CLIMATE CHANGE

22/2016

The EU Emission Trading Schemes‘ effects on the competitive situation within national and international aviation

For our Environment

Umwelt Bundesamt

CLIMATE CHANGE 22/2016

Environmental Research of the
Federal Ministry for the
Environment, Nature Conservation,
Building and Nuclear Safety

Project No. (FKZ) 3712 41 501
Report No. (UBA-FB) 002029/E

The EU Emission Trading Schemes' effects on the competitive situation within national and international aviation

by

Martin Peter, Damaris Bertschmann
INFRAS, Zürich, Switzerland

Jasper Faber, Martine Smit
CE Delft, Delft; The Netherlands

André van Velzen
Transport Analysis and Knowledge Systems (TAKS), Utrecht, The Netherlands

On behalf of the Federal Environment Agency (Germany)

Imprint

Publisher:
Umweltbundesamt
Wörlitzer Platz 1
06844 Dessau-Roßlau
Tel: +49 340-2103-0
Fax: +49 340-2103-2285
info@umweltbundesamt.de
Internet: www.umweltbundesamt.de

/umweltbundesamt.de
/umweltbundesamt

Study performed by:
INFRAS
Binzsatr. 23
CH-8045 Zürich

Study completed in:
October 2014

Edited by:
Section E 2.3 Economic Aspects of Emissions Trading, Monitoring, Evaluation
Alexandra Zirkel

Publication as pdf:
http://www.umweltbundesamt.de/publikationen/the-eu-emission-trading-schemes-effects-on-the

ISSN 1862-4359

Dessau-Roßlau, April 2016

The Project underlying this report was supported with funding from the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear safety under project number FKZ 3712 41 501. The responsibility for the content of this publication lies with the author(s).

Abstract

The EU has partially included Aviation in the EU Emissions Trading Scheme (EU ETS). As a result, operators of flights that are covered in the EU ETS have to surrender allowances, some of which are allocated for free, while others have to be bought. This results in a cost increase. Because not all airlines have the same share of flights in the system, there could be an impact on the competitiveness of airlines.

This report analyses the impacts of the EU ETS on the competitiveness of various types of aircraft operators by means of micro-economic analysis and by extensive short-term and long-term modelling. Because of political negotiation processes on the geographical scope of the EU ETS we analyse the impacts for two scenarios:

1. A scenario in which all emissions from flights between airports in the European Free Trade Association are covered (Stopping the Clock scenario).
2. A scenario in which all emissions from flights in the European airspace are covered (European airspace scenario).

The second scope is larger, as it also includes emissions from flights between airports in Europe and airports on other continents are partly included in the EU ETS. The study shows that the EU ETS has only a small impact on competitiveness.

Kurzbeschreibung

Die EU hat den Luftverkehr teilweise ins EU-Emissionshandelssystem (EU EHS) einbezogen. Luftfahrzeugbetreiber mit vom EU EHS erfassten Flügen müssen für diese Flüge Emissionsrechte abgeben. Diese werden entweder kostenlos zugeteilt oder müssen gekauft werden. Dies führt zu einem Kostenanstieg. Weil die Airlines unterschiedliche Angebotsstrukturen aufweisen und nicht bei allen Airlines derselbe Anteil ihrer Flüge vom EU EHS erfasst wird, kann der Einbezug der Luftfahrt ins EU EHS Auswirkungen auf die Wettbewerbsfähigkeit der Fluggesellschaften haben.

Der vorliegende Bericht untersucht unter Einsatz mikroökonomischer Analyse und umfangreicher Modellierungen die kürzerfristigen und langfristigen Auswirkungen des EU EHS auf die Wettbewerbsfähigkeit für verschiedene Typen von Luftfahrzeugbetreibern. Wegen anhaltender politischer Diskussionen, welche geografische Abgrenzung der Einbezug der Luftfahrt ins EH EHS aufweisen soll, untersuchen wir die Auswirkungen für zwei Szenarien:

1. Das „Stopping the Clock“ (STC)-Szenario, in dem alle Emissionen von Flügen zwischen Flughäfen in der Europäischen Freihandelszone einbezogen werden.
2. Das „European Airspace“ (EAS)-Szenario, in dem alle Emissionen von Flügen innerhalb des europäischen Luftraums erfasst sind.

Das zweite Szenario ist breiter, da es auch Emissionen von Flügen zwischen Europa und Flughäfen in anderen Kontinenten teilweise einbezieht. Die Studie zeigt, dass das EU EHS nur in geringem Umfang Auswirkungen auf die Wettbewerbsfähigkeit hat.

Table of Contents

List of Figures

List of Tables

Summary

The carbon dioxide emissions of aviation are about 2% of global manmade emissions and they are rising rapidly. In order to address the climate impact of these emissions, the EU has partially included them in the EU Emissions Trading Scheme (EU ETS). As a result, operators of flights that are included in the EU ETS have to surrender allowances, some of which are allocated for free, while others have to be bought at an auction or from other participants in the EU ETS. This results in a cost increase on those flights, and because not all airlines have the same share of flights in the system, there could be an impact on the competitiveness of airlines.

This report analyses the impacts of the EU ETS on the competitiveness of various types of aircraft operators by means of micro-economic analysis and by extensive short-term and long-term modelling.

Because of political negotiation processes on the geographical scope of the EU ETS at the time of writing, we analyse the impacts for two scenarios:

1. A scenario in which all emissions from flights between airports in the European Free Trade Association (EFTA) are covered (EU, Norway, Iceland, Switzerland and Liechtenstein) (Stopping the Clock scenario; STC scenario).
2. A scenario in which all emissions from flights in the European airspace are covered (European airspace scenario; EAS scenario).

The second scope is larger, as it also includes emissions from flights between airports in Europe and airports on other continents are partly included in the EU ETS.

We analyse the impacts on six types of airlines: network carriers which operate both continental and intercontinental flights and offer transfer flights to passengers, low cost carriers (LCC) which typically only have continental flights and only offer point-to-point flights, and freighters, and each of these either from Europe (meaning their network is centred in Europe) or from other continents.

Effects on demand and profits

Overall, the impacts on competitiveness are small. According to our analyses European airlines face in 2012 total additional effective costs in the order of 100 m. to 150 m. EUR. This corresponds to 0,07% to 0,10% of their total costs and has the same cost effect as an oil price increase from 100 USD per barrel to 102 USD per barrel.

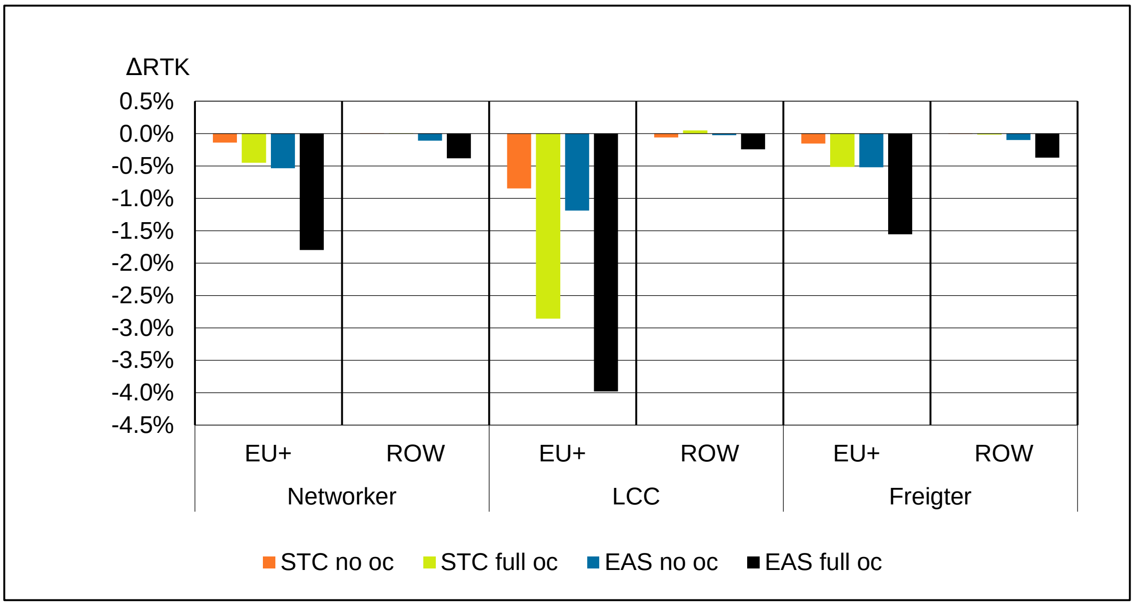
Even with allowance prices that are much higher than the current prices (EUR 25 per tonne instead of 7 € in 2012), the impact on demand is typically less than 4% for all airline types. In most cases the impact stays even below 1%. This is true regardless of whether opportunity costs are passed on or not, and regardless of the geographical scope of the scenario.

In general, the implementation of the EU ETS has a higher impact on LCC than on other airline types but it is still small. There are three reasons for LCC being more affected than other airline types: First, the fuel cost share in total operating costs or the percentual cost increase for LCC is higher than for other airline types. Second, their passengers have in average a higher price sensitivity than passengers and cargo of networker carriers and freighters. Third, LCC have a higher share of their network within the scope of the EU ETS than network carriers and freighters, which have a substantial share of their network on

intercontinental destinations. Whereas the first two reasons are intended (internalisation of external costs) or do also occur if there is another reason for cost increases than EU ETS inclusion (e.g. low willingness to pay of passengers), the third reason leads to minor unintended distortions of competition.

Figure S1 shows the impact of the EU ETS on aviation demand measured in revenue ton kilometres (RTK) in the year 2012, in case the allowance price would be 25 € for the STC scenario and the EAS scenario with and without passing on of opportunity costs.

