through in ticket prices and therefore are not part of the ticket price increase rates presented in this section.

### 2.3.2 Additional costs

According to the Commission's analysis the average fuel blend, containing the minimum mandatory share of sustainable aviation fuels, will remain more expensive than conventional jet fuel up to 2050, although over time the price difference is expected to decrease. The average fuel blend price will, as a consequence of the blending obligation, increase by 3.3% in 2030, 22.3% in 2040 and 32.7% in 2050 compared to the baseline (no new policies). Not all types of SAF will show the same price development, with the price of RFNBOs relatively decreasing most over the period up to 2050, while the price of certain biobased SAFs will slightly increase again after 2035 due to feedstock scarcity.

To calculate the resulting increase of ticket prices, a maximum cost pass through of 100% is assumed as well as a 25% share of fuel costs in ticket prices[15]. This leads to a predicted increase of average ticket prices of 0.8% in 2030, 5.6% in 2040 and 8.2% in 2050. Ticket price increase rates remain limited even up to 2050 mainly because of the decrease in SAF prices over time.

As explained above, apart from the costs due to the blending obligation, fuel suppliers and hence airlines will also incur additional costs related to the RED target for the transport sector. To estimate these additional costs, we consider fuel suppliers that provide fuel for the entire transport sector and assume they distribute their costs in the most cost efficient way over the subsectors to which they supply[16]. In aviation, average renewable fuel prices are higher than in other transport subsectors because some fuel options are not available in aviation and quality standards are higher. Since it is possible to supply renewable fuels in one sector and assign them to another through the system of renewable fuel credits (in Dutch: HBEs), we assume fuel suppliers choose to supply cheaper fuels to e.g. the maritime or road transport sector and count them towards the aviation sector.

As there exist many uncertainties about the sustainable fuel options and their costs in 2030, within the scope of this study it is not possible to give a precise estimate of the additional costs for the aviation sector resulting from the RED transport target. To provide an indication, however, we reason that fuel suppliers — in order to comply with the transport target — would need to account for 8% sustainable fuels additional to the blending obligation (13% transport target — 5% blending obligation)[17]. To account for the fact that supplying sustainable fuels to other sectors than aviation can be cheaper, we define a range of price ratios, assuming providing sustainable fuel to other sectors is 25%, 50% or 75% cheaper compared to providing it to aviation. This leads to an increase in the estimated ticket price increase rate from 0.8% in 2030 (only accounting for the blending obligation) to 1.8%, 1.4%[18] and 1.1%, respectively (also accounting for the RED transport target).

[15] Assumptions in the Impact Assessment (EC, 2021g), with share of fuel costs based on the upper bound of the range estimated by Eurocontrol, Aviation Intelligence Unit, Think Paper #1, June 2019.

[16] Renewable fuel credits can be traded as well, so this applies to all fuel suppliers.

[17] Ignoring the fact that the transport target actually is a greenhouse gas emission intensity reduction target and not a volume-based target such as the blending obligation. In reality, more than 13% renewable fuels are needed to achieve 13% greenhouse gas emission intensity reduction in the transport sector.

[18] 8% against 50% of the costs corresponds to 4% at full costs, so the hypothetical blending obligation rises to 9%. 0.8%/5*9 = 1.4%. Accordingly for the other price ratio assumptions.

Apart from the overall transport target the RED revision also introduces a specific subtarget for RFNBOs of 2.6% in 2030. The total energy consumption of the EU transport sector is projected to be about 310 Mtoe in 2030 (EC (2021e), Figure 22), which means the RFNBO target translates in 8 Mtoe in terms of energy consumption. The EU aviation sector is responsible for about 43 Mtoe energy consumption, with the specific blending obligation of 0.7% for e-fuels corresponding to 0.32 Mtoe. This means the aviation blending obligation for e-fuels only covers a small part of the RED subtarget[19]. RFNBOs include high-quality fuel categories like synthetic fuels that are suitable for aviation, but also hydrogen, which is projected to be applied mostly in heavy road transport. Therefore, it is probable that aviation will have to contribute a significant part of the RFNBO subtarget on top of the blending obligation. The exact share that will be accounted for by aviation, however, depends on various factors that are hard to forecast, such as price development, technological improvements, flexibilities in secondary legislation and strategic choices by fuel suppliers. Therefore additional costs due to the general RFNBO subtarget in the REDII revision are not included in our analysis. However, since RFNBOs are relatively expensive, this subtarget may turn out to cause significant extra costs for the aviation sector up to 2030.

*Impacts for the Dutch aviation sector*

An important feature of the Dutch transport sector is that the distribution of energy consumption over the various transport modes significantly differs from the EU average. In the EU, 72% of the consumed energy in transport is accounted for by road transport, and only 11% both by international aviation and by international maritime bunkers. In the Netherlands, international maritime bunkers are responsible for the largest share of energy consumption (45%), followed by road transport (39%) and international aviation (15%)[20]. This means that the options for Dutch fuel suppliers to sell their sustainable fuels — and to achieve the RED targets — are different than for their EU competitors. In particular, the extension of the RED transport target to include the aviation and maritime modes more than doubles the total amount of energy consumption in the Netherlands regulated by the RED.

### 2.3.3 Effects on $CO_2$ emission reduction

The introduction of a SAF blending obligation leads to a reduction of $CO_2$ emissions by the aviation sector in both a direct way (SAFs replacing fossil jet fuel) and an indirect way (decreasing aviation volume because of higher ticket prices, stimulating purchases of more efficient airplanes and more efficient operations).

In the ReFuelEU Aviation Impact Assessment, the Commission estimates the total tank-to-wing $CO_2$ emission reduction due to the blending obligation to be about -6.8% in 2030, -34.1% in 2040 and -65.3% in 2050, relative to the baseline scenario. The related well-to-wing emission reductions (-6.5%, -31.4% and -60.8%, respectively) are slightly lower, since in EU legislation sustainable biofuels are assigned a zero emission factor by definition, not taking into account possible emissions elsewhere in the production chain. According to the Impact Assessment, the projected reduction of 65.3% in 2050 translates to a 58% reduction compared to 2015 emission levels and a 24% reduction compared to 1990.

[19] If the subtarget of 2.6% would be fully realised in aviation, applying the multiplier of 1.2 would reduce the task from 8 Mtoe to 6.7 Mtoe.

[20] https://assets.website-files.com/6144857e3aac5ad07ebf212f/61aa31d92f1a7c110a874f00_21_1130_PHB_Heuvel_context%20and%20acceleration%20renewable%20fuels.pdf

*Impacts for the Dutch aviation sector*

According to the ReFuelEU Aviation proposal, at all airports within the Union the same minimum blend of SAFs must be offered after the transition phase ends in 2030. We assume minimum application of the legislation, so no additional blending. This would mean that the $CO_2$ emission reduction realised by every Union airport would be the same (assuming tank-to-wing reductions). Therefore, for the Netherlands the same numbers apply as for the EU-27. If we take the well-to-wing reductions into account, a possibly different typical fuel blend in the Netherlands could cause a slightly different amount of emission reduction compared to the numbers presented above, but as discussed above we assume the fuel blend in the Netherlands is the same as the EU average.

### 2.3.4 Overview

See Table 4 for the most important figures from this section, which we refer to later in this study. Both the blending obligation and the RED 2030 transport target are included in the ticket price increase rate. As regards the impact of the RED target, we assume supplying sustainable fuels to other sectors than aviation to be 50% cheaper, leading to an overall price increase rate of 1.4% in 2030. As explained above, this is just an indication as the price effect of the RED target is hard to estimate due to several unknown factors.

**Table 4 - Main figures for ReFuelEU Aviation & RED II revision - ticket price increase and $CO_2$ reduction relative to the baseline scenario. Both the blending obligation and the RED 2030 transport target have been accounted for**

| | 2030 | 2040 | 2050 |
|---|---|---|---|
| Ticket price increase | 1.4% | 5.6% | 8.2% |
| $CO_2$ reduction tank-to-wing | -6.8% | -34.1% | -65.3% |
| $CO_2$ reduction well-to-wing | -6.5% | -31.4% | -60.8% |

## 2.4 Recast of the Energy Tax Directive (ETD)

### 2.4.1 Summary of the proposal

The main objective of the proposal for a recast of the Energy Tax Directive (EC, 2021j) is to align the taxation of energy products and electricity with the adapted climate and energy framework of the European Union, especially its 2030 and 2050 greenhouse gas emission reduction targets. Furthermore, the proposal aims to improve the functioning of the Internal Market and to preserve the capacity of Member States to generate revenues.

To reach these objectives, the Commission proposes major revisions related to the taxation rates and to the scope of the Directive. One of these revisions concerns a switch from volume-based rates to rates based on energy content, to eliminate the disadvantage currently suffered by biofuels, which typically have a lower energy content per unit of volume than fossil fuels. Also, the proposal introduces different categories of energy products and electricity and a ranking of these categories based on their environmental performance and their use (motor fuel, heating fuel or electricity). For each type of use, the ranking of the categories broadly corresponds to the following:
1. Category 1 (Highest rate/reference rate): conventional fossil fuels.
2. Category 2 (2/3 of reference rate): 'transitional' fossil fuels, such as LPG, natural gas and hydrogen of fossil origin. After ten years the rate for this category will increase to equal the reference rate.
3. Category 3 (1/2 reference rate): non-advanced biofuels.

4. Category 4 (lowest rate): electricity, advanced biofuels, bioliquids, biogases and hydrogen of renewable origin.

Tax rates assigned to the different categories by Member States must follow the same ranking order, but not necessarily the same ratio between the category rates. Unlike under the current ETD, under the recast proposal the minimum rates will be adjusted annually to reflect inflation.

Whereas the current ETD does not apply to airborne and waterborne navigation, in the recast the Commission proposes to extend its scope to include these two sectors. Intra-EU business and pleasure flights would be subject to the standard minimum tax rate for motor fuels and electricity; for non-business and non-pleasure flights (i.e. commercial, scheduled passenger flights) the minimum rate starts at zero in 2023 and reaches the same standard minimum tax rate over a transitional period of ten years. For sustainable alternative fuels the transitional minimum rate is zero for this same period of ten years. After that period, the standard minimum rate for each type of fuel applies according to the ranking above.

Full freighter flights are exempt from the tax obligation according to the Commission's proposal, but Member States can decide to apply the same tax rate to the fuels and electricity used by this type of flights, either unilaterally (to domestic cargo flights) or following a bilateral of multilateral agreement (to intra-EU cargo flights between different Member States). Application of the tax rates to extra-EU flights is not mandatory either, leaving the decision to exempt or apply the relevant tax rates up to the Member States. Finally, electricity supplied to stationary aircraft at an airport may also be exempted.

## 2.4.2 Additional costs

According to the proposal for the ETD recast outlined above, the aviation sector would be subject to the minimum tax rate for motor fuels after a transitional period of ten years starting in 2023. During this period, the rate for motor fuels would be phased in gradually, while the rate for sustainable alternatives would be zero for the entire transitional period. See Table 5 for a summary of the applicable minimum rates before indexation.

**Table 5 - Non-indexed minimum fuel tax rates applicable to intra-EU non-business non-pleasure flights according to the ETD recast proposal in €/GJ**

| | 2023 | 2028 | 2030 | 2033 and beyond |
|---|---|---|---|---|
| Kerosene | 0 | 5.38 | 7.53 | 10.75 |
| Sustainable biofuels and biogas | 0 | 0 | 0 | 5.38 |
| Low-carbon fuels | 0 | 0 | 0 | 5.38 |
| Renewable fuels of non-biological origin | 0 | 0 | 0 | 0.15 |
| Advanced sustainable biofuels and biogas | 0 | 0 | 0 | 0.15 |
| Electricity | 0 | 0 | 0 | 0.15 |

Assuming a conversion factor of 0.0353 GJ per litre of kerosene[21], this means a minimum tax rate of € 10.75*0.0353 = € 0.38 per litre of kerosene for the non-indexed rate. For the other

[21] As used by Ricardo et al. (2021).

categories the minimum tax rate per litre depends on the exact type of fuel and its chemical characteristics.

In the Commission's Impact Assessment, the effects of the proposed ETD revisions to the aviation sector have been assessed by using both a general economic model and a dedicated sectoral study carried out by a consortium of Ricardo, GWS, Ipsos NV, TAKS/Vital Link and Alice Pirlot (2021). One of the policy options assessed by Ricardo et al. (2021) includes a fuel tax rate of € 0.33/l of intra-EEA passenger flights, phased in over a 10-year transitional period up to 2033. This corresponds to € 9.35/GJ, comparable but not equal to the post-2033 rate in the ETD recast proposal of € 10.75/GJ. To account for this difference, in the overview table in Section 2.4.4. that we use for further reference we scale all results of the study of Ricardo et al. (2021) by the corresponding factor of 15%. The study assumes the additional costs being fully passed through to the consumers by raising the ticket prices, which leads to a decrease in demand and hence fuel consumption.

In their analysis of ticket prices, Ricardo et al. (2021) distinguish two categories of flights, traditional scheduled carriers and low-cost carries and charter flights. In the € 0.33/l tax rate option, ticket prices are projected to increase by 5.4% in 2030 and 6.0% in 2050 for the traditional carriers, and 10.9% in 2030 and 11.3% in 2050 for the low-cost carriers. The difference is explained by the higher share of fuel costs in operational costs for low-cost carriers.

*Impacts for the Dutch aviation sector*

The study of Ricardo et al. (2021) has made use of disaggregated data for all EEA countries (EU-27 and Norway and Iceland)[22], so we can easily compare the numbers presented above with the corresponding numbers for the Netherlands. For the case of the traditional scheduled carriers, the projected ticket price increase is 5.2% in 2030 and 5.7% in 2050, slightly below the intra-EEA average. For the low-cost carriers, the numbers are 11.9% and 12.5%, significantly above the intra-EEA average. This suggests that low-cost carriers in the Netherlands have more difficulty to absorb the costs related to the kerosene tax rate compared to their average EEA competitor, possibly because of stiffer local competition.

### 2.4.3 Effects on $CO_2$ emission reduction

In contrast to the blending obligation of the ReFuelEU Aviation Regulation, the ETD recast does not have a direct, guaranteed impact on the $CO_2$ emission reduction of the European or Dutch aviation sector. In theory, airlines could just accept the additional fuel costs, refrain from passing them through to their passengers and continue operations as before. In practice, however, emission reduction is expected to take effect indirectly, by decreasing demand due to higher ticket prices and by improvements in aircraft efficiency and flight operations, stimulated by the additional operational costs due to the fuel tax.

To estimate the effect of the proposed revisions in the ETD on aviation emissions, assumptions had to be made about price elasticities for different types of flights and the rate of efficiency improvements. Using this method, for the scenario of a kerosene tax of € 0.33/l, Ricardo et al. (2021) predict an emission reduction of 3.5% in 2025, 9.9% in 2030 and 10.3% in 2050 for all intra-EEA flights taken together.

[22] Data is not published in the Impact Assessment. Detailed results from the model estimations have been provided by TAKS, a partner in the Ricardo consortium.