Figure S1: Impact of the EU ETS on demand (2012, 25 €/tCO2)



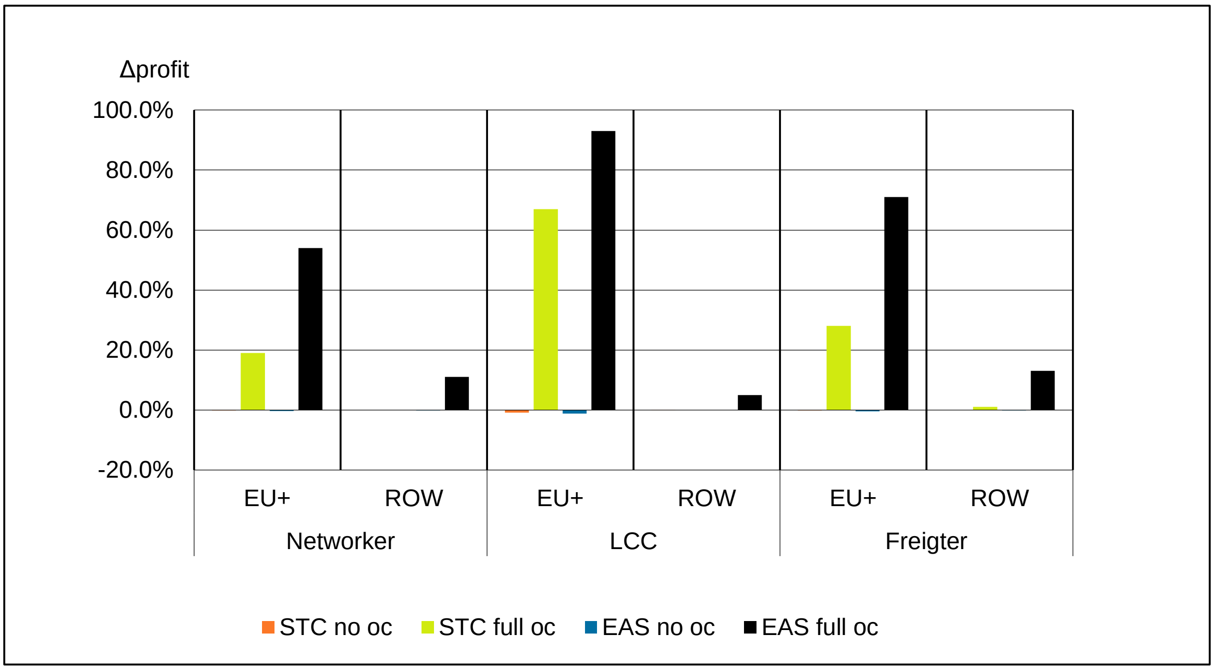
Source: INFRAS (no oc=no passing on of opportunity costs; full oc= full passing on of opportunity costs)

Whereas the impact on demand is always negative the impact on profits depends on the possibility to pass on opportunity costs.

The impacts on profits depend on whether or not opportunity costs can be passed on. In perfect competitive markets, opportunity costs would be passed on, but in oligopolies or when the supply curve slopes upward, they would not or only partially. There is no empirical evidence on cost pass on so far, so we have modelled two options. If opportunity costs cannot be passed on, the profits of LCC decrease the most, as their demand is reduced by the largest share. If, on the other hand, opportunity costs can be passed on, LCC see their profits increase the most, as they receive a large amount of free allowances relative to their emissions due to the higher EU network share and their high number of passengers per aircraft. The difference between these two situations is very large. This also implies that even the pass on of a small share of opportunity costs would suffice to offset the negative impacts of the EU ETS on profits.

The following figure and table show the impact on profits:

Figure S2: Impact of the EU ETS on profits (2012, 25 €/tCO2)



Source: INFRAS (no oc=no passing on of opportunity costs; full oc= full passing on of opportunity costs)

Table S1: Impact of the EU ETS on profits (2012, 25 €/tCO2)

Change in profit	Networker		LCC		Freighter	
	EU+	ROW	EU+	ROW	EU+	ROW
STC no oc	-0,2%	0,0%	-0,9%	0,1%	-0,2%	0,0%
STC full oc	19,0%	0,0%	67,0%	0,0%	28,0%	1,0%
EAS no oc	-0,4%	-0,1%	-1,2%	0,0%	-0,5%	-0,1%
EAS full oc	54,0%	11,0%	93,0%	5,0%	71,0%	13,0%

Source: INFRAS (no oc=no passing on of opportunity costs; full oc= full passing on of opportunity costs)

Looking at the characteristics of the aviation market we expect in the short term (up to about two years after the EU ETS introduction) no passing on of opportunity costs as in this period the network of airlines is basically fixed and prices are set to maximise revenues. In the long run (more than five years after the EU ETS introduction) we expect that a larger part of opportunity costs is passed on. Whether and which share of the opportunity costs are passed on depends largely on the steepness of the supply curve (details see chapter 3). Furthermore, the pass on will be smaller if airlines aim to maximise revenues than when they aim to maximise profits. In the medium term (between about two and five years) there usually is a transition phase between the short and long term behaviour. For the expected pass on of opportunity costs in the long term situation the airlines have to assume the EU ETS to be persistent.

Additional reasons for distortions

In theory, airlines could improve their competitive position in two ways. First, by additional crossfinancing, i.e. airlines redistribute the EU ETS costs to flights that are not covered by the ETS, thus lowering their prices in the EU ETS and gaining market share at the expense of airlines that have fewer flights outside the ETS. Second, by benefiting from the fact that their hub airports are outside the EU so that passengers transferring at an EU airport would have a larger part of their emissions covered by the EU ETS, and therefore higher costs, than passengers that transfer at a hub outside the EU.

Crossfinancing has been subject of much debate in the literature. A theoretical analysis shows that if it is possible at all, it is limited. Our modelling shows that the benefits to airlines would be negligible.

The hub effect is possible, but confined to a limited number of routes. So the overall effect on competitiveness will be small.

Conclusion

In summary, the analysis shows that the impact of the EU ETS is small for all airline types. In the short term LCC are more strongly affected than networker carrier and freighters. As far as this is the result of the internalisation of external costs or a low willingness to pay of their customers, this is an intended result from an economic point of view. Unintended effects arise from the limited scope of the EU ETS. In the long run, if airlines expect the system to be persistent, airlines can benefit from windfall profits due to the passing on of opportunity costs. Windfall profits have the same effect as subsidies and distort the competition in favour of airlines with high shares of their network within the EU ETS. As well as the negative impacts of the EU ETS in a situation without passing on of opportunity costs also these positive long term impacts on airlines are expected to be small.

Zusammenfassung

Die CO_2-Emissionen der Luftfahrt machen rund 2% der globalen, vom Mensch verursachten Emissionen aus und steigen rasch an. Um die Klimawirkungen des Luftverkehrs zu reduzieren, hat die EU ihn ins EU-Emissionshandelssystem (EU EHS) einbezogen. Für die Emissionen der Flüge, die im EU EHS erfasst sind, müssen die Luftfahrzeugbetreiber Emissionsrechte abgeben. Diese werden entweder kostenlos zugeteilt oder müssen gekauft werden. Dies führt zu einem Kostenanstieg. Weil die Airlines unterschiedliche Angebotsstrukturen aufweisen und nicht bei allen Airlines derselbe Anteil ihrer Flüge vom EU EHS erfasst wird, kann der Einbezug der Luftfahrt ins EU EHS Auswirkungen auf die Wettbewerbsfähigkeit der Fluggesellschaften haben.

Der vorliegende Bericht untersucht unter Einsatz mikroökonomischer Analyse und umfangreicher Modellierungen die kürzerfristigen und langfristigen Auswirkungen des EU EHS auf die Wettbewerbsfähigkeit für verschiedene Typen von Luftfahrzeugbetreibern. Aufgrund der anhaltenden politischen Diskussion, welche geografische Abgrenzung der Einbezug der Luftfahrt ins EU EHS aufweisen soll, untersuchen wir die Auswirkungen für zwei Szenarien:

1. Das „Stopping the Clock“ (STC)-Szenario, in dem alle Emissionen von Flügen zwischen Flughäfen in der Europäischen Freihandelszone (EFTA) einbezogen werden (EU, Norwegen, Island, Schweiz und Liechtenstein).
2. Das „European Airspace“ (EAS)-Szenario, in dem alle Emissionen von Flügen innerhalb des europäischen Luftraums erfasst sind.

Das zweite Szenario ist breiter, da es auch teilweise Emissionen von Flügen zwischen Europa und Flughäfen in anderen Kontinenten einbezieht.

Wir untersuchen die Wettbewerbswirkungen für sechs Typen von Fluggesellschaften:

a) Netzwerk-Carrier, die ein Passagier- und Bellyfreight-Netzwerk von kontinentalen und interkontinentalen Flügen betreiben und auch Transferflüge für Passagiere anbieten,

b) Low-Cost-Carrier (LCC), die typischerweise nur kontinentale und nur Punkt-zu-Punkt-Flüge für Passagiere anbieten und

c) reine Frachtairlines.

Für alle drei Airlinearten unterscheiden wir zwischen einem Airlinetyp, der in der EU beheimatet ist und einem, der nicht in der EU beheimatet ist.

Wirkungen auf die Nachfrage und Gewinne

Insgesamt sind die Auswirkungen auf die Wettbewerbsfähigkeit klein. Gemäss unseren Analysen waren die europäischen Luftfahrtgesellschaften 2012 mit zusätzlichen effektiven Kosten im Umfang von 100 bis 150 Mio. € konfrontiert. Das entspricht 0,07% bis 0,1% der Gesamtkosten und ist vergleichbar mit dem Kosteneffekt einer Erhöhung des Ölpreises von 100 USD pro Barrel auf 102 USD pro Barrel.

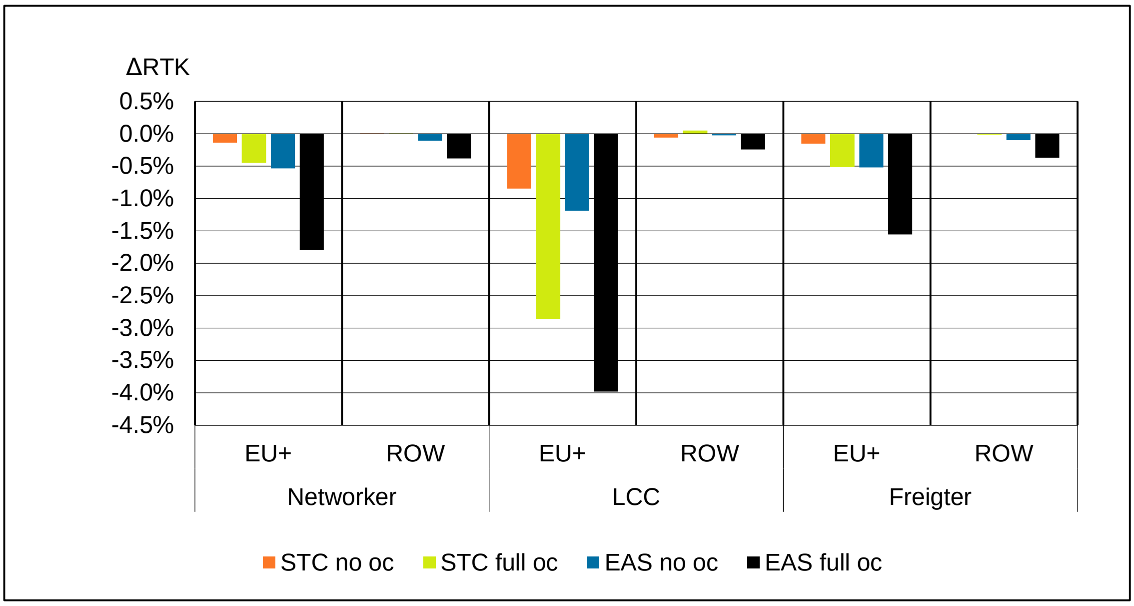
Selbst wenn der Zertifikatspreis im STC-Szenario stark über dem aktuellen Preis liegen würde (25 € pro Tonne anstatt 7 € in 2012) reduziert sich die Nachfrage für keinen Airlinetyp um mehr als 4%. In den meisten Fällen bleiben die Auswirkungen unter 1% bezüglich Nachfrage, Verkehrsleistung und Umsatz. Dies gilt unabhängig davon, ob

Opportunitätskosten[1] überwälzt werden oder nicht sowie unabhängig von der geografischen Abgrenzung des Szenarios.

Allgemein hat der Einbezug des Luftverkehrs ins EU EHS eine stärkere Auswirkung auf die LCC als auf andere Airlinetypen, die aber weiterhin als gering einzustufen ist. Die LCC sind aus drei Gründen stärker betroffen als andere Luftfahrtgesellschaften: Erstens ist der Anteil der Treibstoffkosten an den gesamten Betriebskosten und damit der prozentuale Kostenanstieg für die LCC höher als für andere Fluggesellschaften. Zweitens haben die Passagiere von LCC eine höhere durchschnittliche Preissensibilität als die Kunden von Netzwerk-Carriern und Frachtgesellschaften. Letztere haben einen substantiellen Anteil ihres Netzwerks auf interkontinentalen Destinationen. Während die ersten beiden Gründe gewollt sind (Internalisierung externer Kosten) oder auch auftauchen, wenn Kostenanstiege aus anderen Gründen als dem EU EHS auftauchen (z.B. Zahlungsbereitschaft von Passagieren), führt die dritte Ursache zu kleineren nicht erwünschten Wettbewerbsverzerrungen.

Abbildung Z1 zeigt die Auswirkungen des EU EHS auf die Nachfrage nach Luftverkehrsleistungen in Ertrag pro Tonnenkilometer (revenue ton kilometres (RTK)) im Jahr 2012 für den Fall eines Zertifikatspreises von 25 € für das STC-Szenario und das EAS-Szenario mit und ohne Überwälzung der Opportunitätskosten.

Abbildung Z1: Auswirkungen des EU EHS auf die Nachfrage (2012, 25 €/tCO_2)



Quelle: INFRAS (no oc=keine Überwälzung von Opportunitätskosten; full oc= volle Überwälzung von Opportunitätskosten)

Während die Auswirkungen auf die Nachfrage, Verkehrsleistung und Umsatz in allen Fällen negative sind, hängen die Auswirkungen auf die Gewinne von der Möglichkeit ab, die Opportunitätskosten zu überwälzen.

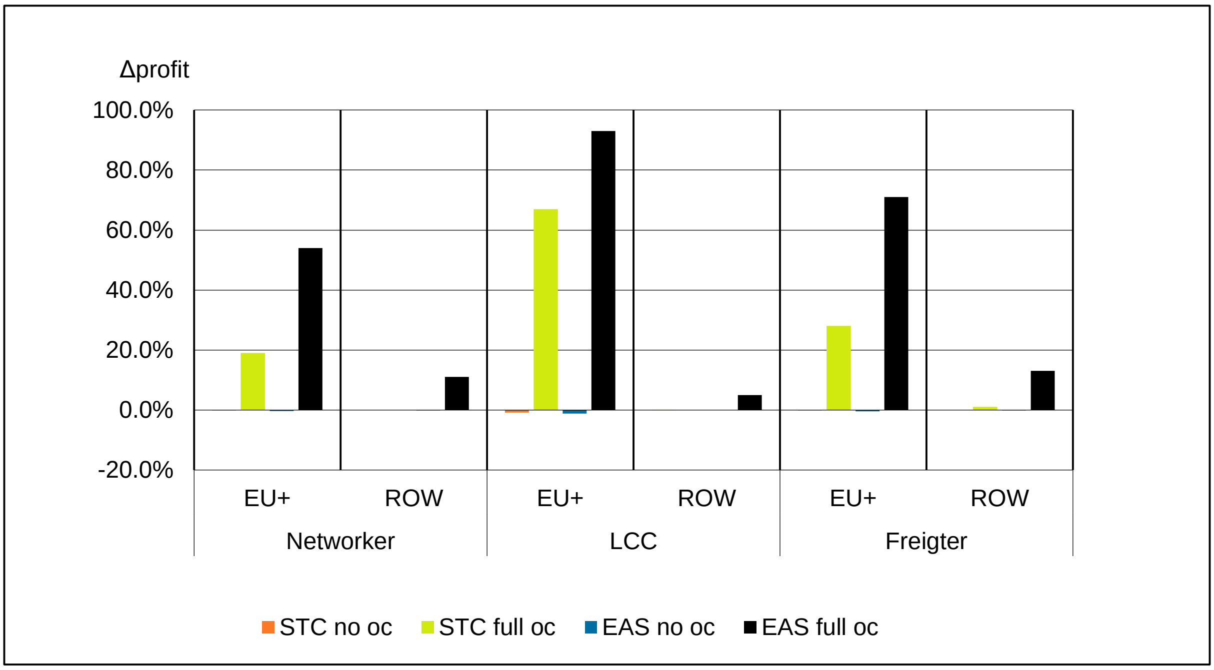
Die Auswirkungen auf die Profite hängen davon ab, ob die Opportunitätskosten von den Fluggesellschaften auf die Ticketpreise überwälzt werden können oder nicht. In Märkten

[1] Wert der kostenlos zugeteilten Emissionsrechte.

mit perfektem Wettbewerb würden Opportunitätskosten überwälzt werden, in oligopolistischen Märkten oder wenn die Angebotskurve eine positive Steigung aufweist, würden sie nicht oder nur teilweise überwälzt. Es gibt bisher keine empirische Evidenz über die Überwälzung von Opportunitätskosten, deshalb haben wir zwei Optionen modelliert (volle und keine Überwälzung). Wenn Opportunitätskosten nicht überwälzt werden können, dann sinken die Gewinne bei den LCC am stärksten, da deren Nachfrage im Vergleich zu den anderen Airlinetypen um den grössten Anteil abnimmt. Wenn dagegen Opportunitätskosten überwälzt werden können, dann erfahren die LCC die höchsten Gewinnzunahmen, da sie einen vergleichsweise hohen Anteil der kostenlosen Zuteilung von Emissionsrechten im Vergleich zu ihren Gesamtemissionen erhalten. Grund dafür ist der hohe Anteil von Europaflügen in ihrem Angebot und die hohe Anzahl an Passagieren pro Flugzeug. Der Unterschied in den Ergebnissen zwischen den beiden Überwälzungsoptionen ist sehr gross. Dies impliziert, dass bereits die Überwälzung eines kleinen Teils der Opportunitätskosten genügen würde, um die negativen Auswirkungen des EU EHS auf die Profite zu kompensieren.

Die folgende Grafik und Tabelle zeigt die Auswirkungen auf die Gewinne.

Abbildung Z2: Auswirkungen des EU EHS auf die Gewinne (2012, 25 €/tCO2)



Source: INFRAS (no oc=keine Überwälzung von Opportunitätskosten; full oc= volle Überwälzung von Opportunitätskosten)

Tabelle Z1: Auswirkungen des EU EHS auf die Gewinne (2012, 25 €/tCO2)

Change in profit	Networker		LCC		Freighter	
	EU+	ROW	EU+	ROW	EU+	ROW
STC no oc	-0,2%	0,0%	-0,9%	0,1%	-0,2%	0,0%
STC full oc	19,0%	0,0%	67,0%	0,0%	28,0%	1,0%
EAS no oc	-0,4%	-0,1%	-1,2%	0,0%	-0,5%	-0,1%
EAS full oc	54,0%	11,0%	93,0%	5,0%	71,0%	13,0%

Source: INFRAS (no oc=keine Überwälzung von Opportunitätskosten; full oc= volle Überwälzung von Opportunitätskosten))

Unter Berücksichtigung der Charakteristika des Luftfahrtmarktes erwarten wir in der kürzeren Frist (bis zu zwei Jahre nach Einbezug ins EU EHS), dass die Opportunitätskosten nicht überwälzt werden können, weil in diesem Zeitraum die Netzwerke der Airlines weitgehend gegeben sind und die Preissetzung auf das Ziel Ertragsmaximierung gerichtet ist. In der langen Frist (mehr als 5 Jahre nach dem Einbezug ins EU EHS) erwarten wir, dass ein grösserer Teil der Opportunitätskosten auf die Ticketpreise überwälzt werden kann. Ob und welcher Anteil der Opportunitätskosten tatsächlich überwälzt wird, hängt stark davon ab, welche Steigungen die Angebots- und die Nachfragekurve aufweisen (Details dazu siehe Kapitel 3). Zudem wird die Überwälzungsrate geringer sein, wenn Luftverkehrsgesellschaften eine Ertragsmaximierung und nicht eine Gewinnmaximierung anstreben. Die mittlere Frist (zwischen ungefähr 2 bis 5 Jahren) ist eine Übergangsphase zwischen dem kurzfristig und langfristig erwarteten Verhalten. Damit die erwartete Überwälzung der Opportunitätskosten in der langen Frist erfolgt, müssen die Luftfahrtgesellschaften zudem die Erwartung haben, dass es sich bei der Integration des Luftverkehrs ins EU EHS um eine langfristig bleibende Situation handelt.

Zusätzliche Gründe für Verzerrungen

Theoretisch könnten Luftverkehrsgesellschaften ihre Wettbewerbsposition auf zwei Arten verbessern. Erstens indem sie die innerbetriebliche Querfinanzierung erhöhen, z.B. indem Fluggesellschaften die Zusatzkosten aus dem EU EHS auch auf Flüge verteilen, welche nicht im EU EHS einbezogen sind. Dadurch müssten sie die Ticketpreise für ihre im EU EHS erfassten Flüge weniger stark erhöhen und könnten so auf Kosten von anderen Fluggesellschaften, welche keinen oder einen kleineren Teil ihrer Flüge ausserhalb des EU EHS aufweisen, Marktanteile gewinnen. Zweitens, indem sie vom Umstand profitieren, dass ihr Hubflughafen ausserhalb der EU liegt. Flugpassagiere, welche auf einem EU-Flughafen umsteigen, sehen einen grösseren Teil ihres Fluges vom EU EHS erfasst und haben somit höhere Zusatzkosten als Passagiere, welche auf einem Hub ausserhalb der EU umsteigen. Um das Thema Querfinanzierungen hat es in der Literatur eine breite Debatte gegeben. Eine theoretische Analyse zeigt, dass, falls Querfinanzierung überhaupt möglich ist, die Wirkung davon nur sehr beschränkt ausfallen kann. Unsere Modellanalysen zeigen ebenfalls, dass die Vorteile der Luftfahrtgesellschaften daraus vernachlässigbar sein würden. Der angesprochene Hub-Effekt ist möglich, aber eingeschränkt für eine kleine Anzahl an Flügen. Das heisst, dass der Gesamteffekt auf die Wettbewerbsfähigkeit gering sein wird.