*Impacts for the Dutch aviation sector*

According to Ricardo et al. (2021), the corresponding emission reduction for the Dutch aviation sector is projected to be 9.5% in 2030 and 9.7% in 2050, about half a percentage point less than the reduction achieved at EEA level[23].

### 2.4.4 Overview

See Table 6 and Table 7 for an overview of the main figures from this section for later reference, for intra-EEA and the Netherlands respectively.

**Table 6 - Main figures for ETD revision — ticket price increase and $CO_2$ reduction compared to baseline — all intra-EEA flights. The data from Ricardo et al. (2021) have been inflated by 15% to account for the difference in minimum kerosene tax rate between that study and the Commission's proposal. The original data as discussed in the text are in brackets**

| Intra-EEA | 2030 | 2050 |
|---|---:|---:|
| Ticket price - traditional scheduled carriers | 6.2% (5.4%) | 6.9% (6.0%) |
| Ticket price -low-cost carriers and charter flights | 12.5% (10.9%) | 13.0% (11.3%) |
| $CO_2$ emissions | -11.4% (-9.9%) | -11.8% (-10.3%) |

**Table 7 - Main figures for ETD revision - ticket price increase and $CO_2$ reduction compared to baseline - flights between the Netherlands and other EEA airports. The data from Ricardo et al. (2021) have been inflated by 15% to account for the difference in minimum kerosene tax rate between that study and the Commission's proposal. The original data as discussed in the text are in brackets**

| Netherlands | 2030 | 2050 |
|---|---:|---:|
| Ticket price - traditional scheduled carriers | 6.0% (5.2%) | 6.6% (5.7%) |
| Ticket price - low-cost carriers and charter flights | 13.7% (11.9%) | 14.4% (12.5%) |
| $CO_2$ emissions | -10.9% (-9.5%) | -11.2% (-9.7%) |

[23] Also based on the detailed results from TAKS model estimations.

# 3 Analysis of impacts for the Dutch aviation sector

## 3.1 Introduction

In the previous chapter we have established the additional costs, including the resulting ticket price increase, and $CO_2$ emissions reduction associated with each of the Fit for 55 proposals relevant for aviation, for 2030 and 2050. In this chapter we explain how we combine these figures and existing model scenarios to establish the cumulative impact of the proposals on the Dutch aviation sector. The results of this analysis are presented in the following chapters.

Below, we elaborate on the different steps needed to arrive at these results. We look at, respectively, the WLO scenarios and underlying data that are the basis of our analysis, the interactions between the various proposals and, lastly, our method to estimate $CO_2$ emission reductions.

## 3.2 WLO scenarios and AEOLUS data

The backbone of our analysis is formed by the existing Welvaart en Leefomgeving (WLO) reference scenarios for aviation by PBL and CPB (CPB & PBL, 2016) and the underlying AEOLUS model data. We make use of the Low and High scenarios as defined in the WLO study of 2015, combined with the updated AEOLUS model calculations of 2018 (Significance, 2020; Significance & TO70, 2019).

### *WLO assumptions*

The WLO scenarios express two different coherent views of the state of the Dutch physical environment for both 2030 and 2050. The main distinction between the Low and the High scenarios is the corresponding economic growth rate, coupled to a demographic growth rate (also low or high, respectively). As regards aviation, the Low scenario features a slow development of aviation technology, a slow adoption of Single European Sky and a high oil price, among other things. The High scenario, in contrast, is characterised by a fast technological development, fast adoption of Single European Sky and a low oil price. See for more details on both scenarios CPB &PBL (2016).

For our analysis it is especially important to consider the WLO assumptions that have to do with projected climate policies. Ideally, the AEOLUS assumptions on climate policies should be in line with the baseline scenarios from the Impact Assessments analysed in Chapter 2, such that additional effects resulting from the Fit for 55 package are also additional in the AEOLUS model. Most notably, the AEOLUS model includes the options of a fuel charge and an ETS carbon price[24]. The fuel charge is assumed to be zero for all scenarios and projection years, so there is no double-counting with respect to the ETD revision. For the Low scenario the model assumes the ETS to be applicable for flights within Europe and to and from

[24] There is no option in the model for a SAF blending obligation or SAF application in general, so there is no risk of double-counting with the ReFuelEU Aviation regulation or the RED II revision. In the WLO SAF blending is considered during post-processing of the AEOLUS output.

Europe. In the High scenario, the ETS is assumed to be in force globally. See Table 8 for the ETS carbon price assumed in the AEOLUS model and the ETS and CORSIA carbon prices as estimated in Chapter 2 for 2030 and 2050.

**Table 8 - ETS carbon prices assumed in the AEOLUS model (2013 price level) and Impact Assessment low and high price scenario for ETS and CORSIA (2020 price level)**

| | 2030 | 2050 |
|---|---|---|
| AEOLUS Low scenario | € 15.20 | € 40.60 |
| AEOLUS High scenario | € 40.60 | € 162.40 |
| IA ETS baseline | € 32 | € 88 |
| IA ETS high price scenario | € 84.50 | € 315 |
| IA CORSIA low price scenario | € 1 | € 30 |
| IA CORSIA high price scenario | € 13.20 | € 160 |

It follows that the ETS prices in the AEOLUS Low scenario are approximately half of those in the ETS baseline scenario from the Impact Assessment; the same holds for the AEOLUS High scenario compared to the ETS High price scenario. For extra-EEA flights the relationship is more complicated as in AEOLUS these flights are subject to the ETS instead of CORSIA. In 2050 the CORSIA prices as estimated in Chapter 2 are comparable to the AEOLUS ETS prices; in 2030 they are much lower.

Note that the two WLO scenarios as modelled in AEOLUS are comprehensive and relate to many more aspects than the ETS price, while our high price and low price scenario as defined in Chapter 2 only refer to the ETS and CORSIA carbon price. When we look in more detail into the Impact Assessment's baseline scenario and AEOLUS it follows that both models use different assumptions, for example on the development of the baseline ticket price, which renders their projections on the ticket price increase rate resulting from the carbon price incomparable. It is therefore not possible to identify an unambiguous relationship between the way carbon pricing is incorporated in the Impact Assessment's baseline scenario and in AEOLUS.

### *Data segmentation for estimations*

From the AEOLUS runs underpinning the WLO scenarios we obtain data on demand for passenger flights and cargo for all Dutch airports for 2030 and 2050. For our assessment, we aggregated these data into four broad categories: we distinguish intra-EEA and extra-EEA flights and the categories passengers and cargo. This leads to four separate segments of the aviation sector that are aligned with the different scope of the proposals treated in the previous chapter. See Table 9 for the segments and the proposals that are in force in each segment. We refer to the ReFuelEU Aviation regulation and the RED II revision together as 'Fuels'.

**Table 9 - Four segments of the aviation sector and the applicable Fit for 55 proposals in each segment**

| | Intra-EEA | Extra-EEA |
|---|---|---|
| Passenger flights | ETS<br>ETD[25]<br>Fuels<br>1 | CORSIA<br>Fuels<br>2 |
| Full freighters | ETS<br>Fuels<br>3 | CORSIA<br>Fuels<br>4 |

25 As explained in Section 2.4.1, Member States have the option to apply the ETD provisions also to extra-EEA flights and cargo flights, but this is not included in the table as in this study we assume minimum compliance.

In reality the scope of the various proposals is not exactly as clear-cut as suggested by Table 9. The ETS for aviation applies (and will continue to do so, according to the proposal) to the EEA countries plus flights from the EEA to the UK and Switzerland. The other proposals apply in principle to the EU 27, but in general EU environmental legislation is copied by the other EEA member states[26]. The proposals also include exemptions for elements of the scope that contribute to emissions to a very limited extent.[27] As these exemptions are designed to prevent a disproportionally high administrative burden without significantly changing the emissions scope of the proposals, we can safely ignore them in our analysis. See Annex I for the details of how we adjusted the AEOLUS output data to coincide with EEA territory.

For the passenger segments, we further distinguish business and non-business passengers, which are typically associated with different values for the price elasticity, and Low Cost Carriers (LCC) and Full Service Carriers (FSC). The effects of the Fit for 55 proposals translate differently for the last two categories, as the share of fuel costs in total operational costs is higher for LCC. Lastly, we distinguish Origin-Destination (OD) passengers travelling through Dutch airports and transfer passengers travelling on itineraries that include a transfer at Schiphol airport. This will enable us to estimate the effects of the Fit for 55 proposals on the competitiveness of Schiphol Airport as an international hub (see Chapter 5).

**Text box 3 - 2024-2027**

Apart from the WLO projection years of 2030 and 2050, CE Delft was requested to include in our analysis the period 2024-2027 as well. This period is characterized by the phasing out of free allowances under the ETS. Also, CORSIA will still be in its first, voluntary phase from 2024-2026, which makes it hard to establish its *de facto* scope. The blending obligation of the ReFuelEU Aviation regulation will only be enforced as an average for each fuel supplier, not yet at airport level. Another uncertainty is the post-COVID-19 recovery of the aviation sector. Several studies suggest that we can safely assume that in 2030 the post-COVID-19 effects are very small[28], but whether the sector will return to its 2019 level already around 2024 or much later this decade is hard to tell while the pandemic is still around.

Taken everything together, we conclude that in 2024-2027 the sector will be very much in the middle of a period of change. Therefore, rather than presenting a quantitative analysis like for the projection years 2030 and 2050, we will qualitatively describe the most important features of the transition between the current situation and the situation in 2030. We will do this in a section devoted to this period in Chapters 4 and 6.

26 The ETD is primarily taxation legislation, however. We will not further elaborate on the applicability of the Fit-for-55 proposals to Non-EU EEA states, as this is a legal matter.

27 For example CORSIA does not apply to airlines that emit less than 10,000 tonnes of $CO_2$ annually, aircraft with a take-off mass of less than 5,700 kg and humanitarian, medical and firefighting flight operations. The ETS uses similar exemptions. ReFuelEU Aviation exempts airports with less than 1 million passengers or 100,000 tons of cargo annually.

28 Eurocontrol forecasts the aviation sector to be back at 2019 levels in 2024 (https://www.eurocontrol.int/article/aviations-recovery-covid-19-crisis-will-be-long-haul-flight); McKinseypredicts the sector to recover fully 'not before 2024' (https://www.mckinsey.com/industries/travel-logistics-and-infrastructure/our-insights/back-to-the-future-airline-sector-poised-for-change-post-covid-19). Although these projections may be outdated and/or uncertain, they suggest that full recovery is likely well before 2030.

*Establishing the price effect on demand*

With all relevant demand data in place, we establish the impacts of the Fit for 55 proposals on demand by applying the relevant values of the price elasticity to the ticket price increase rates that we obtained in Chapter 2. The resulting change rate of demand is then applied to the model data to obtain the demand affected by the Fit for 55 package. However, as the provisions of the proposals do interact with each other, we cannot simply add up the price increase rates of the individual proposals. See Paragraph 3.3 below for the justification of how we take these interactions into account.

The price elasticity reflects total demand change as a result of price changes and includes several elements. When ticket prices rise in aviation, passengers who want to avoid paying the price increase have three options: refrain from travelling, travel by another transport mode like train or car (modal shift) or make use of a flight departing from another airport at a lower ticket price. Note, however, that the proposals under consideration have effect at EU level, hence comparable ticket price increases will materialize in neighbouring countries as well. Therefore, diversion of demand of OD flights to airports in Belgium or Germany is not applicable in this study. We account for this by adjusting the literature values for the price elasticity. We use different price elasticity values for intra-EEA, extra-EEA and transfer flights and distinguish business and non-business passengers in each case.

As regards the cargo segments, shipping cargo by plane is always significantly more expensive than shipping it through other transport modes, and therefore only happens if transport by air is necessary in relation to the nature of the transported goods. Therefore, a price increase will not easily lead to a modal shift or cancellation of the shipment. As diverting to another airport is no option either since the Fit for 55 proposals act at EU level, cargo carriers will pass through the additional costs to their clients. Those clients will either accept the additional costs or pass them through further down the production chain. Therefore we assume the price elasticity for cargo to be zero for the purposes of this study[29]. See Annex II for details on the applied price elasticities.

Lastly, so far we have interpreted modelled passenger and cargo data as demand, but this is only true in case there are no restrictions to airport capacity. Especially in the High scenario the Dutch aviation sector is subject to capacity restrictions. Therefore, the model runs for both scenarios have been carried out twice, one time with capacity restrictions taken into account, and one time unrestricted[30]. The unrestricted data reflect real demand, the restricted data demand that can be accommodated at the Dutch airports. In case the number of flights is limited by capacity restrictions, we use the real demand to determine the effects of the price increase resulting from the Fit for 55 proposals. We compare the outcome to the accommodated demand to establish whether the decreased demand still surpasses the capacity of the Dutch airports, in which case the number of flights will not decrease, or the demand drops below the total capacity and aviation volumes will diminish.

[29] Obviously this reasoning will not hold in case of extreme cost increases. However, the highest cost increase for full freighters found in this study is 11.3% (see Table 11), which we believe is not sufficient to decrease demand for cargo shipping.

[30] The capacity of Lelystad Airport (LEY) is only taken into account in the restricted runs, as it is supposed to be a spillover airport for Amsterdam.

## 3.3 Interactions between the proposals

As was already noted several times in this study, the proposals under consideration interact which each other, which is why their respective impacts in terms of additional costs or emission reduction cannot be added straightaway. In this paragraph, we explain how we account for these interactions and present the resulting cumulative ticket price increase rates.

Throughout this study, we distinguish three different types of policy provisions that arise from the Fit for 55 proposals: carbon pricing (ETS/CORSIA), a SAF blending obligation (in the context of the broader target for the transport sector in the RED revision) and a minimum tax rate for aviation fuels. The blending obligation defines the composition of the average fuel blend[31], which in turn forms the tax base for the fuel tax and, through the $CO_2$ emissions resulting from this fuel blend, the basis for the obligation to surrender ETS allowances. We therefore adjust the price increase resulting from the ETD, which was calculated for kerosene-fuelled flights, to the actual composition of the fuel blend under the blending obligation. We do the same for the price increase resulting from the ETS, to account for the actual $CO_2$ emissions resulting from the fuel blend[32]. Now we can add the (adjusted) ticket price increase rates to obtain the resulting, net rate for the proposals cumulatively.

To arrive at the net ticket price increase rates for all proposals cumulatively, we perform three more adjustments:

1. As in our assessment we add the data of incoming and outgoing flights to obtain a symmetric representation of demand, we need to correct for the fact that incoming extra-EEA flights are not subject to a blending obligation[33]. We do this by applying 50% of the contribution of the Fuels proposals to extra-EEA flights.
2. In Chapter 2, only our data on the revision of the ETD were disaggregated in FSC and LCC flights. Since this distinction is important for the Dutch aviation sector and leads to significant differences in price increase rate, we analytically applied the FSC/LCC ratio from the ETD revision to the price increase rates related to the other proposals as well.
3. In 2050, also SAF will be subject to minimum tax rates under the ETD (see Table 5). In our addition of price increase rates we accounted for the fact that only 37% of the fuel blend will consist of kerosene, but we have to adjust for the fact that the remaining 63% of SAF will create new, albeit lower, additional costs. In 2050 the sub-target for blending of RFNBOs is 28% (minimum tax rate € 0.15). Assuming the remaining 35% will consist of non-advanced biofuels (€ 5.38), we arrive at an additional price increase rate of 2.6% for intra-EEA LCC flights in 2050 and 1.2% for intra-EEA FSC flights.