Folgerungen

Insgesamt zeigt die Analyse, dass der Einfluss des EU EHS für alle Airlinetypen klein ist. Kurzfristig sind die LCC stärker betroffen als Netzwerk-Carrier und Luftfrachtgesellschaften. Soweit dies ein Ergebnis der Internalisierung von externen Kosten der Luftverkehrsaktivitäten oder der tiefen Zahlungsbereitschaft der Kunden ist, handelt es sich dabei um ein aus einem volkswirtschaftlichen Analysestandpunkt angestrebtes Ergebnis. Unerwünschte Effekte ergeben sich jedoch aus dem eingeschränkten geografischen Raum des EU EHS. Wenn die betroffenen Luftfahrtgesellschaften erwarten, dass der Einbezug ins EHS langfristig Bestand hat, können sie langfristig dank der Überwälzung von Opportunitätskosten auf die Ticketpreise von unerwarteten Gewinnen (windfall profits) profitieren. Diese unerwarteten Gewinne (windfall profits) haben ökonomisch denselben Effekt wie Subventionen und führen zu Wettbewerbsverzerrungen durch das EU EHS. Ebenso wie bei den negativen Auswirkungen des EU EHS in der kürzeren Frist werden auch diese positiven Wirkungen für die Luftfahrtgesellschaften gemäss Modellanalysen gering ausfallen.

1 Introduction

1.1 Aim of the project

The aim of the project is the scientific consulting of the German Emissions Trading Authority (Deutsche Emissionshandelsstelle; DEHSt) in the Federal Environment Agency (Umweltbundesamt; UBA) and the Federal Ministry for the Environment, Nature Conversation, Building and Nuclear Safety (Bundesumweltministerium; BMUB) concerning the assessment and development of the EU Emissions Trading Scheme (EU ETS) with regard to the inclusion of aviation. The main focus of the analysis is on the impacts of the inclusion of aviation in the EU-ETS on the competitiveness of various airline types . The impacts are theoretically analysed and quantified. In order to gain a consistent picture of the effects on the competitiveness the quantitative analysis is done with two different models that complement one another. Potential effects on the competitivenes are observed for two levels; effects and shifts of haul capacity i) within the European Economic Area (EEA) and ii) outwards.

1.2 Approach

The study has the following elements:

- A presentation of the scope of two different EU ETS regimes for aviation (cf. Chapter 2).
- A description of the competition in the aviation market and potential impacts so as the description of different market segments and actors (cf. Chapter 3).
- A presentation of cost functions for different airline types and a discussion how these cost functions are affected by the EU ETS (cf. Chapter 4).
- General information on the models SECAN-ET and AERO-MS and their interaction (cf. Chapter 5)
- A modulation of the effects of the EU ETS on competition in the short term (2012) with the model SECAN-ET (cf. Chapter 6).
- A modulation of the effects of the EU ETS on competition in the long term with the model AERO-MS (cf. Chapter 7).
- Conclusions on the competitive impacts of different EU ETS scenarios and discussion of results (cf. Chapter 8).

The chapters 1 to 4 lay the foundation for the study. They present the actual situation of the aviation sector and show, on a theoretical level, how the EU ETS influences the costs of the aviation sector.

The chapters 5 to 7 analyse the effects of the EU ETS in a quantitative manner based on two model approaches. The two models are complementary. Whereas the SECAN-ET analyses the short-term demand side effects and the evasive responses after one year of EU ETS (2012), the AERO-MS model analyses the long-term effects on the demand and supply side after several years of emissions trading (2026). How these two models interact is described in more detail in chapter 5.

In chapter 8 the results are discussed with respect to competitive impacts.

2 Scope of the different EU ETS designs

The original scope of the EU ETS according to Directive 2008/101/EC included all emissions from flights from and to the EU[2] from 2012 onwards. We name this originally intended EU ETS scope in this study "regular" EU ETS. At the moment, and considering international developments outlined below, it is not very probable that the EU will reintroduce this design.

In the autumn of 2013 the Assembly of the International Civil Aviation Organisation (ICAO) agreed on a roadmap to develop a global market-based measure (MBM) until 2016 to address rising CO_2 emissions from international aviation. After its intended adoption at the next ICAO Assembly in 2016, the global MBM is due to be implemented in 2020.

In response to the significant opposition from third countries against the EU ETS coverage of their international flights both before and after the EU ETS implementation, and to the progress made in ICAO, the EU decided to amend the original "full" scope of the EU ETS. While in 2012 the EU merely "stopped the clock" (Decision No. 377/2013/EU) regarding the inclusion of international flights, from 2013 to 2016 the EU ETS scope is temporary reduced to an Intra-EEA system established by Regulation (EU) No. 421/2014 which has been in force since April 2014.

After the ICAO Assembly and when negotiations regarding the adjustment of the EU ETS scope started, the EU has been also discussing the Commission's proposal (COM (2013) 722 final) of a hybrid option intending that the EU ETS would have continued to fully cover emissions from flights within the EEA but the coverage of emissions from flights to and from third countries would have been limited in proportion to the distance flown within the EEA ("European airspace").

This projects examines the effects on competitiveness of two alternative designs: The "Stopping the Clock" (STC) and "European airspace" (EAS) design. We describe them in the following sections.

2.1 Scope STC scenario

According to the "Stopping the Clock" decision, all flights between and within the following countries/regions are included in the EU ETS:

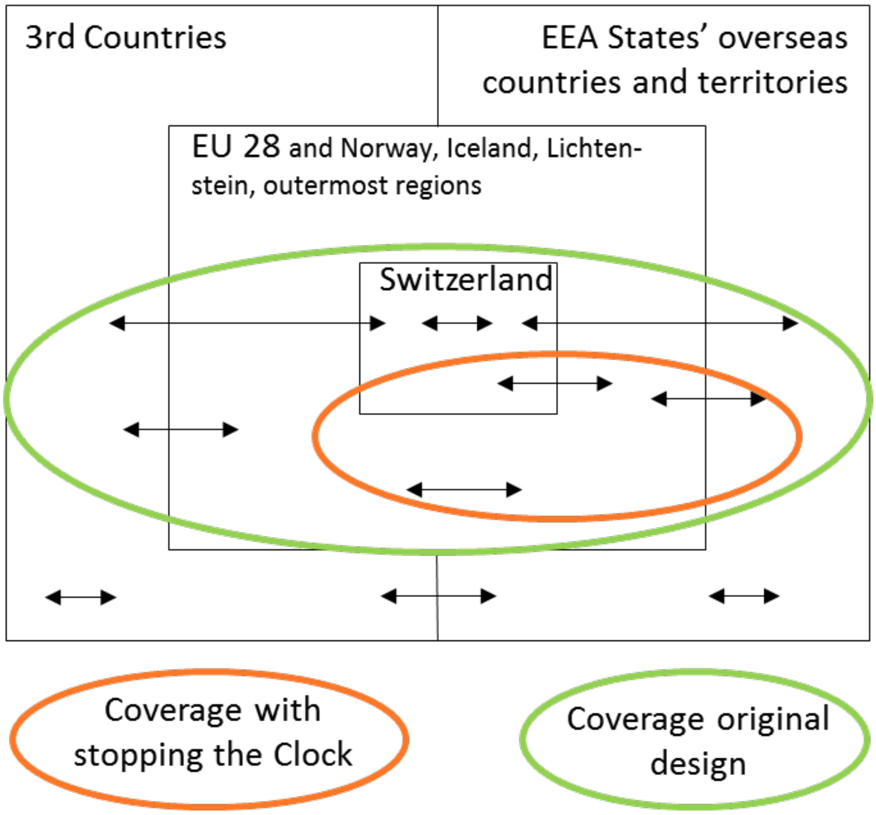
- EU28;
- Norway, Iceland and Liechtenstein (non-EU countries which are a member of the European Economic Area – EEA);
- Outermost regions and territories of the EEA States (Azores, Madeira, Canary Islands,Melilla, Ceuta, French Guiana, Guadeloupe, Martinique, Réunion, Saint Martin, Aland Islands, Jan Mayen and Gibraltar).

Furthermore flights between the above mentioned countries and a) Switzerland and b) EEA's States overseas countries and territories are included.

[2] Iceland, Norway and Liechtenstein – not being EU members – are also linked to the EU ETS.

Figure 1 shows the system boundaries which are applied in the further work steps in this study.

Figure 1: Scope STC scenario



Source: Infras

Although neither the STC scenario nor the Intra-EEA scope under Regulation (EU) No. 421/2014 include flights between the EEA and third countries, the scope of the EU ETS between 2013 and 2016 is not exactly the same as in the STC scenario in 2012. Under this Regulation, only flights between airports in the EEA are included in the EU ETS, as well as flights *within* outermost regions of the EU. Thus, as flights between the EEA and outermost regions as well as overseas countries and territories of the EEA States are excluded, the current EU ETS scope is even being downsized. Another difference to STC in terms of the number of flights and emissions is that flights between EEA countries and Switzerland are not included in the EU ETS.

2.2 Scope EAS scenario

In October 2013 the European Commission (EC) has launched a proposal to include aviation emissions which take place in the European Air Space (EAS) in the EU ETS (COM (2013) 722 final).The definition of the EAS scope takes into account five groups of countries, regions and territories:

Table 1: Groups of countries

	Country group	Countries
1.	EEA countries	EU28, Norway, Iceland and Liechtenstein
2.	EEA outermost regions	Outermost regions which belong to the territorial scope of the EEA (see Annex 2 of the FAQ document with respect to COM (2013) 722 final)
3.	EEA overseas countries and territories	Countries and territories which belong to EEA countries, but are not part of the territorial scope of the EEA (see annex 3 of the FAQ document with respect to COM (2013) 722 final)
4.	Third countries - excluded	Third countries for which flights to/from EEA countries are fully exempted from the EU ETS.
5.	Third countries - included	Third countries for which the flights to/from EEA countries are subject to EU ETS (only part of flights through European Regional Airspace)

Third countries, for which flights to/from these countries are excluded from the EU ETS, are countries which benefit from the EU's Generalised System of Preferences and have a share of less than 1 % of revenue ton kilometers in international aviation. A provisional list of these countries (73 countries in total) is published by the EC in Annex 5 of the FAQ document on COM (2013) 722 final (EC 2013c). All other third countries, with direct flights to one of more of the EEA countries, are included in the EU ETS.

Included in the EAS scope are:

- flights between and within EEA countries;
- flights between and within EEA outermost regions;
- flights between EEA countries and EEA outermost regions;
- For flights between EEA countries and the included third countries, emissions through European Regional Airspace.

All carriers operating on the routes which are covered by the EAS scenario (also the carriers with their home base in the excluded third countries) are subject to the EU ETS.

The proposal specifically states that the following flights are exempted from the EU ETS:

- Flights between EEA countries and EEA overseas countries and territories;
- Flights between EEA countries and the excluded third countries:
- Flights between EEA outermost regions and all third countries;

According to the EC proposal, the European Regional Airspace is defined as the airspace above EEA territory, where the EEA territory is defined by the borders/coastline of EEA countries and EEA outermost regions. Furthermore the proposal states that:

- A distance of 12 nautical miles from the furthest point on the outer coastline of the EEA territory to the EEA airport of departure/arrival should be taken into account.
- Intermediate distances over sea areas between EEA country territories of 400 nautical miles or less should be included (and hence intermediate distances that exceed 400 nautical miles should be exempted).

- Intermediate distances over third country areas (Switzerland, Kalingrad, Serbia, Bosnia and Herzegovina, Montenegro, Albania) should be excluded.

Annex IIc of the proposal describes how, for flights between EEA countries and third countries, the percentages of emissions of these flights which are subject to EU ETS, should be computed. This percentage (X) is to be computed based on the following formula:

$$X = (Y / Z) \times 100$$

Where:

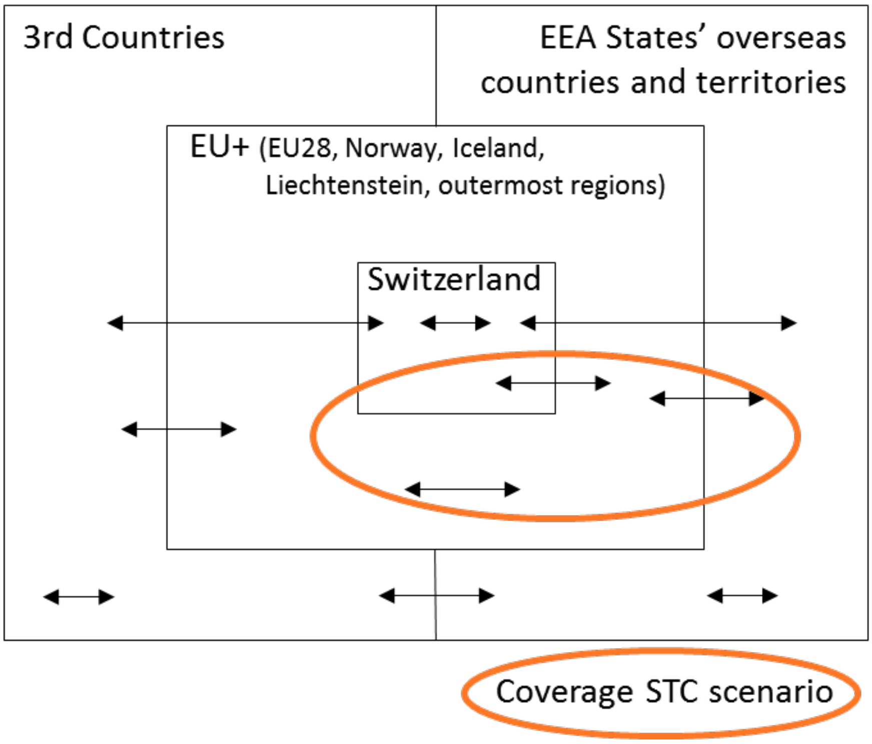
Z = The Great Circle Distance of a flight from the airport in each of the EEA countries with the highest number of flights to and from all destinations in third countries in 2012 ("the reference EEA country airport") to the airport in the relevant third country with the highest number of flights to and from all destinations in EEA Member countries in 2012 ("the reference third country airport").

Y = The part of the Great Circle Distance of the flight defined in Z through the European Regional Airspace

In this way for each country pair (i.e. country pairs between EEA countries and third countries) a percentage is computed. The percentage for any country pair is applicable for all flights between the two countries. Where there are flight operations from EEA countries to multiple time zones in a third country, a percentage is to be computed for each time zone in a third country.

The following figure shows the coverage of the EAS scenario.

Figure 2: Scope EAS scenario



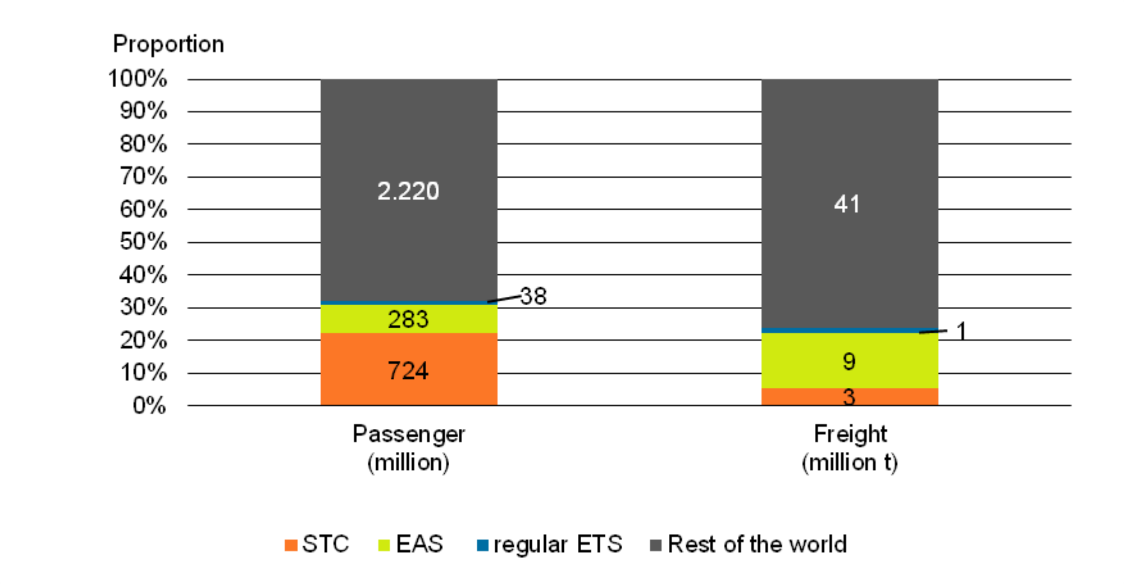
Source:Infras

2.3 Facts and Figures

To have a fist impression of the impact of different EU ETS scopes, we show the distribution of some important characteristic figures.

Figure 3 shows the share of the worldwide passengers and freight that is covered by the EU ETS in the STC scenario (orange part), in the EÀS scenario (orange and green part) and in the regular design (orange, green and blue parts). Note that for the EAS scope passengers and freight on routes partly included in the EU ETS are counted as EU ETS passengers.

Figure 3: Share of passengers and freight included in the different EU ETS designs in 2012

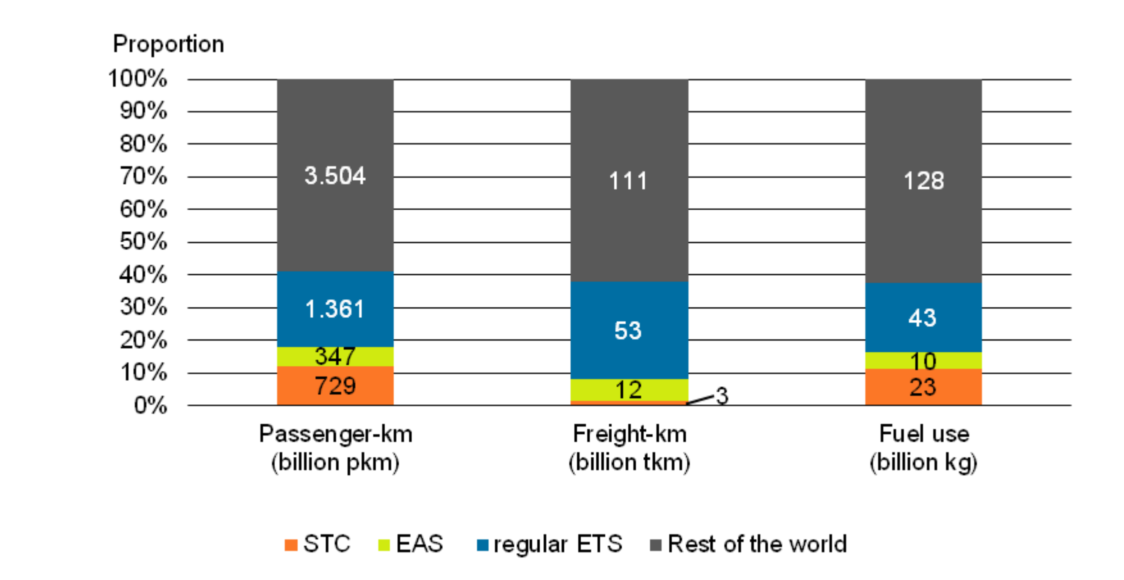


Data source: AERO-MS Database for 2006 and IATA growth numbers for 2006-2012

For the year 2012 it is estimated that globally 3,3 bn passengers and 54 m t freight asked for aviation services. In the STC scenario 22% of the global passenger demand and 5% of global cargo demand is included. In the EAS scenario the shares rise to 31% and 22% respectively. The full regular EU ETS would cover 32% of all passengers and 24% of all freight.

Looking at pkm and freight-km the shares change (see figure 4). Only 12% of global pkm and 2% of global freight-km are included in the STC design. The EAS design enlarges the scope with respect to pkm by 50% and by the factor 5 with respect to freight-km. The regular EU ETS design would increase the covered part of worldwide aviation by another 29% with respect to pkm and 30% for cargo-km. Fuel use is similar distributed as pkm.