In Table 10 the resulting cumulative price increase rates for passengers are presented. For 2050, we distinguish a low price and a high price variant as discussed in Chapter 2.

[31] Concretely: in 2030 a blending obligation of 5% applies, so the fuel blend consists of kerosene for 95%. In 2050, the blending obligation is 63% and the share of kerosene is 37%.

[32] To be exact, not the actual $CO_2$ emissions as emitted to the atmosphere, but the actual emissions as accounted for under the ETS Directive, counting SAF emissions as zero.

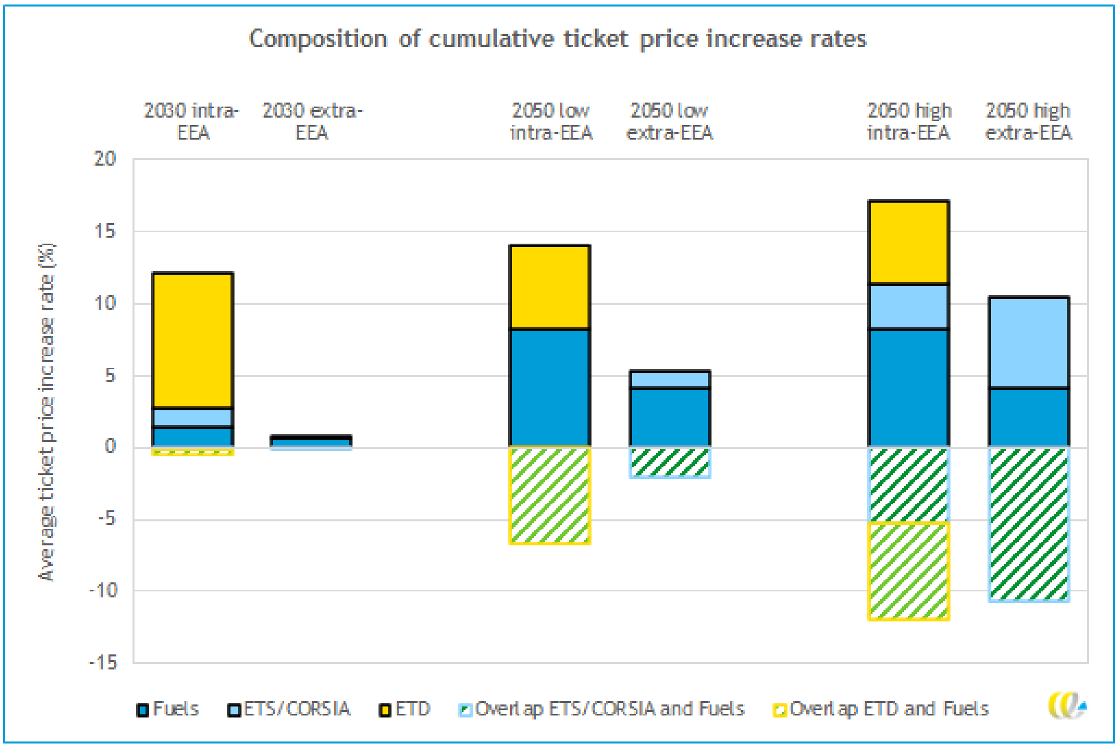
[33] Although the tankering provision in the ReFuelEU Aviation regulation does only apply to intra-EEA flights, we assume significant tankering is not possible on intercontinental flights, so departing extra-EEA flights have to comply with the blending obligation.

**Table 10 - Cumulative passenger ticket price increase rates (segments 1 and 2) resulting from the Fit for 55 proposals compared to the baseline**

| | 2030 | 2050 | |
|---|---|---|---|
| | | Low price scenario | High price scenario |
| Intra-EEA LCC | 16.8% | 19.4% | 23.7% |
| Intra-EEA FSC | 7.3% | 8.5% | 10.4% |
| Extra-EEA LCC | 1.1% | 7.4% | 14.5% |
| Extra-EEA FSC | 0.5% | 3.2% | 6.2% |

In Figure 2, the cumulative ticket price increase rates are presented graphically, showing the contribution of each of the proposals. The distinction LCC and FSC has been left out in this figure for reasons of clarity[34]. Below the horizontal axis, the 'overlap' is shown between the Fuels proposals and the ETS/CORSIA and ETD proposals. This overlap represents the share of the ETS/CORSIA and ETD related price increase that does not contribute to the total, cumulative price increase. This is because the Fuels proposals, especially the blending obligation, reduce the share of kerosene in the fuel blend, and therefore less ETS allowances or CORSIA credits need to be surrendered, and less kerosene tax is due (in 2050, however, a minimum tax rate applies also for SAF).

**Figure 2 - Composition of the cumulative ticket price increase rates (segments 1 and 2) in a graphical presentation. The bars below the horizontal axis represent the overlap between the proposals, representing the share of the ETS/CORSIA and ETD related ticket price increase rates not counting towards the total rate**




[34] Note that therefore the cumulative price increase rates in Figure 2 are not directly comparable to the ones presented in Table 10, as they have been averaged over LCC and FSC flights.

This figure clearly shows that in 2050 the cumulative price increase is higher than in 2030, as expected. It also shows that in 2050 the shares of the ETD and ETS/CORSIA price increases that are ‘cancelled’ by the growing share of SAF in the fuel blend are much higher as well, especially in the high carbon price variant. As a consequence, the net contribution of the ETD to the cumulative price increase is lower in 2050 than it is in 2030, when it represents by far the largest contribution. The ETS and CORSIA contributions are mainly dependent on the carbon price in 2050.

For segments 3 & 4 (full freighters) we assume the same price increase rates relative to a unit of cargo, as the applicable proposals (Fuels and ETS/CORSIA) only act on the fuel used and the resulting emissions[35]. In Table 11 the resulting price increase rates are shown.

**Table 11 - Cargo price increase rates for full freighters (segments 3 and 4) resulting from the Fit for 55 proposals compared to the baseline**

| | 2030 | 2050 | |
|---|---|---|---|
| | | Low price scenario | High price scenario |
| Intra-EEA | 2.7% | 8.2% | 11.3% |
| Extra-EEA | 0.8% | 5.3% | 10.4% |

## 3.4 Impacts on $CO_2$ emission reduction

In our assessment of the impacts of the Fit for 55 proposals on $CO_2$ emission reduction, we distinguish direct and indirect routes of emission reduction. Direct emission reduction follows inevitably from the provision itself. This can be in-sector, which, in our analysis, is only the case for the SAF blending obligation (assuming constant aviation volume). Direct emission reduction in other sectors (offsetting) happens under the ETS and CORSIA. Indirect emission reductions are induced by the additional costs resulting from the provisions. They can be achieved through the development of more efficient planes, more efficient flight and air traffic operations and through a lower demand because of ticket price increases (behavioural effect). These indirect reductions can apply to all proposals, as long as the financial incentive is strong enough. In general, the indirect effects have been taken into account in the model calculations on which the Commission’s Impact Assessments are based.

As with the ticket price increase rates, the different amounts of $CO_2$ emission reduction resulting from the individual proposals cannot simply be added to obtain the net emission reduction. This is because the Impact Assessments do not take into account interactions between the different proposals. Again, the Fuels proposals (ReFuelEU Aviation and revision of the RED II) define the actual composition of the fuel blend. Emission reductions caused by the ETD revision and ETS/CORSIA were calculated on the basis of kerosene-fuelled flights, and have to be adjusted to obtain the net, cumulative $CO_2$ aviation emission reduction resulting from the Fit for 55 package as a whole, which we present in Chapter 6.

[35] As we assigned the ticket price increase rate for segments 1 & 2 fully to the passengers, this means we do not consider belly cargo in our analysis.

# 4 Results: financial effects

## 4.1 Introduction

In this Chapter the results of our assessment of the financial impacts of the Fit for 55 package on the Dutch aviation sector are presented. Building on the ticket price increase rates estimated in Chapter 3, we obtain the projected change in demand resulting from these price increase rates for all types of flights. Next, we apply these changes in demand to the AEOLUS output data. Thus, we establish for both scenarios whether the change in demand will lead to an actual decrease in total number of passengers or will be absorbed by the demand surplus resulting from airport capacity restrictions. This determines the scale of financial effects suffered by airlines and airports. For both scenarios we also look at disaggregated data to identify the impacts at the level of airport or type of flight (OD/transfer). Lastly, we pay attention to other types of costs and benefits induced by the Fit for 55 package that were not included in our assessment of price increase rates, and to the transitional period 2024-2027.

## 4.2 Price increase effects on demand

In Chapter 2 we have estimated the ticket price increase rates resulting from the individual Fit for 55 proposals affecting aviation. In Paragraph 3.3 we explained how we account for the interactions between the proposals to arrive at a net, cumulative price increase rate. By multiplying this rate by the corresponding price elasticity, distinguishing business and non-business passengers, we obtain the resulting change in demand. Table 12 shows the demand changes as a percentage for all categories of OD flights and both projection years. For 2050, we distinguish a Low carbon price and a High carbon price scenario, as discussed in Chapter 2.

**Table 12 - Changes in demand resulting from net ticket price increase rates calculated in Chapter 3 and price elasticities, origin-destination flights from and to Dutch airports**

| Intra/Extra EEA | Travel purpose | FSC/LCC | 2030 | 2050 | |
|---|---|---|---|---|---|
| Origin-Destination flights | | | | Low price | High price |
| Intra-EEA | Business | FSC | -3.4% | -3.9% | -4.8% |
| Intra-EEA | Business | LCC | -7.7% | -8.9% | -10.9% |
| Intra-EEA | Non-business | FSC | -6.8% | -7.9% | -9.6% |
| Intra-EEA | Non-business | LCC | -15.5% | -17.8% | -21.8% |
| Extra-EEA | Business | FSC | -0.2% | -1.0% | -2.0% |
| Extra-EEA | Business | LCC | -0.4% | -2.3% | -4.6% |
| Extra-EEA | Non-business | FSC | -0.3% | -2.0% | -3.9% |
| Extra-EEA | Non-business | LCC | -0.7% | -4.7% | -9.1% |

From this table we conclude that LCC, non-business intra-EEA flights suffer the highest decrease in demand, and FSC, business extra-EEA flights the least. The high impact on LCC flights can be explained by the high proportion of fuel costs in operational costs. The distinction between a business and non-business travel purpose arises from the difference in price elasticity values, with non-business passengers typically being associated with a higher price elasticity. Lastly, the difference between intra-EEA and extra-EEA flights reflects the way the Fit for 55 proposals affect these two categories of flights. ETS carbon prices are always higher than the corresponding CORSIA carbon prices. Furthermore, the ETD does not apply to extra-EEA flights and hence does not contribute to the related ticket price increase. Also, in the case of extra-EEA flights only 50% of the Fuels contribution to the ticket price increase is applicable, since incoming flights from outside the EEA are not subject to a SAF blending obligation.

Table 13 shows the demand changes for transfer flights via Amsterdam. For transfer flights we do not distinguish FSC and LCC flights as this can be different for the two legs of the transfer flight; we instead use the average price increase rate of both categories.

**Table 13 - Changes in demand resulting from net ticket price increase rates calculated in Chapter 3 and price elasticities, transfer flights via AMS**

| Route (Intra/Extra-EEA) | Travel purpose | 2030 | 2050 | |
|---|---|---|---|---|
| Transfer flights via AMS | | | Low price | High price |
| Intra-EEA <> Intra-EEA | Business | -6.0% | -7.0% | -8.5% |
| Intra-EEA <> Extra-EEA | Business | -3.2% | -4.8% | -6.9% |
| Extra-EEA <> Extra-EEA | Business | -0.4% | -2.6% | -5.2% |
| Intra-EEA <> Intra-EEA | Non-Business | -12.1% | -14.0% | -17.1% |
| Intra-EEA <> Extra-EEA | Non-Business | -6.4% | -9.6% | -13.7% |
| Extra-EEA <> Extra-EEA | Non-business | -0.8% | -5.3% | -10.4% |

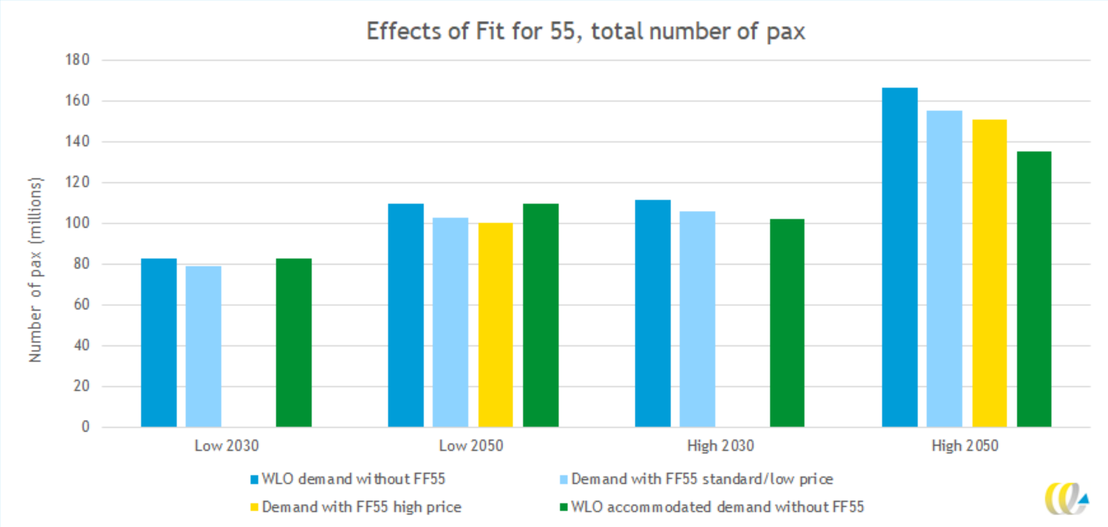
From this table it follows that non-business transfers within the EEA through Amsterdam are most affected by the Fit for 55 proposals. Next most affected are non-business flights with one leg within and one leg outside the EEA. It is furthermore notable that mainly transfer flights with both legs outside the EEA suffer only a slight decrease in demand in 2030, but a much larger one in 2050. This category of transfer flights, for instance connecting North-America with Africa or Asia through Amsterdam, is an important part of Schiphol Airport's hub functionality.

As regards the full freighters segments (3&4) no effect on demand (cargo volumes) is to be expected, as we assumed the price elasticity to be zero in our assessment.

## 4.3 Impacts on the Dutch aviation sector

We applied the changes in demand obtained in the previous paragraph to the AEOLUS forecasts for both WLO scenarios (see Paragraph 3.2). In the Low scenario, it turns out that demand is approximately at the level of the total airport capacity. Hence, there is no difference between real demand and accommodated demand and we do not distinguish between the two different AEOLUS datasets. On the contrary, the WLO High scenario is characterised by a demand that surpasses the total capacity of most Dutch airports. Therefore, we determine the impact of the Fit for 55 proposals on real demand and compare the outcomes to the available capacity, using the accommodated demand. In Figure 3 all results are presented for the total number of passengers travelling through Dutch airports. For 2050, we distinguish a low carbon price and a high carbon price variant.