Figure 4: Share of pkm, freight-km and fuel use included in the different EU ETS designs in 2012

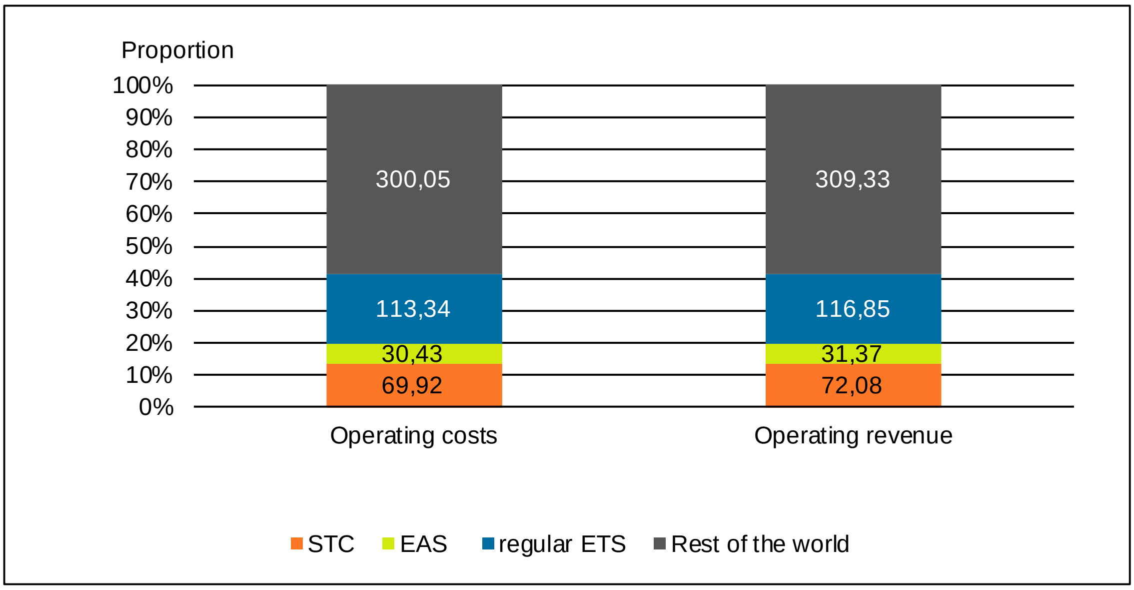


Data source: AERO-MS Database for 2006 and IATA growth numbers for 2006-2012

Another important figure is the distribution of costs and revenues. In the AERO-MS model all direct operating costs of airlines such as fuel use, flight crew, airport charges can be attributed to single flight stages (airport pairs) and hence to the different market parts. The other (indirect) airline costs such as overhead and marketing costs are attributed to different markets in such a way that total operating costs and total operating revenues on different markets are balanced (with a reasonable level of airline profitability)[3].

[3] The exact definition of direct and indirect airline costs is described in the chapter 4 with respect to cost functions.

Figure 5: Share of operating costs and revenue included in the EU ETS in 2012.



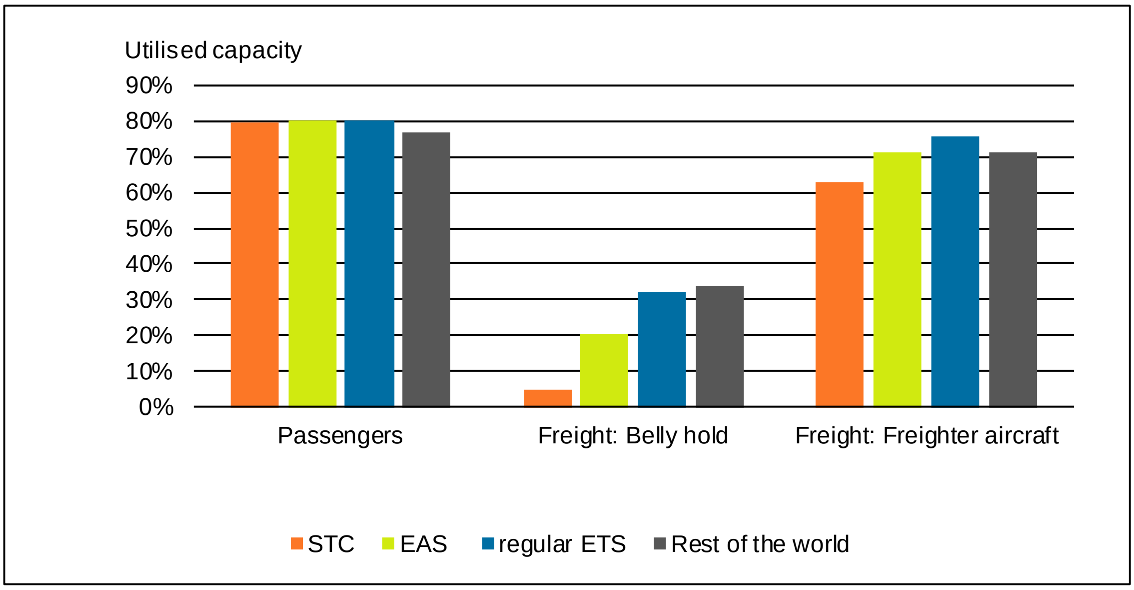
Data source: AERO-MS Database for 2006 and IATA growth numbers for 2006-2012

The costs of the global airline service supply in the year 2012 amounts to 514 bn € and the revenues are estimated to 503 bn EUR. 14% of costs and revenues fall under the STC ETS. A further 6% is covered by the enlargement to the EAS design. The regular EU ETS covers 22% of all costs and revenues. These shares are in the magnitude of the shares in the field of passenger kilometres.

As shown below, the degree of capacity utilization concerning passengers in the flights covered by the EU ETS scenarios is higher than in the global average. Concerning belly freight,[4] the capacity utilization is rather low for flights covered by the STC and EAS scenario. The same is true for freighter aircraft transports within the STC scenario. This is due to the high level of competition between surface transportation and aviation for cargo transport on intra-European routes.

[4] Freight transported in the belly hold of passenger aircraft

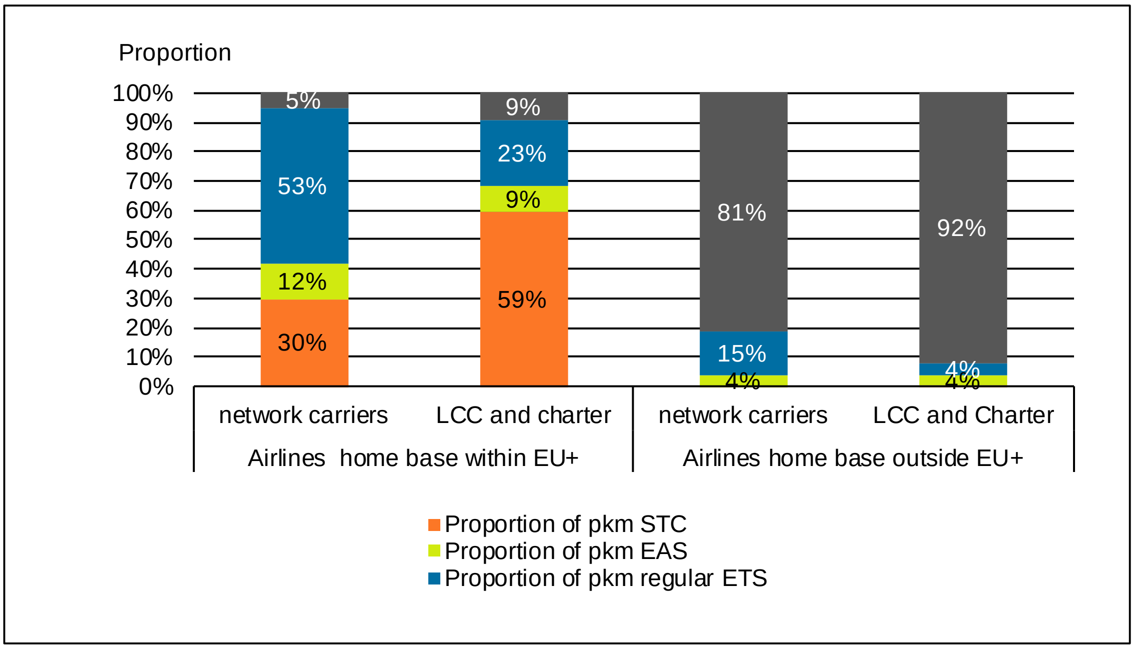
Figure 6: Degree of capacity utilization within the EU ETS and the rest of the world in 2012.



Data source: AERO-MS Database and IATA growth numbers for 2006-2012

To assess the competitive impact of the EU ETS on airlines it is of crucial importance to know how the different airline types are affected by the EU ETS. The following figure shows the different impact of airlines with home base within the EU+ and of airlines with home base outside the EU+. A further distinction is made between 'network carriers' and 'low-cost carriers (LCC) and charter airlines'.

Figure 7: Impact of the EU ETS on passenger airlines in 2012.



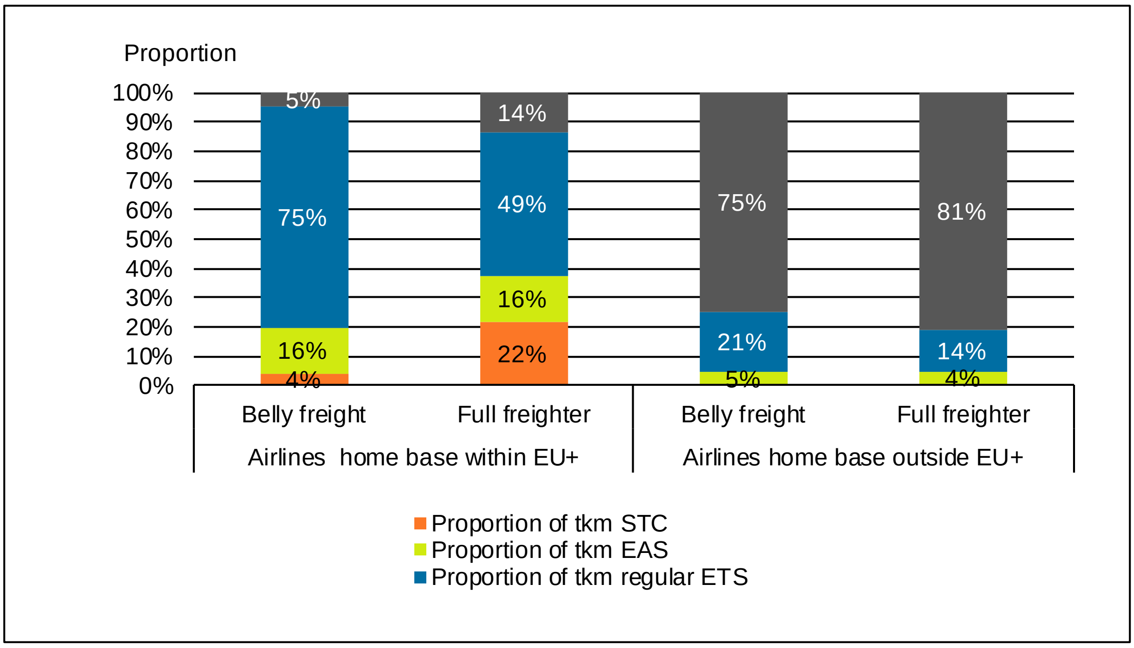
Data source: AERO-MS Database and IATA growth numbers for 2006-2012

95% pkm of the EU+ network carriers and 91% passengers-km of the EU+ low cost and charter airlines are covered by the regular EU ETS. In contrast only 19% and 8% pkm of respectively network carriers and LCC domiciled outside EU+ are affected by this design.