**Figure 3 - Effects of Fit for 55 on total number of passengers (pax) travelling through Dutch airports in WLO Low and High scenario in 2030 and 2050. For 2050, a low carbon price and a high carbon price variant are distinguished**




In this figure, the dark blue and green bars represent model output of real and accommodated demand, respectively. In the Low scenario, these are considered equal. For 2030, the light blue bar represents the effects of the Fit for 55 package applied to real demand. For 2050, the light blue bar reflects the Fit for 55 effects on demand in the low carbon price variant and the yellow bar reflects these effects in the high carbon price variant. Thus, it can be concluded that in the WLO Low scenario the amount of passengers decreases as a consequence of the ticket price increases induced by the Fit for 55 package, since capacity restrictions do not apply. In 2050 the high carbon price scenario leads to a slightly larger decrease in demand than the low carbon price scenario, as expected since the effect of ETS and CORSIA is stronger in this case.

In the High scenario, we can see that demand does decrease because of the ticket price increases, but both in 2030 and 2050, this decrease is not sufficient to push demand below the capacity limits of the collective Dutch airports. This means that, despite the impacts of the Fit for 55 proposals, the number of passengers travelling through Dutch airports will, according to our estimate, not diminish under the WLO High scenario. The increase in ticket prices due to the Fit for 55 proposals substitutes part of the shadow costs that occur in AEOLUS to match demand and supply. These shadow costs are additional profits that airlines can generate due to scarcity of slots.

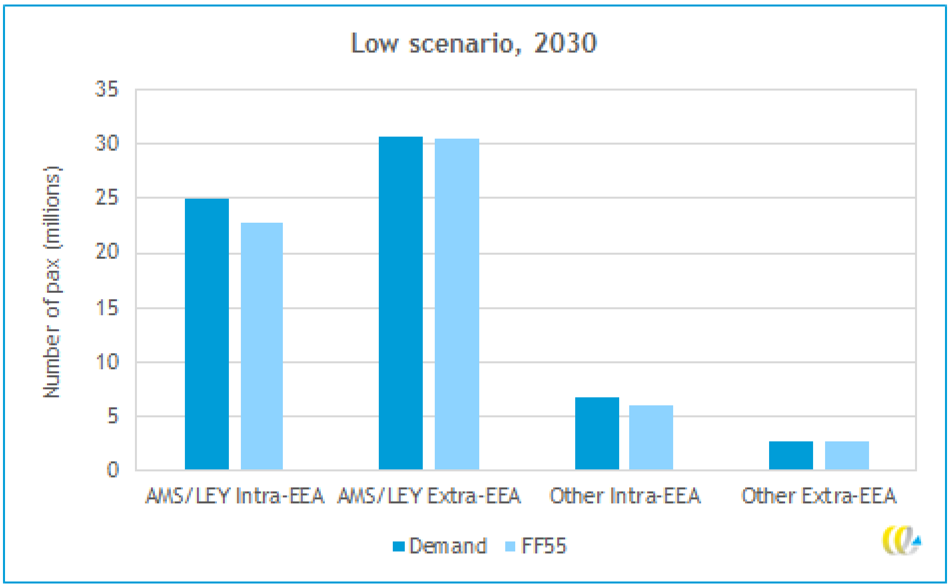
Below, we further elaborate on the effects of the Fit for 55 package in both scenarios, disaggregating the data where relevant[36].

[36] We selected a limited number of interesting cases to present in this section. In Annex III, the full model output for passenger demand is included. By combining this Annex with Table 12 and Table 13 showing demand change rates for all types of flights, the Fit for 55 effects on number of passengers can be calculated for any selection of flight categories.

### *Low scenario*

Knowing that in the Low scenario the total number of passengers will decrease, it is interesting to see how this effect will play out for the various airports in the Netherlands. In Figure 4 we present the number of OD passengers in this scenario for 2030, distinguishing passengers travelling through Schiphol/Lelystad and the other Dutch airports (Rotterdam/The Hague, Eindhoven, Groningen (Eelde) and Maastricht) and passengers flying to destinations within and outside the EEA. The disaggregation in business/non-business and LCC/FSC has been left out, in the first place for reasons of clarity and secondly because the differences between the results in these categories are not a consequence of the Fit for 55 provisions and hence less relevant for our conclusions.

**Figure 4 - Number of OD passengers in Low scenario in 2030, demand and effects of Fit for 55 on demand. Disaggregated for AMS/LEY and other Dutch airports (RTM, EIN, MST, GRO) and for intra-EEA and extra-EEA flights**




From this figure we can conclude that in the Low scenario in 2030 the number of passengers decreases significantly for intra-EEA flights (-8.5% for AMS/LEY and -12.3% for the other airports), but very slightly for extra-EEA flights (-0.3% for AMS/LEY and -0.4% for the other airports).

In Figure 5 and Figure 6, the corresponding results are presented for 2050, both for the low carbon price and the high carbon price variant.

**Figure 5 - Number of OD passengers in Low scenario in 2050 (low carbon price), demand and effects of Fit for 55 on demand. Disaggregated for AMS/LEY and other Dutch airports (RTM, EIN, MST, GRO) and for intra-EEA and extra-EEA flights**

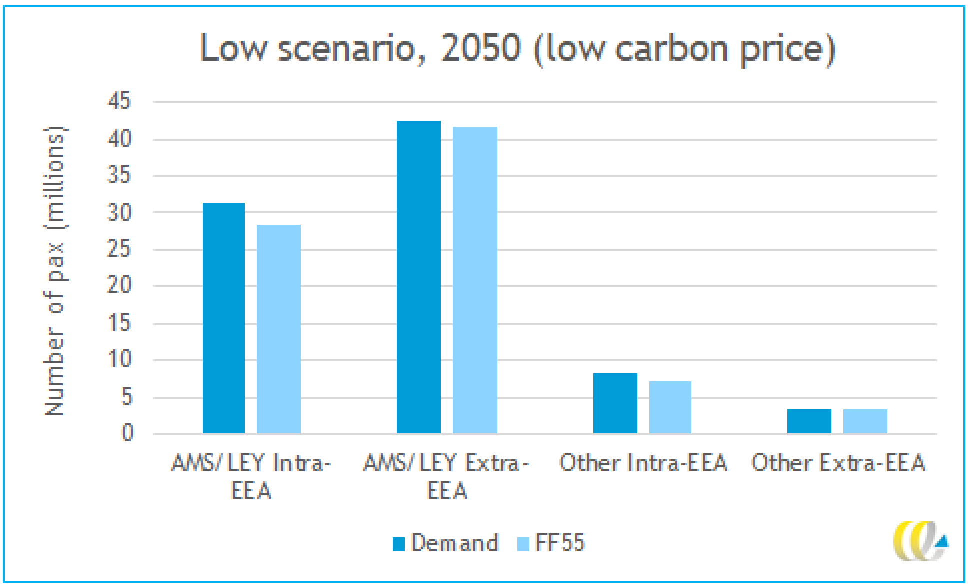
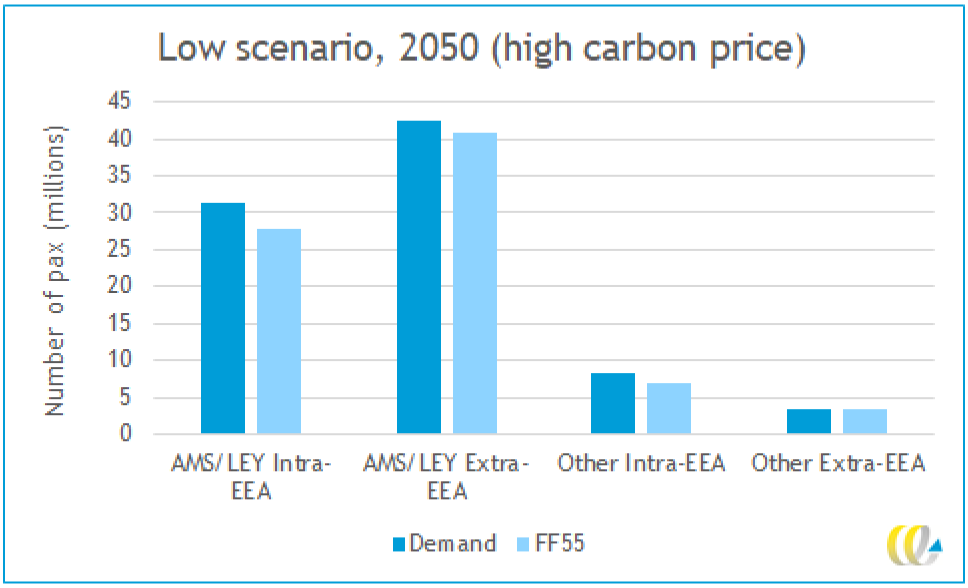



**Figure 6 - Number of OD passengers in Low scenario in 2050 (high carbon price), demand and effects of Fit for 55 on demand. Disaggregated for AMS/LEY and other Dutch airports (RTM, EIN, MST, GRO) and for intra-EEA and extra-EEA flights**

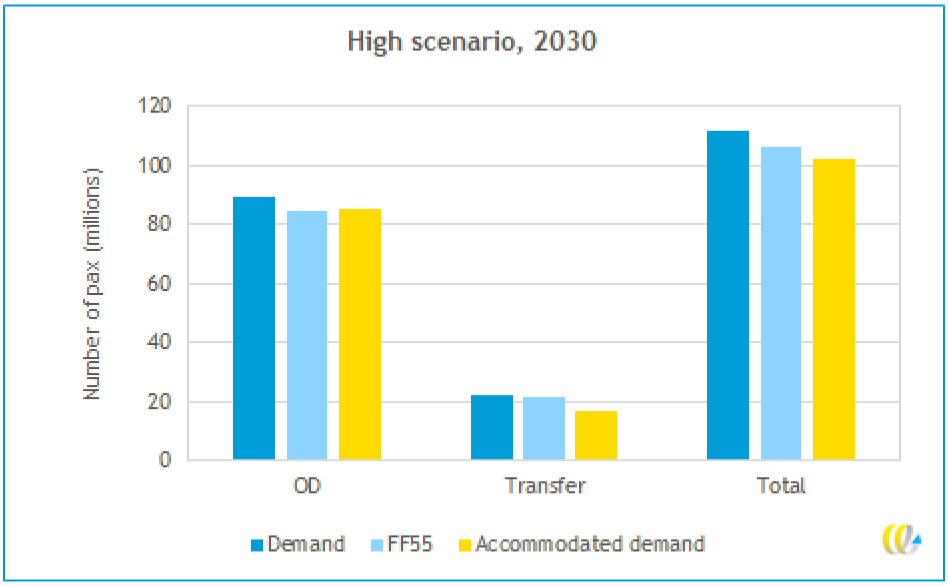



From this figures it follows that in the Low scenario in 2050 all categories of flights are affected, with the high carbon price variant resulting in larger impacts on demand than the low carbon price variant, as expected. The largest decrease in demand (relatively) takes effect for intra-EEA flights from the regional airports in the high price variant: -16.9%.
In absolute terms, the largest decrease is associated with intra-EEA flights from Amsterdam: 3.6 million passengers less would fly from Schiphol Airport to intra-EEA destinations as a consequence of the ticket price increases due to the Fit for 55 package.

*High scenario*

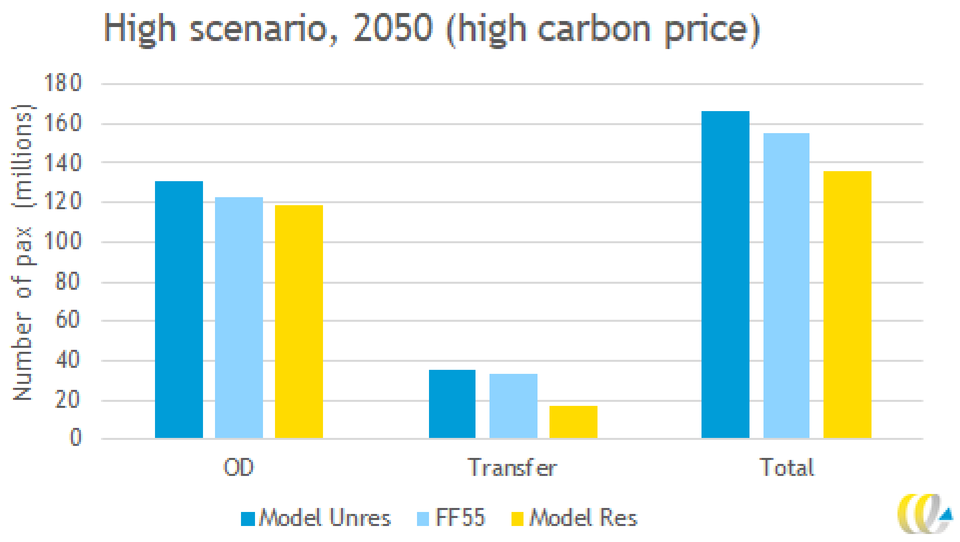
We found that in the WLO high scenario, the price effect of the Fit for 55 package is not strong enough to induce a decrease in total number of passengers. This is not necessarily the case for subcategories of passengers. In Figure 7, the total number of passengers in 2030 is disaggregated in OD and transfer passengers.

**Figure 7 - Number of passengers in High scenario in 2030. Demand, Fit for 55 effects applied to demand and accommodated demand. Total, OD and transfer passengers for all Dutch airports**




From this figure we can conclude that for OD passengers demand slightly falls below the accommodated demand as a consequence of the Fit for 55 package, which would mean a real decrease in number of passengers. For transfer passengers the capacity restrictions still define demand in spite of the decrease induced by the Fit for 55 proposals. In Figure 8, the results for the high scenario in 2050 are presented, for the high carbon price variant. It follows from this figure that in 2050, for both the OD and transfer passengers the decrease in demand due to the Fit for 55 proposals is not sufficient to push demand below the capacity restrictions. As the impact of the Fit for 55 proposals is still less when the low carbon price is applied in 2050, the same conclusion holds for that variant.

**Figure 8 - Number of passengers in High scenario in 2050. Demand, Fit for 55 effects applied to demand and accommodated demand. Total, OD and transfer passengers for all Dutch airports. High carbon price variant**




## *Financial effects*

From the analysis above we can conclude that the projected financial impacts of the Fit for 55 package strongly depend on the development path that the Dutch aviation sector will take. In the WLO Low scenario, reflecting relatively low economic and demographic growth and moderate technical and operational developments in the aviation sector, demand will not surpass the capacity of the Dutch airports in both 2030 and 2050. Therefore, the decrease in demand due to price increases resulting from the Fit for 55 proposals will actually lead to a lower amount of passengers travelling through Dutch airports. In 2030, the number of passengers will mainly decrease on intra-EEA flights: 8.5% from Amsterdam/Lelystad and 12.3% from the other regional airports in the Netherlands. In 2050, the effect is more uncertain as a consequence of the uncertainty in the impact of the ETS and CORSIA in 2050. In both the low carbon price and the high carbon price variant demand decreases still mostly on intra-EEA flights, but also extra-EEA flights will diminish. For airlines operating at Dutch airports, this means significant financial effects in terms of lost income from ticket sells.

**Text box 4 - Income loss for KLM as a consequence of Fit for 55**

To provide an indication for the resulting financial impacts for KLM, we look at the specific effects of the Fit for 55 package on Full Service Carriers (FSC) serving Schiphol Airport, as KLM is by far the most important representative of this category. From our analysis it follows that the number of intra-EEA FSC passengers at AMS/LEY in the Low scenario in 2030 will decrease by 5.4% and the number of extra-EEA FSC passengers by 0.3%. We can estimate the financial effects of this reduction in demand by considering data from KLM's 2018 annual report on passenger destination and passenger revenue, and extrapolating this results to 2030 by making use of the AEOLUS data for 2018 and 2030.

In 2018, the region Europe/North Africa was responsible for about 18% of KLM's passenger-kilometres that year and total passenger revenue was € 7,822 mln (KLM, 2019). This leads to an income loss of about € 75 million on intra-EEA passengers and € 20 million on extra-EEA passengers, when Fit for 55 effects are projected on 2018 data[37].

According to AEOLUS outputs, intra-EEA FSC passengers from Amsterdam totalled 11.2 million in 2018. In the WLO Low scenario this is projected to increase to 15.1 million in 2030. Adjusting for this increase, we estimate the income loss of KLM on intra-EEA ticket sells due to the Fit for 55 package in 2030 in the Low scenario to be around € 100 million[38]. The number of extra-EEA passengers from Amsterdam is projected to increase from 16.3 million in 2018 to 22.4 million in 2030, which means a loss of income on extra-EEA passengers of around € 27 million. Thus, the total income loss would add up to about € 127 million in 2030. Assuming passenger revenue increases proportional to total number of passengers transported, this would represent about 1.2% of passenger revenue in 2030, suggesting the impact of the decrease of passenger demand due to the Fit for 55 proposals on KLM's revenues is limited.

Note that this estimate is only a rough indication, assuming many variables to remain constant over time. Furthermore, we did not take into account administrative and other indirect costs (see Paragraph 4.4.). It provides an order of magnitude, though, for the financial impacts incurred by KLM as a consequence of the Fit for 55 package, in case the Dutch aviation sector would develop more or less according to the WLO Low scenario up to 2030.

For the airports themselves, the financial effects are best expressed in terms of number of flights. The 8,5% decrease in intra-EEA passengers from Amsterdam in the Low scenario in 2030 corresponds to 2.1 million passengers. Assuming an average of 150 passengers per intra-EEA flight, this means an annual reduction of 14,000 in number of intra-EEA flights from Amsterdam. In 2050 under the high price variant, the (more uncertain) decrease amounts to 3.6 million intra-EEA passengers or 24,000 flights. The regional airports collectively would see a reduction of 5,500 intra-EEA flights in 2030 and 9,500 intra-EEA flights in 2050 (at high carbon price).

In the WLO High scenario, associated with high economic and demographic growth rates and fast developments in aviation, the number of passengers travelling through Dutch airports is mainly defined by the capacity restrictions. We found that both in 2030 and 2050, total demand decreases as a consequence of the ticket price increases resulting from the Fit for 55 proposals, but it still surpasses the total capacity. Therefore no net effect on total number of passengers or flights is expected, although specific flight categories, such as OD flights in 2030, could show a small decline. This does not mean that there will be no financial effects at all, as the surplus demand will diminish and therefore scarcity profits will decrease.

## 4.4 Indirect costs and benefits

Until now we have focused on additional costs for fuel suppliers and airlines that follow directly from the Fit for 55 proposals and, according to the Commission's Impact Assessments, are passed through to passengers, either fully or to a large extent. Below, we briefly reflect on possible indirect costs and benefits that may follow from the Fit for 55 package, but were not included in our assessment of price increase rates and change in demand.

37 Assuming a linear relationship between passenger-kilometres and passenger revenues.

38 In 2018 prices, and assuming everything else (such as the passenger distribution over regions of destination) to remain unchanged.

Several of the provisions in the Fit for 55 proposals include new obligations in terms of administration, monitoring or reporting, which can lead to additional administrative costs. This is mainly the case for the ReFuelEU Aviation regulation, which is a new instrument. Administrative costs for airlines are projected to be about € 16.8 million annually in 2025 and € 24 million annually by 2050 for the entire EU aviation sector, resulting in a total of € 340 million over the entire period 2021-2050, relative to the baseline. Assuming a Dutch share in the EU aviation sector of 8%[39], this comes to about € 27 million for the Dutch aviation sector over the entire period and € 0.9 million on average annually. Additional costs for Member States are estimated at € 264 million (€ 21 million for the Netherlands over 2021-2050). No additional administrative costs are expected for fuel suppliers

Under the RED and the ETS no additional administrative costs are expected for all parties as the monitoring and reporting systems are already in place. The implementation of CORSIA may lead to administrative costs for airlines, but since CORSIA will be applied globally these costs are not a consequence of the introduction of the Fit for 55 proposals. The ETD may lead to some administrative costs for Member States who are responsible for collecting the taxes on aviation fuels.

Besides administrative costs also other types of costs can arise from the Fit for 55 proposals, for instance logistic costs in case of the ReFuelEU Aviation regulation. Until 2030, fuel suppliers have the flexibility to supply SAF to a limited number of airports, as long as they comply with the blending obligation as an average over all fuel supplied. For this transitional period no additional logistic costs are expected. After 2030, suppliers must supply all airports with the minimum amount of SAF, and this will result in some additional logistic costs. Towards 2040 and 2050 the network of SAF production sites will become denser and more evenly distributed, and logistic costs will decrease per unit of SAF supplied. The total additional logistic costs are estimated at € 190 million for the entire period 2021-2050. Applying the share of 8% this would amount to € 15 million for the Dutch fuel sector, but this probably is an overestimation as the Netherlands already disposes of a high quality network for fuel distribution, with for instance Eindhoven Airport being supplied by pipeline from Schiphol. Also, as mentioned in Section 2.3.1, the revision of the AFID will result in additional costs related to providing electricity to aircraft at gates and outfield posts, accumulating to € 949 million over the period 2021-2050 (€ 76 million for the Dutch aviation sector, € 2.5 million on average annually, but the Commission expects these investments to be done mainly in the first years after the AFID revision enters into force).

With regard to all these types of costs (administrative, logistic and investments in electricity supply) it is possible and even probable that eventually they will be passed through to airlines and to passengers to a certain extent. However, as cost pass through rates are not known and the costs can be diluted over several years or even decades, it is not possible to accurately project their effect on ticket price increase rates. Therefore they were not included in our assessment of change in demand as a result of the Fit for 55 package.

Lastly, the Fit for 55 proposals also yield benefits in terms of tax revenues resulting from the extension of the ETD scope to aviation. Ricardo et al. (2021) present the ETD revenues disaggregated for all Member States. For the Netherlands, the additional revenues, relative to the baseline, are projected to be € 186 million in 2030 and € 259 million in 2050. In this figure reduction in demand due to ticket price increases has been taken into account, but

[39] Based on number of passengers in 2018 at Dutch airports (79.6 mln) compared to the EU 27 (UK excluded) (996.3 mln) https://ec.europa.eu/eurostat/databrowser/view/AVIA_PAOC__custom_1724230/default/table?lang=en

not the interplay with the blending obligation. Therefore, it is probably an overestimation. Including the blending obligation would lead to lower net tax rates, especially in 2050, as the kerosene minimum tax rate is at least twice as high as the SAF minimum tax rate, and hence to lower revenues.

## 4.5 2024-2027 developments

As indicated in Chapter 3, the period between 2024 and 2027 can be characterised as a transitional phase associated with high levels of uncertainty and it is not possible to accurately predict the financial effects of the Fit for 55 package on a year-on-year basis. Therefore, in this paragraph we focus on the general differences between the situation in 2030, the current situation and the transition in 2024-2027 in terms of financial effects.

Firstly, the aviation sector may not have fully recovered from the COVID-19 pandemic by 2024 or even 2027. This has a major impact on demand and possibly means that during this period, demand will not surpass the capacity restrictions of the Dutch airports. In other words, COVID-19 means that the aviation sector will actually develop in the direction of the WLO Low scenario projections, or even below them. However, since demand is limited by an external factor instead of by low economic or demographic growth, other features of the High scenario could still play a role. For instance, ambitious climate targets may increase pressure on the development of more efficient aircraft and more efficient operations. Thus, 2024-2027 may be characterised by a mix of both scenarios, leading to both loss of income through decrease of demand and relatively high expenses on sustainability measures to prepare for sharp post-COVID recovery.

If we look at the relevant Fit for 55 proposals themselves in the period 2024-2027, we estimate that the SAF blending obligation will be most relevant for the aviation sector in terms of investments needed. In 2025 the blending obligation stands already at 2%, which is significant as current SAF blending levels are very low. SAF production needs to be kick-started and distribution networks need to be developed to be prepared for the increasing blending obligation from 2030 on.

As regards the other proposals affecting aviation, from Figure 2 we estimate that in 2024-2027 the contribution of the ETD revision will already be relatively large, even though these years mark the beginning of the 10-year transition period. ETS free allowances will have been phased out in 2027 but, as discussed in Chapter 2, also free allowances incur (opportunity) costs to airlines, so the financial effect will be limited. The linear reduction factor of the cap will have been applied retroactively from 2021, so by 2027 this may have led to a significant increase in the ETS carbon price. However, as we have seen, even an ETS price of € 84.50 in 2030 results in a limited ticket price increase rate (1.4%). CORSIA will lead to very limited financial effects before 2027 due to partial participation and low carbon credit prices. Also, it is not yet clear whether the baseline will remain at 2019, in which case any effect of CORSIA before 2027 is improbable, or will be extended to 2020 after 2023 as the Commission proposes.

# 5 Results: competitiveness effects

## 5.1 Introduction

Since the Fit for 55 package is introduced at EU level it leads to comparable ticket price increases for all EU airports. Hence, OD passengers travelling to Dutch airports cannot avoid the additional costs by travelling to an airport across the Dutch border. However, this is not valid for transfer passengers at Amsterdam Airport (Schiphol), who have the option of choosing an alternative route via a competing hub outside the EU.

In this chapter the effect of the Fit for 55 proposals on the transfer passenger segment at Schiphol Airport is assessed. In the transfer market, differences in price developments determine the respective market share of the airlines that operate on a certain transfer route. The Fit for 55 proposals result in a ticket price increase that will be of the same order of magnitude throughout the EU. In our assessment we look at the risks of losing market share in the most important transfer routes for airlines operating at Schiphol Airport as a consequence of this type of pan-European price increase[40].

We first analyse the significance of transfers and their geographical characteristics. Secondly, we establish the competitive risks that exist, split out for different categories of transfers (European vs. intercontinental and business vs. non-business). This results in a percentage of transfer passengers that may be prone to bypassing Schiphol. For our assessment of the risks of losing market share to alternative hubs, we mainly look at two elements:

- Additional travelling time and/or longer flight time. This is not attractive to passengers, but neither to airlines operating on competing routes as fuel costs would increase.
- Available capacity at alternative hubs. This depends on the actual passenger volume of a the transfer routes and the share of this volume that can be realistically taken over by alternative hubs, taking into account their capacity development.

All data in this chapter are based on the Schiphol Continue Onderzoek 2019 dataset (Schiphol, 2019).

## 5.2 Geographical distribution of transfer flights

Of all Dutch airports, only Schiphol is a hub that facilitates international transfers. In 2019, 36% of all passengers at Schiphol were transfer passengers. Of these transfer passengers, 65% travelled for non-business purposes. See Annex IV for an overview of the share of business and non-business passengers on all transfer routes via Schiphol.

The largest number of transfers on Schiphol is on routes between North-America and Europe (28% for both directions), followed by intra-European routes (26%). In total, 89% of all transfer passengers have either the origin or the destination of their itinerary in Europe. The most important segment containing intercontinental legs is between North-America and

[40] Unlike in our more quantitative analysis of financial effects and $CO_2$ emission reduction, here we do not take into account the specific features of the provisions of the Fit for 55 proposals, such as their scope or share in the total price increase. The outcome of the analysis in this chapter therefore is independent of the origin of the price increase. It is important, though, that the price increase works at EU level, otherwise the outcomes would be different.

Africa with a total market share of 4%. An overview of the market shares of transfer passengers on continent level is shown in Table 14.

For all connections, the majority of passengers is non-business, except for the connection Latin-America — Asia (62% business). However, business transits are also important for intra-Europe flights (47%), and for Middle-East — North-America transfers (46%), see Table 15 and Table 16.

To establish the relative importance of certain connections for Schiphol, a threshold of 1% of total transfers is applied. Connections that represent at least 1% of the total number of transfers can be considered important for Schiphol. This leads to the connections highlighted in green in Table 14, representing more than 99% of all transfers.

**Table 14 - Market shares of transfer passengers per combination of continents at Schiphol in 2019**

| To<br>From | Africa | Asia | Europe | Middle-East | Latin-America | N-America |
|---|---|---|---|---|---|---|
| **Africa** | 0% | 0% | 4% | 0% | 0% | 2% |
| **Asia** | 0% | 0% | 6% | 0% | 1% | 1% |
| **Europe** | 3% | 8% | 26% | 1% | 5% | 12% |
| **Middle-East** | 0% | 0% | 1% | 0% | 0% | 1% |
| **Latin-America** | 0% | 1% | 7% | 0% | 0% | 0% |
| **N-America** | 2% | 1% | 16% | 1% | 0% | 0% |

In the next two paragraphs, the relevant routes with more than 1% market share are analysed in more detail. We distinguish between routes with at least one intra-European leg and routes with two intercontinental legs.

## 5.3 Routes with at least one European leg

Transfers with Europe either as origin or destination constitute 89% of all transfers. The biggest share is for transfers connecting North-America and Europe, followed by intra-European itineraries. Business transfers are especially important for intra-European connections. All other transfers have a significantly lower share of business travellers. On some routes, alternative hubs could take over the itinerary. The likeliness of this depends however on geographic proximity to the route and availability of capacity. The more alternative hubs exist along the route, the higher the competitive risk, see Table 15.

**Table 15 - Overview of transfer segments with one Intra-European leg**

| Transfers from Europe to | % transfer | Passengers (in millions) | % business | Possible alternatives | Competitive risk |
|---|---|---|---|---|---|
| Europe | 26.0% | 3.4 | 47% | UK | Low |
| Africa | 6.8% | 0.9 | 30% | UK, (Istanbul) | Low |
| Asia | 14.1% | 1.8 | 35% | Istanbul, Gulf, Moscow, (UK) | High |
| Middle-East | 2.1% | 0.3 | 36% | UK, Istanbul, Kiev | Medium |
| Latin-America | 11.6% | 1.5 | 23% | UK | Low |
| N-America | 28.5% | 3.7 | 30% | UK | Low |
| **Total** | **89.2%** | **11.5** | **34%** | | |

Flights within Europe and those that have either their origin or destination in Europe can, for reasons of volume, geography and/or capacity circumvent Schiphol only in a limited way. Mainly the UK and Turkey offer possibilities of rerouting transfers. Due to more alternative hubs available per route, transfers to and from Asia are subject of higher risk of competition. These transfers represent also a significant number of passengers. However, a certain part of the travellers will have Europe as final destination/point of departure and can therefore not consider other routes.