If the EU ETS is reduced to the EAS scope 42% pkm of EU+ network carriers and 68% EU+ LCC are covered by the EU ETS. The shares of the affected non-EU+ network carrier passenger decrease in this case to 4%. Non-European airlines are in the STC scope only marginally affected (>0,1%). European network carriers have 30% and European LCC 59% of their pkm within the STC scope.

Figure 8 shows the picture for the freight market.

Figure 8: Impact of the EU ETS on freight airlines in 2012.



Data source: AERO-MS Database and IATA growth numbers for 2006-2012

95% of all belly freight tkm by EU+ airlines are included in the regular EU ETS. For the non-EU+ networker this share is about 25%. If the EU ETS is reduced to the EAS scope, the shares decrease to respectively 20% and 5%. Non-European Network Carriers are with respect to freight not affected by the STC scope whereas European Network Carriers have 4% of their belly freight tkm within the scope of the STC scenario.

Of the freight transported by EU+ full freighter airlines 86% of all tkm are covered by the regular EU ETS. For non-EU+ supplier this share is only 19%. If the design is reduced to the EAS scenario, respectively 38% (home base is EU+) and 5% (home base is non-EU+) of the freight tonnes are affected by the EU ETS. The STC design affects only European full freighters with 22% of their tkm significantly.

3 Competition in aviation markets

In this chapter we present, on a theoretical level, how the EU ETS can influence the competitive position of the aviation sector. First we look at the general competition situation in the European aviation market. Then we look at the specific impacts of the EU ETS. We give a description of the different markets and actors which are relevant for the analysis of effects of the EU ETS on the cost structure of the airlines.

Through literature review we analyse the possible distortion impact of the introduction of EU ETS on the aviation market with respect to the competitive position of the airlines. Whether the distortion will actually take place in practice will be analysed in chapter 6.

Based on these mechanisms we will identify a.) the markets and routes on which these distortions could take place and b.) which actors (airline operators) on the market are affected.

In our analysis we consider two EU ETS scenarios:

a) European airspace scenario;

b) Stopping the Clock (STC) scenario.

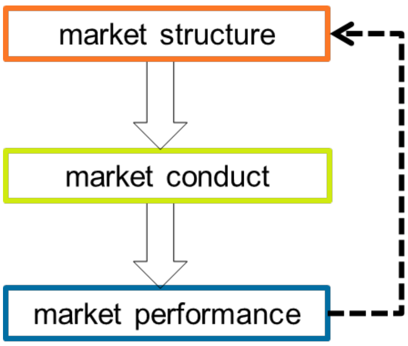
More detail on the scope of these two scenarios is provided in section 3.2.

3.1 General situation

In order to understand the competition impact of the EU ETS on aviation, it is important, to analyse the market situation of airlines without the EU ETS. This chapter describes the intensity of competition in the airline market.

To have a consistent framework to analyse the impact of the EU ETS on aviation, we follow the concept of the effective competition (Schmidt 2005). It differentiates between market structure, market conduct and market performance. The market structure influences the market conduct and thereby the market performance results. In the long run the market performance influences again the market structure, which has an impact on the market conduct and a change in the conduct modifies the market performance.

Figure 9: Concept of the effective competition



Source:INFRAS

In the following we describe the aviation market situation before the introduction of the EU ETS. We define for each field of the ‘effective competition’ competition indicators.

Then, we describe their effect on competition, impacts of a change and the situation in relation to the indicator before the EU ETS was established (Commissariat general à la stratégie et à la prospective 2013, European Commission 2012). Finally we identify possible impacts of the EU ETS on the competition.

The following table describes the market structure. The main characteristics are the number of players, barriers, which could hinder the free market access and how airlines are affected by the EU ETS.

Table 2: Competition indicators: Market structure

	Number of players in the market	Market access barriers
Effect on competition	The number of player in a market is one indicator for the competition intensity.	Market access barriers hinder the entrance of new players.
Impact of changes	The more players are active in a market, the stronger the competition is.	If market access barriers are removed, the competition becomes more intense. Airlines, which were protected by the barriers, are negatively affected. Airlines which were hindered by the barriers are positively affected.
Market situation before EU ETS	Since the liberation of the European aviation market new players – mainly LCC – entered. The three main low cost players are Ryanair, easyJet and AirBerlin. A number of small LCC are active as well. That leaded to a consolidation of the traditional airlines. The number of network carriers was reduced to three main players (Lufthansa, Air France-KLM, IAG). They are constituted in consolidated companies with a number of different brands, which belongs partly as well to the low cost segment. Moreover on specific routes they do also compete with prices which are similar to those of the LCC. In the short distance segment the railway acts with high speed trains as a third competitor. In the intercontinental market the European network carriers stands in competition with network carrier from other continents.	Within Europe the market is liberalized. Still there are three important kinds of market barriers: i) Timeslots for taking off and landing on airports are allocated by grandfathering. On airports which are short in capacity, this can take effect like a market barrier. ii) the risk of predatory pricing. iii) provisions about safety and technics. Some intercontinental markets of intercontinental flights are regulated and market access is restricted based on bilateral agreements. This is for example relevant for flights to and from many Asian, African and South-American counties. The EU and the US have an open skies agreement.. Additionally European airlines complain about unfair subsidies to airlines or airports in other world regions. And some European airlines complain about subsidies for smaller regional airports enabling LCC to offer to some extent unfair lower prices.
Possible impact of the EU ETS	The EU ETS requires investments in monitoring, reporting and verification systems. These sunk costs lower profit margins and may increase the pressure to a consolidation of the market. The effective costs of the EU ETS are an additional cost bloc for the airlines that has to be financed via earnings on the market. This may increase intensity of competition depending on whether opportunity costs will be passed on or not.	The investment in MRV systems act as an additional market barrier.

The following table gives an overview of the conduct in the aviation market. In the center of the conduct are the indicators product design and the pricing.

Table 3: Competition indicators: Market conduct

	Product design	Pricing
Effect on competition	The product design in aviation has mainly the aspects quality of the equipment (aircrafts, airports) and service quality. A unique product design lowers the competition pressure.	Assuming an equal product design, the rule applies 'The lower the price level the more passengers'.
Impact of changes	The more a product is differentiated the lower the competition pressure since the competitor does not have exactly the same product.	An increase in price level lowers the passenger volume of an airline. Since the marginal cost of an additional passenger is small, a decline in the passenger volumes affects the profit margin of a flight. The effect of price increases on demand depends on the price elasticity[5] of the customers. In general the price elasticity of business travellers is lower than the price elasticity of leisure travellers and the price elasticity on intercontinental flights is lower than on continental flights.
Market situation before EU ETS	The differentiability of air transport services tends to be low. Mainly, there are two different price systems. LCC combine a low service quality with low prices, whereby the service quality can be enhanced by extra payments. Normally they have new aircrafts but use secondary airports with low fees. LCC supply point to point connections and do not have a hub and spoke system. In contrast, in the prices of network carriers most services are included. They connect normally the main and central airports, which they use as their basis for the hub and spoke system. Additionally frequently flyer programs try to increase the loyalty of airline customers.	Airlines have a highly differentiated price setting system. They try to differentiate as much as possible between passengers with different willingness to pay. Cross financing is a part of the system. The two main cross financing strategies are a) cross finance continental feeder flights to the hub in order to fill up intercontinental flights and b) cross finance economy class tickets by business class tickets.

[5] The price elasticity of demand indicates how the customer reacts on price increases. If price elasticity is high, the customer reacts more on a price change then if the price elasticity is low.

	Product design	Pricing
Possible impact of the EU ETS	A possible impact is, that services and equipment of aircraft, which are related to significantly more weight (e.g. baggage transport, galley equipment for hot meals) become more expensive, since weight influences the fuel use significantly.	The additional costs due to the EU ETS in relation to total costs of an airline differ between airline types (cf. Figure 8). Airlines will allocate a higher share of additional costs to market segments with the lowest elasticity of demand, so that for example. As a result, airlines with a high cost increase and with a small share of customers with low price elasticity will face the stronger effect than airlines with more passengers with low price elasticity. Conversely, airlines with small cost increases operating in a market where the price elasticity of demand is low, are the least affected.

The table below describes the market performance. It has two main characteristics: the production and allocation efficiency and the dynamic efficiency. Since the market performance is an outcome of the competition, the ‘effect on competition’ and ‘impact of changes’ are not discussed.

Table 4: Competition indicators: Market performance

	Production and allocation efficiency	Dynamic efficiency
Market situation before EU ETS	Since external costs are not reflected in the aviation prices, the demand for aviation tends to be too high. Moreover the allocation efficiency is hindered by different market barriers and market distortions (regulated market access, subsidies, etc.)	The dynamic efficiency is hindered by different market barriers and market distortions (regulated market access, subsidies, etc.).
Possible impact of the EU ETS	Due to the EU ETS at least a part of the external costs are internalised and demand converges to its optimum.	The EU ETS increases the future benefits of fuel-saving innovations and thus increases the dynamic efficiency. Since not all airlines are affected the same, in the short run the market share of highly affected airlines could become lower and the market share of less affected airlines higher than in the reference situation. The impact in the long run depends on the possibility to pass on opportunity costs (see chapter 3.2.2).

Summing up, the **market structure** for continental flights within Europe is characterized by a strong competition. The market is still growing, but with lower growth rates than in the previous time. During the past years a lot of traditional airlines ran out of business or merged to bigger conglomerates. It is assumed, that this consolidation process will go on during the next years.

The intercontinental market is still substantially regulated. The highest growth is observed in the Asian market segment where European airlines compete with established as well as relatively new Asian airlines. Often European airlines argue that their potential to grow in this market segment would be negatively affected by airlines from the gulf region, which would be supported by their countries in substantial magnitude.

The introduction of the EU ETS potentially increases, through the additional costs, the pressure to a consolidation of the market. Since the European airlines are more affected by the EU ETS than non-European airlines, it is more likely to lead to consolidation amongst European airlines than amongst other airlines.