A medium risk exists for the connection Europe — Middle-East, with a limited number of possible alternative hubs available and also a small number of passengers.

## 5.4 Routes with two intercontinental legs

The connections that do not have Europe either as origin or destination and represent at least 1% of total transfers, consist of slightly more than 10% of all transfers. The most important connection is between Africa and North-America and business transfers are especially important on the connection Asia — Latin-America, see Table 16.

**Table 16 - Overview of transfer segments with two intercontinental legs.**

| Intercontinental transfer | % transfer | Passengers (in millions) | % business | Possible alternatives | Competitive risk |
|---|---|---|---|---|---|
| Africa - N-America | 4.4% | 0.6 | 31% | Istanbul, Gulf, African airports, UK | Low |
| Asia - Latin-America | 1.6% | 0.2 | 62% | Istanbul, Gulf, Moscow, UK | High |
| Asia - North-America | 2.2% | 0.3 | 24% | Istanbul, Gulf, Moscow, UK | High |
| Middle-East - North-America | 1.9% | 0.2 | 46% | Istanbul, Gulf, UK | High |
| **Total** | **10.2%** | **1.3** | **41%** | | |

As is the case for connections to and from Europe, not all transfers can easily be rerouted, due to capacity and geographical restrictions. However, the transfers that are fully extra-European have a wider geographical span and have therefore broader options of alternative hubs. This implies a bigger competitive risk. The risk of the most important connection in this segment (Africa — North-America) is assessed as low because only certain parts of Africa can be deemed within the geographical scope of competitor hubs.

## 5.5 Effects on competitiveness

The connections that were assessed as high and medium risk in the previous paragraphs are listed together in Table 17. In total around 22% of all transfers can be considered as prone to the risk of losing market share to alternative hubs, the most important transfer routes being those between Europe and Asia. The highest share of non-business travellers is associated with the connection Asia — North-America.

For the two European transfer connections, Europe will be point of departure or destination, and therefore European airports will continue to take charge of at least a certain part of the total distance of the flight.

**Table 17 - High and medium risk transfer connections.**

| Segment | Transfer | Risk | % Transfers | Passengers (millions) | Business |
|---|---|---|---|---|---|
| European | Europe - Asia | High | 14.1% | 1.8 | 35% |
| European | Europe - Middle-East | Medium | 2.1% | 0.3 | 36% |
| Intercontinental | Asia - Latin America | High | 1.6% | 0.2 | 62% |
| Intercontinental | Asia - North-America | High | 2.2% | 0.3 | 24% |
| Intercontinental | Middle-East - North America | High | 1.9% | 0.2 | 46% |
| **Total** | | | **21.9%** | **2.8** | |

# 6 Results: effects on $CO_2$ emission reduction

## 6.1 Introduction

In this last chapter on the results of our analysis, we focus on the effects of the Fit for 55 proposals on $CO_2$ emission reduction. Firstly, we assess the $CO_2$ emission reduction at EU level based on our results in Chapter Fit for 55 proposals affecting aviation, which provides a global estimate for the projected contribution of aviation to the 2030 climate target of at least 55% domestic, net greenhouse gas emissions reduction compared to 1990 levels. Secondly, we focus on the $CO_2$ emission reduction realised by the Dutch aviation sector, based on the AEOLUS model output and our earlier results on the effects on demand. Lastly, we briefly pay attention to developments in the transitional period of 2024-2027.

## 6.2 Contribution of the aviation sector to the European climate targets

In Chapter 2 we derived the $CO_2$ emission reduction resulting from each of the Fit for 55 proposals from the Impacts Assessments and related studies. In Paragraph 3.4 we explained how the net, cumulative emission reduction from all the proposals together can be estimated. For 2050, we did not establish $CO_2$ emission reduction rates for ETS and CORSIA since uncertainties about the functioning of these mechanisms in 2050 did not allow for a meaningful estimate of such rates. For 2030, we assumed that $CO_2$ emission reduction resulting from the ETS would take place only in other sectors within the scope of the ETS. For CORSIA, reduction takes place in other sectors by definition. We therefore can conclude that the direct emission reductions from ETS and CORSIA do not contribute to gross $CO_2$ emission reductions within the aviation sector[41]. In Table 18, we present the results both for gross reductions (resulting from Fuels and ETD, leaving out ETS/CORSIA) and net reductions (including ETS/CORSIA). As regards the Fuels proposals we assume well-to-wing emission reductions.

**Table 18 - Cumulative $CO_2$ emission reduction rates resulting from the Fit for 55 proposals affecting aviation, EU level, compared to the baseline scenario. For 2030 we distinguish gross reductions (without ETS/CORSIA) and net reductions (including ETS/CORSIA). For 2050, ETS and CORSIA are not included due to uncertainties about their functioning in 2050**

| | 2030 | | 2050 |
|---|---|---|---|
| | Gross | Net | (Gross) |
| Intra-EEA | -17.3% | -17.3% | -65.2% |
| Extra-EEA | -6.5% | -15.4% | -60.8% |

41 There is still the reduction in emissions due to reduction in demand resulting from the ETS/CORSIA, but according to the Impact Assessment accompanying the ETS Aviation revision (EC, 2021b), this reduction is negligible in 2030.

Note that the gross and net reduction rate for intra-EEA flights in 2030 are the same since reductions are measured against the baseline and net reductions under the ETS are, albeit significant, not additional according to the Impact Assessment (EC, 2021b).

To determine the contribution of aviation to the EU's greenhouse gas emission reduction target for 2030 we have to account for the fact that this target is domestic, meaning that all emission reduction has to be realised on EU territory. Therefore, emission reductions realised by extra-EEA flights do not count towards the 2030 target. From the Climate Target Plan and ReFuelEU Aviation Impact Assessments, we estimate the total baseline intra-EEA aviation well-to-wing emissions to be about 70 Mt in 2030 (EC, 2020 & Ricardo, Öko-Institut & E-Modelling, 2021). The emission reduction rate resulting from the Fit for 55 package would then lead to 12 Mt of additional avoided $CO_2$ emissions in 2030. This represents 3% of the total amount of Mt $CO_2$-eq. reduction needed, compared to the baseline, to arrive at 55% net domestic reduction in 2030. Note that the Fit for 55 proposals also lead to emission reductions in extra-EEA aviation, but these are not included in the domestic 55% target for 2030.

## 6.3 $CO_2$ emission reduction in the Dutch aviation sector

A rough estimate of the $CO_2$ emission reduction in the Dutch aviation sector resulting from the Fit for 55 proposals could be obtained by applying the results of the previous paragraph to the projected emissions of the Dutch aviation sector. In this case, however, the specific characteristics of the development of the Dutch aviation sector would not be taken into account. Therefore, we make use of a post-processing analysis of the AEOLUS output (see PBL, 2020) to estimate the $CO_2$ emission reduction in both WLO scenarios[42]. This means we can make use of the behavioural effect we have established in Chapter 4 for the different scenarios and projection years. It also means we use the assumptions on e.g. technical and operational improvements as incorporated in the AEOLUS baseline, instead of the assumptions in the modelling that underpinned the Impact Assessments. Since a strong incentive to develop more efficient planes and apply more efficient operations already exists, also without the Fit for 55 package, we do not expect this choice to alter the results significantly.

In Table 19 $CO_2$ emissions in the Dutch aviation sector are presented for both scenarios and projection years, both for the AEOLUS baseline and effects of the Fit for 55 package on top of the baseline (i.e. the SAF blending obligation and effects on demand). Also the realised level of $CO_2$ emissions by the Dutch aviation sector in 2005 is shown for comparison.

**Table 19 - $CO_2$ emissions in Mt $CO_2$ in the Dutch aviation sector, baseline and effects of the Fit for 55 package. In brackets the increase or reduction with respect to 2005 are shown**

| | 2005 | 2030 | 2050 | |
|---|---|---|---|---|
| | | | Low price variant | High price variant |
| Low scenario baseline | 10.9 | 14.2 (+30%) | 17.1 (+57%) | |
| Low scenario Fit for 55 | | 12.9 (+18%) | 5.3 (-51%) | 4.8 (-56%) |
| High scenario baseline | | 15.6 (+43%) | 15.3 (+40%) | |
| High scenario Fit for 55 | | 14.8 (+36%) | 5.7 (-48%) | 5.7 (-48%) |

42 In the WLO Low scenario, 10% SAF blending is assumed for both 2030 and 2050. In the WLO High scenario this is 10% in 2030 and 20% in 2050. Note that these blending shares are applied a posteriori, so this is not in contradiction with the statement in Chapter 3 that the AEOLUS model does not include assumptions on SAF usage.

In the High scenario in 2050 there is no difference between the low carbon price and high carbon price variant, as in Chapter 4 we concluded that in this scenario no net reduction of demand will materialise, regardless of the carbon price . From this table it can be seen that in the Low scenario Dutch aviation emissions are estimated to drop below 5.5 Mton, which is the 50% reduction target set in the Luchtvaartnota 2020-2050 (ministerie van I&W, 2020). In the High scenario the total aviation emissions remain slightly above this figure, due to the absence of a decrease in demand. According to our projections, the Fit for 55 package will not be sufficient to realise the Luchtvaartnota target for 2030 (emissions at 2005 levels). Note that in this estimate demand reduction due to the COVID-19 pandemic is not taken into account. It is possible that demand in 2030 is lower than estimated in the current WLO scenarios.

## 6.4 2024-2027 developments

As concluded in Paragraph 4.5, COVID-19 recovery could have a major impact on the development of the Dutch aviation sector in 2024-2027. The number of passengers would be reflected best by the WLO Low scenario, but as the demand reduction in case of COVID-19 has an external origin, elements of the High scenario could also be of importance. Increased climate ambition could for instance lead to fast technological developments aimed at reducing aircraft emissions, in the light of expected recovery of the sector. This combination of Low and High scenario features may result in relatively high (temporarily) emission reductions, caused by the combination of low demand and strong technological investments.

Looking at the phasing in of the Fit for 55 proposals in 2024-2027, we expect their *direct* effects on $CO_2$ emission reduction to be limited before 2027. Direct reductions will be induced mostly by the 2% SAF blending obligation in 2025 and the ETS, which is already in place and will continue to realise emission reductions in other ETS sectors. CORSIA-related reductions will be very small prior to its mandatory phase and pending the discussion on its baseline. However, the indirect effects of the proposals on emission reduction can already be significant in 2024-2027. This can happen through the demand effect, but as explained in Paragraph 4.5 the financial incentive for a decrease in demand is also still limited in this period. It is probable, though, as mentioned above, that global climate ambitions and the future obligations rising from the Fit for 55 package will incentivise technological improvements and/or more efficient operations and thus, indirectly, lead to $CO_2$ emission reductions at an early stage.

# 7 Conclusions

## 7.1 Introduction

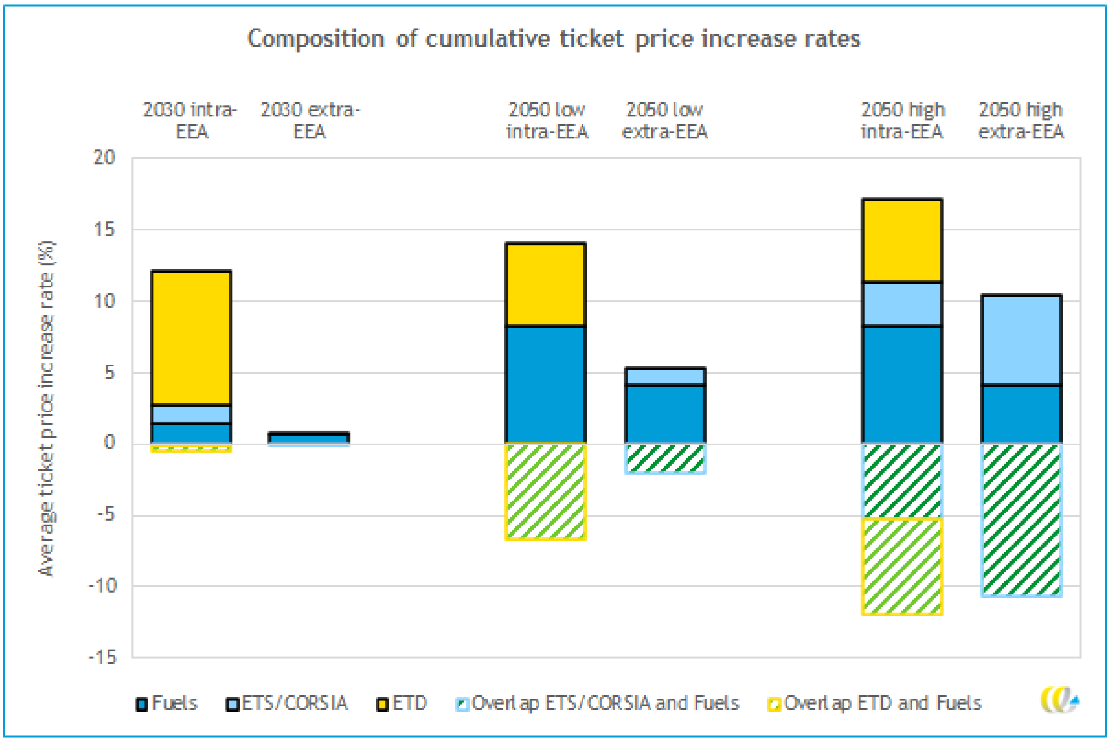
In this study we investigated the impacts of the European Commission's Fit for 55 package, presented in July 2021 to implement the EU's enhanced climate targets, on the Dutch aviation sector. We focussed on the proposals that directly affect aviation: the revision of the ETS for Aviation, including the introduction of CORSIA; the ReFuelEU Aviation regulation; the revision of the Renewable Energy Directive; and the recast of the Energy Tax Directive. We assessed the financial effects, including effects on competitiveness, and the effects related to $CO_2$ emission reduction both for the proposals individually and cumulatively. As our baseline for the development of the Dutch aviation sector, we made use of the WLO Low and High scenarios for 2030 and 2050. Below, we present our results for each of the research questions identified in the Introduction. Next, we briefly comment on limitations and uncertainties associated to these results due to the limited scope of this study.

## 7.2 Financial effects

In Chapter 2 we estimated the ticket price increase rates resulting from the relevant Fit for 55 proposals individually. Based on these figures, we calculated a net, cumulative price increase rate for all proposals together, taking into account the interactions between the proposals. These interactions occur because the SAF blending obligation leads to a smaller share of kerosene in the fuel blend, hence less ETS allowances and kerosene tax are due compared to fully kerosene-fuelled aircraft.

In Figure 9, the cumulative price increase rate is shown for both scenarios and projection years distinguishing intra-EEA and extra-EEA flights. Below the horizontal axis, the overlap between the proposals is shown, reflecting the shares of the ticket price increase resulting from the ETS/CORSIA and ETD proposals that do not contribute to the total because of the blending obligation.

**Figure 9 - Composition of the cumulative ticket price increase rate as a consequence of the Fit for 55 package. Areas below the horizontal axis show the shares of the price increase rates of the individual proposals that do not contribute to the total, cumulative ticket price increase rate**

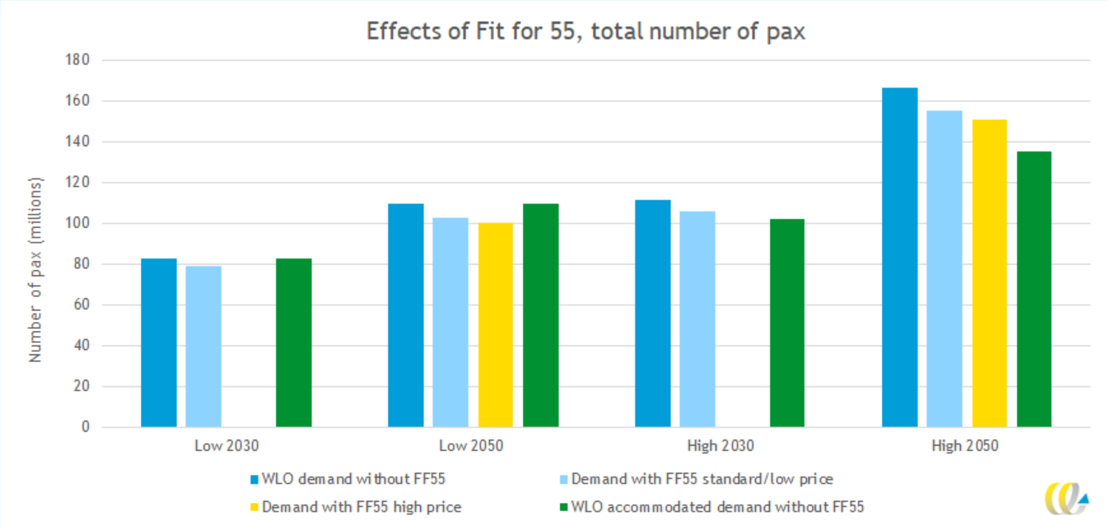



Building on the ticket price increase rates obtained, in Chapter 4 we estimated the change in passenger demand induced by the Fit for 55 package for all types of flights. As regards OD flights, we concluded that LCC, non-business intra-EEA flights suffer the highest decrease in demand, and FSC, business extra-EEA flights the least. As regards transfer flights via Amsterdam, non-business transfers within the EEA are most affected by the Fit for 55 proposals.

As shipping cargo by plane only happens if transport by air is necessary in relation to the nature of the transported goods, a price increase will not easily lead to a modal shift or cancellation of the shipment. As diverting to another airport is no option either since the Fit for 55 proposals act at EU level, cargo carriers will pass through the additional costs to their clients. Therefore, we assumed the price elasticity for full freighters to be zero due to the EU-wide application of the proposals, which means no change in cargo demand is expected.

Applying the changes in passenger demand to the model outcomes for the WLO Low and High scenarios, we conclude that the projected financial impacts of the Fit for 55 package strongly depend on the development path that the Dutch aviation sector will take. We found that in the Low scenario, the Fit for 55 proposals will lead to a decrease in total number of passengers and flights. In the High scenario this is not the case, as the decreased demand still surpasses the total capacity of the Dutch airports, see Figure 10.

**Figure 10 - Effects of Fit for 55 on total number of passengers travelling through Dutch airports in WLO Low and High scenario in 2030 and 2050. For 2050, a low carbon price and a high carbon price variant are distinguished**




Zooming in on the Low scenario and distinguishing Amsterdam Airport (including Lelystad) and the regional Dutch commercial airports, we found that in 2030, the number of intra-EEA passengers from Amsterdam would be reduced by 8.5% and from the regional airports by 12.3%. This translates in around 14,000 and 5,500 intra-EEA flights, respectively. Demand for extra-EEA flights decreases only slightly in 2030. In 2050, projections of demand lead to higher reductions but are also more uncertain. The largest decrease in demand (relatively) takes effect for intra-EEA flights from the regional airports in 2050 in the high price variant: -16.9%. In absolute terms, the largest decrease is associated with intra-EEA flights from Amsterdam: 3.6 million passengers less would fly from Schiphol Airport to intra-EEA destinations in 2050 as a consequence of the ticket price increases due to the Fit for 55 package, corresponding to around 24,000 flights.

## 7.3 Competitiveness

In Chapter 5 the possible effects of the Fit for 55 proposals on the hub functionality of Amsterdam Airport were assessed. The most important transfer routes on continent-level via Amsterdam were determined in terms of total transits. The largest number of transfers through Amsterdam Airport is on routes between North-America and Europe (28% for both directions), followed by intra-European routes (26%). Transfers with Europe either as origin or destination constitute 89% of all transfers.

Next, for each of these routes it was estimated whether they could easily be rerouted through an alternative hub. This is considered indicative for the risk of Amsterdam Airport losing market share on a particular route as a result of price increases due to the Fit for 55 package. In total around 22% of all transfer routes can be considered as subject to the risk of losing market share to another hub airport, the most important being routes between Europe and Asia, accounting for 14.1% of transfers and 1.8 million passengers annually. Whether this risk will actually materialise depends, among other things, on the capacity of alternative hubs like Istanbul, London and airports in the Gulf States.

## 7.4 $CO_2$ emission reductions

In Chapter 6 we estimated the $CO_2$ emission reductions due to the Fit for 55 package at EU level on the basis of the Impact Assessments and supporting studies. We estimated gross well-to-wing emission reductions in 2030 to be 17.3% for intra-EEA flights and 6.5% for extra-EEA flights. Net emission reductions were projected to be 17.3% for intra-EEA flights and 15.4% for extra-EEA flights. For 2050, emission reductions were estimated at 65.2% for intra-EEA flights and 60.8% for extra-EEA flights. We did not identify emission reductions as a result of ETS and CORSIA in 2050 because of inherent uncertainties. EU domestic aviation emission reductions were estimated to be about 3% of the total reduction task needed in all sectors to achieve the 55% reduction target in 2030. Note that the Fit for 55 package also yields emission reductions outside the EU, but these do not count towards the 55% as this is a domestic target.

As regards the Dutch aviation sector, we estimated the total emissions for both WLO scenarios, with and without the impacts of the Fit for 55 package, see Table 20. We concluded that in the Low scenario in 2050, Dutch aviation emissions will drop below 5.5 Mton, which is the target set in the recent Luchtvaartnota, as a consequence of the Fit for 55 package. In the High scenario emissions stay slightly above this goal. Additional policies are needed to realise a further decrease. In 2030 emissions are projected to be significantly higher than the 2005 level in both WLO scenarios. This means that the 2030 target of the Luchtvaartnota will, according to our estimations, not be achieved by the Fit for 55 proposals. Note, however, that the results for 2050 are more uncertain than in 2030 as policies can change and sector developments are subject to various assumptions. Furthermore, for 2030 we did not take into account possible COVID-19 effects on demand. If recovery would take longer than expected, demand in 2030 would be lower than shown in our projections.

**Table 20 - $CO_2$ emissions in Mt $CO_2$ in the Dutch aviation sector, baseline and effects of the Fit for 55 package. In brackets the change in emission with respect to 2005 is shown**

| | 2005 | 2030 | 2050 | |
|---|---|---|---|---|
| | | | Low price variant | High price variant |
| Low scenario baseline | 10.9 | 14.2 (+30%) | 17.1 (+57%) | |
| Low scenario Fit for 55 | | 12.9 (+18%) | 5.3 (-51%) | 4.8 (-56%) |
| High scenario baseline | | 15.6 (+43%) | 15.3 (+40%) | |
| High scenario Fit for 55 | | 14.8 (+36%) | 5.7 (-48%) | 5.7 (-48%) |

## 7.5 Limitations

For our assessment we made use of the Impact Assessments accompanying the Commission's proposals, other studies supporting these Impact Assessments and model results from the AEOLUS model, on which the WLO scenarios are based. Within the scope of this study it was not possible to design a model of the development of the Dutch aviation sector or adjust the assumptions in an existing model like AEOLUS, and this brought significant limitations with respect to the level of detail and/or certainty in our results. Being dependent on different data sets, we had to account for differences in assumptions or baselines behind these data sets as accurately as possible. Sometimes, in particular in comparing the way carbon pricing was incorporated in the baselines of the ETS Aviation Impact Assessment and AEOLUS, we concluded that there was no single, unambiguous relationship between the two datasets. This has caused an additional degree of uncertainty in our results, on top of the uncertainty associated with the given data themselves, which mostly reflected model outcomes.

Another limitation in our assessment that we would like to point out is related to the inherent uncertainty in projections about the far future, in our case 2050. The Fit for 55 package is, as the name suggests, mostly focused on implementing the EU's climate target of at least 55% net greenhouse gas emissions reduction in 2030, compared to 1990 levels. It certainly is meant to pave the way for the climate neutrality target in 2050 as well, but EU policies will also almost certainly change (again) in the coming 30 years. While for most of the assessed proposals their effect in 2050 could nevertheless be estimated in a relatively straightforward way, in the case of the ETS and CORSIA this led to serious complications. For both instruments it is not clear at this moment how they will function in 2050. We have accounted for this uncertainty by defining a low carbon price and a high carbon price scenario based on literature and presenting our results for both scenarios. Still, the 2050 results from this study should be interpreted in terms of a sketch of possible outcomes rather than exact figures. A follow-up study based on including the Fit for 55 features into a model of the aviation sector development would be needed to be able to draw conclusions with a higher level of certainty, for example on the achievement of the Luchtvaartnota targets.

# References

**CE Delft, 2019.** $CO_2$-emissies van KLM en Schiphol. Delft, CE Delft.

**CE Delft, 2021**. Additional profits of sectors and firms from the EU ETS 2008-2019. Delft, CE Delft.

**CPB & PBL, 2016.** Mobiliteit en Luchtvaart Achtergronddocument: WLO-Welvaart en Leefomgeving, Toekomstverkenning 2030-2050. Den Haag, Centraal Planbureau (CPB); Planbureau voor de Leefomgeving (PBL).

**EC, 2020.** Impact Assessment Report accompanying the document Communication from the European Commission to the European Parliament, the Council, The European Economic and Social Committee and the Committee of the Regions. Stepping up Europe's 2030 climate ambition. Investing in a climate-neutral future for the benefit of our people. SWD(2020) 176 final [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020SC0176&from=EN [Accessed December 2021].

**EC, 2021a**. Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC as regards aviation's contribution to the Union's economy-wide emission reduction target and appropriately implementing a global market-based measure, COM (2021) 552 final [Online]. Brussels: European Commission (EC). Available: https://ec.europa.eu/info/sites/default/files/revision_of_the_eu_emission_trading_system_for_aviation.pdf [Accessed October 2021].

**EC, 2021b.** Impact Assessment Report accompanying the Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC as regards aviation's contribution to the Union's economy-wide emission reduction target and appropriately implementing a global market-based measure, SWD(2021), 603 final [Online]. Brussels: European Commission (EC). Available: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021SC0603&from=EN [Accessed October 2021].

**EC, 2021c**. Impact Assessment Report accompanying the Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC establishing a system for greenhouse gas emission allowance trading within the Union, Decision (EU) 2015/1814 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading scheme and Regulation (EU) 2015/75, SWD (2021), 601 (final) [Online]. Brussels: European Commission (EC). Available: https://ec.europa.eu/info/sites/default/files/revision-eu-ets_with-annex_en_0.pdf [Accessed November 2021].

**EC, 2021d.** Proposal for a Directive of the European Parliament and of the Council amending Directive (EU) 2018/2001 of the European Parliament and of the Council, Regulation (EU) 2018/1999 of the European Parliament and of the Council and Directive 98/70/EC of the European Parliament and of the Council as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652, COM(2021) 557 final [Online]. Brussels: European Commission (EC). Available: https://eur-lex.europa.eu/resource.html?uri=cellar:dbb7eb9c-e575-11eb-a1a5-01aa75ed71a1.0001.02/DOC_1&format=PDF [Accessed October 2021].

**EC, 2021e**. Impact Assessment Report accompanying the Proposal for a Directive of the European Parliament and of the Council amending Directive (EU) 2018/2001 of the European Parliament and of the Council, Regulation (EU) 2018/1999 of the European Parliament and of the Council and Directive 98/70/EC of the European Parliament and of the Council as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652, SWD(2021) 621 final [Online]. Brussels: European Commission (EC). Available: https://eur-lex.europa.eu/resource.html?uri=cellar:0f87c682-e576-11eb-a1a5-01aa75ed71a1.0001.02/DOC_1&format=PDF [Accessed October 2021].

**EC, 2021f.** Proposal for a Regulation of the European Parliament and of the Council on ensuring a level playing field for sustainable air transport, COM(2021) 561 final [Online]. Brussels: European Commission (EC). Available: https://ec.europa.eu/info/sites/default/files/refueleu_aviation_-_sustainable_aviation_fuels.pdf [Accessed October 2021].

**EC, 2021g.** Impact Assessment Report accompanying the Proposal for a Regulation of the European Parliament and of the Council on ensuring a level playing field for sustainable air transport, SWD(2021) 633 final [Online]. Brussels: European Commission (EC). Available: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021SC0633&from=EN [Accessed October 2021].

**EC, 2021h**. Proposal for a Regulation of the European Parliament and of the Council on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU of the European Parliament and of the Council, COM(2021) 559 final [Online]. Brussels: European Commission (EC). Available: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021PC0559&from=en [Accessed December 2021].

**EC, 2021i**. Impact Assessment Report accompanying the Proposal for a Regulation of the European Parliament and of the Council on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU of the European Parliament and of the Council, SWD/2021/631 final [Online]. Brussels: European Commission (EC). Available: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021SC0631&from=EN (Accessed December 2021].

**EC, 2021j.** Proposal for a Council Directive restructuring the Union framework for the taxation of energy products and electricity (recast), COM(2021) 563 final [Online]. Brussels: European Commission (EC). Available: https://eur-lex.europa.eu/resource.html?uri=cellar:1b01af2a-e558-11eb-a1a5-01aa75ed71a1.0001.02/DOC_1&format=PDF [Accessed November 2021].

**EC, 2021k.** Impact Assessment Report accompanying the document Proposal for a Council Directive restructuring the Union framework for the taxation of energy products and electricity (recast), SWD(2021) 641 final [Online]. Brussels: European Commission (EC). Available: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021SC0641&from=EN [Accessed November 2021].

**ICF Consulting, Air Transportation Analytics, NewClimate Institute, CambridgeEconometrics, HFW & Starckx. 2020**. Assessment of ICAO's global market-based measure (CORSIA) pursuant to Article 28b and for studying cost pass-through pursuant to Article 3d of the EU ETS Directive [Online]. Brussels: European Commission. Available: https://www.actu-environnement.com/media/pdf/news-37353-Etude-commission-europenne-corsia-compensation-carbone-aviation.pdf [Accessed November 2021].

**IETA, 2020.** Future carbon credit demand, supply and prices [Online]. International Emissions Trading Association (IETA). Available: https://ieta.org/resources/Conferences_Events/2021/IETA%20LIVE%20Series/Trove%20Research_Carbon%20Credit%20Demand%20and%20Prices.pdf [Accessed November 2021]

**Intervistas, 2007.** Estimating Air Travel Demand Elasticities. Final Report. Intervistas. Available: https://www.iata.org/en/iata-repository/publications/economic-reports/estimating-air-travel-demand-elasticities---by-intervistas/ [Accessed December 2021].

**KLM, 2019.** Annual Report 2018. Amsterdam: KLM. Available: https://www.klm.com/travel/nl_en/images/KLM_Annual_Report_2018_tcm542-1045331.pdf [Accessed December 2021]

**NLR, 2021.** Analysewerkzaamheden CO2-plafond – Eindresultaten 'vingeroefening' (Confidential). NLR – Royal Netherlands Aerospace Centre.

**NLR & SEO, 2021.** Destination 2050. A Route To Net Zero European Aviation. NLR - Royal Netherlands Aerospace Centre & SEO Amsterdam Economics. Available: https://www.destination2050.eu/wp-content/uploads/2021/03/Destination2050_Report.pdf [Accessed November 2021]

**PBL, 2020.** $CO_2$-emissie van de luchtvaart op de lange termijn. Notitie. The Hague, Planbureau voor de Leefomgeving (PBL).

**Ricardo, GWS & Ipsos, 2021.** Study on the taxation of the air transport, final report. London: Ricardo. Available: https://ec.europa.eu/taxation_customs/system/files/2021-07/Aviation-Taxation-Report.pdf [Accessed October 2021]

**Ricardo, Öko-Institut & E-Modelling, 2021**. Study supporting the impact assessment of the ReFuelEU Aviation initiative. Final report. Brussels: European Commission. Available: https://op.europa.eu/en/publication-detail/-/publication/071366e9-0b94-11ec-adb1-01aa75ed71a1/language-en/format-PDF [Accessed December 2021]

**Schiphol, 2019**. Schiphol Continue Onderzoek 2019 (confidential)

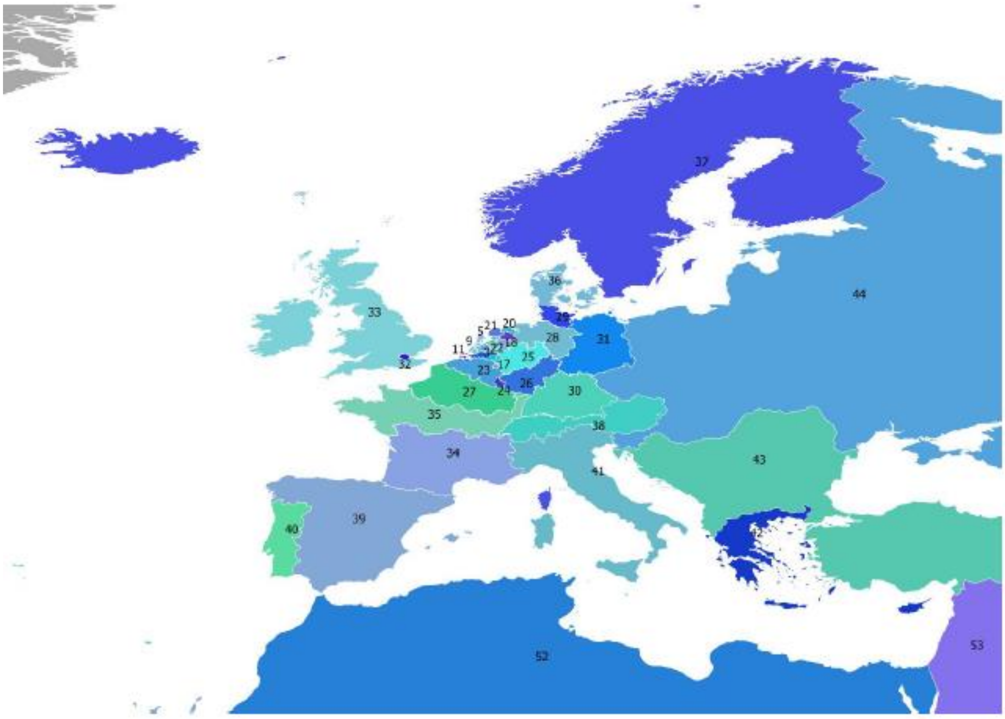
**Significance, 2020.** AEOLUS Documentatie 1.1 : Rapport voor Rijkswaterstaat WVL, (confidential). Significance.

**Significance & To70, 2019.** Actualisatie AEOLUS 2018 en geactualiseerde luchtvaartprognoses. The Hague, Significance.

# Annex I – Adjustment of AEOLUS regions to fit EEA territory

In the AEOLUS model, the world has been divided in 56 model zones in order to calculate all relevant air traffic, see Figure 11. The zones do not always follow the external border of the EU or the EEA. Several model zones include both areas within the EEA and outside the EEA. To take this into account, we disaggregated the 2019 data (Schiphol, 2019) for these regions over EEA and non-EEA countries. The resulting share of EEA passengers for each of these regions was then applied to the modelled data for 2030 and 2050 in order to make the data set coincide with the EEA territory.

**Figure 11 - Map of AEOLUS model zones covering the EEA**




Figuur E.2 Passagierszones (Europa).

Table 21 shows the AEOLUS model zones that include both EEA and non-EEA countries with their respective share of passengers (2019 data).

**Table 21 - AEOLUS model zones including both EEA and non-EEA countries and the respective shares of passengers according to 2019 passenger data**

| AEOLUS model zone | Region | EEA | non-EEA |
|---|---|---|---|
| 33 | UK, IE | **20%** | 80% |
| 38 | AT, CH | **36%** | 64% |
| 43 | South Eastern Europe | **28%** | 72% |
| 44 | Eastern Europe | **71%** | 29% |

# Annex II - Price elasticities

We estimated the price elasticities used in our analysis on the basis of data from Intervistas (2007). Table 22 shows the price elasticities as applied in this study. Figure 12 shows price elasticity values for different routes as presented by Intervistas (2007).

For intra-EEA non-business passengers, we used the value for Pan-National Level/Short-haul/Intra-Europe from Figure 12. For extra-EEA non-business passengers we used the average value of Pan-National Level/Long-haul/Trans Atlantic and Pan-National Level/Long-haul/Europe-Asia. For non-business transfer passengers we used the value of 1.0 as a rough estimation. This value should be higher than the intra-Europe value, but not as high as the Route/Market level values involving Europe, as for the purposes of this study passengers will only divert to non-EU hubs and not to other hubs within the EU. To obtain price elasticity values for business passengers, we took 50% of the non-business value in all cases. The price elasticity for cargo was considered to be zero as explained in Chapter 3.

**Table 22 - Price elasticities as used in the analysis of demand change due to the Fit for 55 package**

| Pax/cargo | Flight type | Purpose | Price elasticity |
|---|---|---|---:|
| Passengers | Intra-EEA | Business | -0.46 |
| | | Non-business | -0.92 |
| | Extra-EEA | Business | -0.32 |
| | | Non-business | -0.63 |
| | Transfer | Business | -0.50 |
| | | Non-business | -1.00 |
| Cargo | | | 0 |

**Figure 12 - Price elasticities for different routes and at different levels.**

| | Route/Market Level | | National Level | | Pan-National Level | |
|---|---|---|---|---|---|---|
| | Short-haul | Long-haul | Short-haul | Long-haul | Short-haul | Long-haul |
| Intra North America | -1.54 | -1.40 | -0.88 | -0.80 | -0.66 | -0.60 |
| Intra Europe | -1.96* | -1.96 | -1.23 | -1.12 | -0.92 | -0.84 |
| Intra Asia | -1.46 | -1.33 | -0.84 | -0.76 | -0.63 | -0.57 |
| Intra Sub-Sahara Africa | -0.92 | -0.84 | -0.53 | -0.48 | -0.40 | -0.36 |
| Intra South America | -1.93 | -1.75 | -1.10 | -1.00 | -0.83 | -0.75 |
| Trans Atlantic (North America – Europe) | -1.85 | -1.68 | -1.06 | -0.96 | -0.79 | -0.72 |
| Trans Pacific (North America – Asia) | -0.92 | -0.84 | -0.53 | -0.48 | -0.40 | -0.36 |
| Europe-Asia | -1.39 | -1.26 | -0.79 | -0.72 | -0.59 | -0.54 |

*The short-haul adjustor has not been applied to the Intra Europe short-haul elasticity in order to maintain elasticities below 2.0

Source: Intervistas (2007).

# Annex III - AEOLUS model output

In Table 23 all AEOLUS model output is presented that was used for the assessments of the impacts of the Fit for 55 proposals in this study. In combination with Table 12 and Table 13 it can be used to determine the effects on the number of passengers for any selection of flights.

**Table 23 - AEOLUS model output (number of passengers) as used in this study. Tr = Transfer; OD = Origin-Destination. Other = regional airports other than AMS/LEY. Non-bss = Non-business. L = Low scenario. H = High scenario. 30 = 2030. 50 = 2050. Unres = unrestricted dataset. Res = restricted dataset**

| Tr/OD | Airport | FSC/LCC | Purpose | Intra/Extra EEA | L 30 unr | H 30 unr | L 30 res | H 30 res | L 50 unr | H 50 unr | L 50 res | H 50 res |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tr | AMS | | Business | Intra<>Intra | 704799 | 753973 | 702552 | 621812 | 937544 | 1032412 | 936893 | 643913 |
| Tr | AMS | | Business | Intra<>Extra | 3415925 | 3917583 | 3917583 | 3156242 | 4723278 | 5776963 | 4720833 | 3333993 |
| Tr | AMS | | Business | Extra<>Extra | 2217996 | 2555057 | 2200465 | 1905510 | 3097701 | 3765169 | 3093856 | 1688326 |
| Tr | AMS | | Non-bss | Intra<>Intra | 722079 | 940918 | 720601 | 729040 | 831381 | 1158816 | 831732 | 643041 |
| Tr | AMS | | Non-bss | Intra<>Extra | 5769843 | 7991323 | 5744333 | 6196077 | 7950065 | 12829245 | 7945558 | 6811987 |
| Tr | AMS | | Non-bss | Extra<>Extra | 4525286 | 6208288 | 4487383 | 4447163 | 6619684 | 10973034 | 6610444 | 4389347 |
| OD | AMS/LEY | FSC | Business | Intra-EEA | 5806001 | 6284811 | 5917118 | 5687608 | 7955212 | 9082515 | 8121886 | 6865952 |
| OD | AMS/LEY | LCC | Business | Intra-EEA | 2978779 | 3844275 | 3006410 | 3901962 | 4003350 | 5510412 | 3903055 | 5331604 |
| OD | AMS/LEY | FSC | Non-bss | Intra-EEA | 8707564 | 11808551 | 9215181 | 10644823 | 10876133 | 16087717 | 11486137 | 11347229 |
| OD | AMS/LEY | LCC | Non-bss | Intra-EEA | 7286511 | 11970680 | 6827564 | 10533600 | 8561197 | 15367283 | 7859814 | 13220839 |
| OD | AMS/LEY | FSC | Business | Extra-EEA | 7116881 | 8122221 | 7099656 | 7527454 | 10098289 | 12608701 | 10060634 | 10475511 |
| OD | AMS/LEY | LCC | Business | Extra-EEA | 3127458 | 4022520 | 3430242 | 4308777 | 4330876 | 6048173 | 4765640 | 6492183 |
| OD | AMS/LEY | FSC | Non-bss | Extra-EEA | 15242461 | 21329387 | 15346267 | 19902029 | 21024709 | 33953229 | 21005596 | 28326186 |
| OD | AMS/LEY | LCC | Non-bss | Extra-EEA | 4459571 | 7640347 | 4820003 | 7859874 | 6103109 | 11610185 | 6740710 | 12657659 |
| OD | Other | FSC | Business | Intra-EEA | 110560 | 134671 | 110989 | 139820 | 158824 | 215263 | 159487 | 239396 |
| OD | Other | LCC | Business | Intra-EEA | 2484441 | 3197635 | 2519453 | 3292027 | 3340978 | 5215380 | 3410946 | 5712592 |
| OD | Other | FSC | Non-bss | Intra-EEA | 101716 | 173539 | 103682 | 184739 | 140155 | 268601 | 142398 | 309292 |
| OD | Other | LCC | Non-bss | Intra-EEA | 3815766 | 6726922 | 4053830 | 7354565 | 4405688 | 9121881 | 4672883 | 10630600 |
| OD | Other | FSC | Business | Extra-EEA | 350308 | 391823 | 339021 | 374900 | 506421 | 560964 | 487407 | 585807 |
| OD | Other | LCC | Business | Extra-EEA | 857585 | 1127488 | 870147 | 1172161 | 1181984 | 1896557 | 1197284 | 2063126 |
| OD | Other | FSC | Non-bss | Extra-EEA | 457457 | 687349 | 443309 | 644007 | 650602 | 1067661 | 620973 | 1081026 |
| OD | Other | LCC | Non-bss | Extra-EEA | 921889 | 1656537 | 972974 | 1778213 | 1150723 | 2516091 | 1200172 | 2803263 |

# Annex IV - Transits at Schiphol Airport

Table 24 shows the shares of all transfer routes via Schiphol at continent level, disaggregated for travel purpose.

**Table 24 - Share of (non)-business transits via Schiphol Airport**

| | Africa | Asia | Europe | Middle-East | Latin-America | N-America | Total |
|---|---|---|---|---|---|---|---|
| **Africa** | 0% | 0% | 4% | 0% | 0% | 2% | 6% |
| Non-business | 0% | 0% | 3% | 0% | 0% | 1% | 4% |
| Business | 0% | 0% | 1% | 0% | 0% | 1% | 2% |
| **Asia** | 0% | 0% | 6% | 0% | 1% | 1% | 8% |
| Non-business | 0% | 0% | 4% | 0% | 0% | 1% | 5% |
| Business | 0% | 0% | 2% | 0% | 1% | 0% | 3% |
| **Europe** | 3% | 8% | 26% | 1% | 5% | 12% | 55% |
| Non-business | 2% | 5% | 14% | 1% | 4% | 9% | 34% |
| Business | 1% | 3% | 12% | 0% | 1% | 4% | 21% |
| **Middle-East** | 0% | 0% | 1% | 0% | 0% | 1% | 2% |
| Non-business | 0% | 0% | 1% | 0% | 0% | 1% | 1% |
| Business | 0% | 0% | 0% | 0% | 0% | 0% | 1% |
| **Latin-America** | 0% | 1% | 7% | 0% | 0% | 0% | 8% |
| Non-business | 0% | 0% | 5% | 0% | 0% | 0% | 6% |
| Business | 0% | 0% | 2% | 0% | 0% | 0% | 2% |
| **N-America** | 2% | 1% | 16% | 1% | 0% | 0% | 21% |
| Non-business | 2% | 1% | 11% | 0% | 0% | 0% | 14% |
| Business | 1% | 0% | 5% | 0% | 0% | 0% | 6% |
| **Total** | **5%** | **10%** | **60%** | **2%** | **6%** | **17%** | **100%** |