The **market conduct** is given by the product design and the pricing policies. Since the possibilities for product diversifications are limited (mainly differences with respect to included frequency, services, service quality and connection speed) the main competition factor is the price level. During the past years airlines developed differentiated pricing systems. The aim of these systems is to differentiate the passengers according to their willingness to pay and let each passenger pay according to his willingness to pay. This leads to substantial cross financing flows between passengers and routes.

The different impact of the EU ETS on different airline types associated with the cross financing strategies could potentially degrade the market position of the European airlines, since they have more additional costs which they have to distribute among their customers. Moreover, the coverage of the EU ETS could influence the choice over the opening and closing of supplied routes.

With respect to the **market performance** in the situation without the EU ETS the demand for air traffic services is too high, since the external costs of CO_2-emissions are not considered in the prices. The EU ETS internalizes at least a part of these costs and contributes to a more efficient demand level.

The dynamic efficiency is impaired by market barriers. European airlines often argue, that in particular in the intercontinental market they would be disadvantaged (e.g. indirect subsidies to golf airlines, Chapter 11 of the United States Bankruptcy Code, strict environmental conditions). If this would be true, the market share of European airlines could lie lower than before inclusion of aviation into ETS.

In chapter 6 and 7 we will analyse, if the named impacts of the EU ETS really exists and how big the effects are.

3.2 Description of the affected market segments and actors

In this section we analyse the impacts of the EU ETS on different market segments and market actors in the aviation industry. First, we will define the different market segments and actors, where after we identify the impact per distortion mechanism for the scenarios STC (only within market segment EU+) and EAS.

Market segments

In the aviation industry, markets are usually defined in terms of city pairs (routes) where passengers or cargo are transported from one location to another, for example London-Dubai. A city-pair connection can be served by different airports and different airlines. Some routes are direct ones, others may require a transfer through a hub-airport. In this study, we aggregate the market to city-pair groups which are impacted in a similar way by the four potential distortions described in the previous section. Examples would be from Europe to North Africa, the East Coast of the United States to the Middle East, and so on. Table 5 shows the market segments that have been distinguished for this study.

Table 5: Market segments

	From/to*	To/from*
1	EU+	EU+
2	EU+	Africa
3	EU+	Japan, Korea, Australia, New Zealand
4	EU+	Rest of Asia and Pacific
5	EU+	Lat America / Caribbean
6	EU+	Middle East
7	EU+	North America
8	EU+	Rest of Europe

* Route groups between region A and region B relate to flights from A to B and B to A

Market actors

In the aviation industry, we distinguish between three different market actors, namely airlines that operate on only intra-EU+ level, intra-EU+ and intercontinental level, and only intercontinental level. We also distinguish between low cost carriers, network carriers and cargo carriers. For the latter two, the nationality also matters.

Only intra EU+

Airlines that operate only within and between EU+ countries are often small network carriers or low cost carriers (also known as discount or budget carriers). The routes on which they operate are predominantly within the EU+, and if the network carriers have a hub, it is located in one of the EU+ countries. Low cost carriers have a low-cost model and offer tickets at lower fares and with less comforts. Their strategy is to keep ticket prices low and to charge additional costs for extras like food, priority boarding, seat allocating, and baggage etc. Most low-cost airlines use point-to-point networks (Pels, 2009).

Intra-EU and intercontinental

EU+ based network carriers and cargo airlines operate both intra-EU+ flights and intercontinental flights. Their hubs are located in an EU+ country. Airlines operating on intercontinental flights are often network carriers. Network carriers use their networks to keep costs per seat relatively low. They offer more service and comfort than low cost carriers. They usually use hub-and-spoke networks, offering high frequencies to and from the hub airport for passengers with a high willingness-to-pay. Through their hub airport and spoke airports many different (indirect) markets are served (Pels, 2009).

Intercontinental

Non-EU based network carriers have mostly long haul flights in the EU ETS and short haul flights in their home markets. Their hubs are located outside the EU+. For more detailed of network carriers, see description above.

In the following sections we analyse the different distortion mechanisms for two scenarios (STC und EAS). We will try to answer the question which market segments and airline operators are affected by the distortion of competition for the four mechanisms (cross financing, hub effect, profit margin and de-minimis).

3.3 Competitive distortions due to EU ETS

Although the introduction of the EU ETS is based on a non-discriminatory principle and aims to limit the competition distortion, regional schemes may experience disadvantages from changes in competition and cost structure.

In the literature on the inclusion of aviation in the EU ETS (CE Delft et al. 2005, Ernst & Young and York Aviation 2007, CE Delft and MVA 2007, Vivid Economics 2007, European Commission 2006, Forsyth 2008, CE Delft 2008, INFRAS 2009, Anger and Köhler 2010, Scheelhaase et al. 2010; Schaeffer et al. 2010; BNEF 2011, Malina et al. 2012, Netherlands Institute for Transport Policy Analysis, 2012) four mechanisms have been put forward through which EU ETS may distort the competitive market:

a) Cost pass on rate and cross financing
b) Hub-effect
c) Profit margin
d) Effect on small airlines: De-minimis exclusion rules

Each of these 4 mechanisms will be described in more detail below in sections 3.3.1**Fehler! Verweisquelle konnte nicht gefunden werden.** through 3.3.5. All mechanisms depend on the ability of airlines to pass on costs of EU ETS. Therefore, our analysis starts with a discussion of pass on in section 3.3.1

3.3.1 Pass on rate of additional costs of the EU-ETS in the aviation market

General Aspects

The inclusion of aviation (STC or EAS) in the EU ETS leads to two elements that could lead to changes in the prices for services in the aviation market:

- The parts of emission allowances airlines need to buy for a certain reporting period (one year) is connected with explicitly additional expenditures and increase the production costs of the airlines. For all emissions above the volume of emissions of the basic period and 15% of the basic period airlines need to buy emission allowances in each period. The emission rights that an airline has to buy reflect additional marginal costs in the short run. In the short run structure and number of flights are largely fixed. There are several reasons why in the short run a bloc of effective additional costs might not totally passed on on the ticket prices. One example is the German aviation ticket tax. Because there existed alternatives on other European Airports, German Airlines could not pass on the full amount of the tax (but the largest part) and had to bear reduction of gains (raising of losses, reduction of producers rent) instead (Infras 2012). But in the end airlines need to finance their total costs over earnings if they do not want to disappear from the markets and they can adjust supply to meet demand. In our study we therefore assume a full pass on rate of the effective monetary costs, because the very short run (within month, transitory) responses from market actors facing additional effective monetary costs are not representative. And the ETS for Aviation is introduced in a wider space above national level than the German aviation tax.
- The free allowances an airline gets (for all airlines reporting emissions for the base period totally 85% of the reported volume in the base year) do not result in explicitly monetary expenditures and do not influence effective production costs. But the freely allocated volume of emission rights represent a value, that could be sold at the market in order to generate a flow of earnings. An airline sells freely allocated emission rights e.g. if she cancels an existing flight out of her offers without replacement. This makes all other flights slightly less expensive, so that in sum the values of the tradable emission certificates of cancelled flights theoretically should not be regarded at first

as directly monetary marginal costs. An airline does not need to cover the opportunity costs through earnings in order to avoid insolvency.

In the literature we observe an agreement that the effective costs are passed on to a larger extent in the short run and almost completely in the longer run. Concerning the question of whether and how much passing on of the opportunity costs, there is a disagreement in the economic literature. So far neither profound argumentation of this topic for "pass on" nor "no pass on" exists.

Some argue that a 0% pass on rate is plausible and therefore end up in the analysis of the economic impacts of EU ETS on aviation with an additional cost bloc for the airlines. The cost bloc is due to the effective monetary costs part. The additional costs influence the position of competition of the airlines negatively, depending on the relative relevance of the extra costs.

Some argue that a 100% pass on rate can be expected and end up in the analysis with a net benefit of EU ETS for European aviation. This is as long as the sum of free allowances is higher than the amount of allowances that airlines have to buy in addition.

In the following two subchapters we describe the two positions and finally conclude what the economic reasoning for these two ways of economic analysis is. In order to determine the range of the possible effects of the two positions for the interpretation of the economic impact of EU ETS for Aviation we assess the results with 0% pass on rate of opportunity costs and the results with 100% pass on rate of opportunity costs.

Argumentation A: No pass on of opportunity costs in the aviation market

In the shorter run – meaning a period of up to two years - we expect no pass on of opportunity costs in the (still growing) European aviation markets segments with high intensity of competition and a quite high price elasticity of demand. Especially from airlines outside Europe the pressure on prices is expected to remain high. Under these conditions we expect a supply curve that depicts that different airlines have different cost functions and differing marginal costs. Therefore we assume a supply curve showing a positive but not infinite grade. If you want to survive as an airline you have to cover your effective running costs. This means if an airline would pass on opportunity costs on the ticket prices, other airlines at the edge of profitability could gain additional demand by lowering the prices under the opponent's prices. With this behaviour they could gain additional earnings above or equal the marginal costs and therefore increasing their cost coverage of the effective costs. If you are the marginal supplier operating with the price just at the marginal cost curve you will not be able to take any additional monetary advantage of the free allowances in a monetary way. If you are a supplier operating with a somewhat more advantageous cost function that enables you to obtain a producer's rent. A (partly) pass on of opportunity cost would mean a diminishing demand, lower cost coverage and somewhat higher return per ticket. In a market with typically high price elasticity of demand you would be quickly confronted with the opponent's reaction trying to take advantage of your price ceiling. The opponents may undercut your prices since for a healthy surviving at the market they need to cover effective costs and no opportunity costs. So the main reasons why opportunity costs are not expected to be passed on in the shorter term are:

- The supply curve has a positive but far from infinite elasticity. Different airlines have different production functions. The demand shows quite high price elasticity.
- In the shorter run routes and nets are more or less given.

- In the shorter run costs are given or quote stable and airlines act as optimizer of earnings.
- Many airlines optimize a network of routes (with intercontinental connections and feeders/defeeders) and not just independent single routes.
- For airlines the monetary costs of the emissions rights they have to buy in one year is a additional effective cost block that has to be refinanced over earnings in order to survive on the market.
- Competition in Aviation market plays within „overlapping catchments“. This means European Airlines under the EU ETS on routes not or only partly included in the EU ETS. Could opportunity costs be passed on on ticket prices, airlines would lose market shares against opponents less affected of the EU ETS in relation to their total costs.
- Airlines risk the loss of sunk costs connected with the market entrance on the aviation market, if they broadly pass on opportunity costs, risk a sharp decrease in demand and to be eliminated out of the market.

Facing the pressure from competition from East (Arabian or Asian airlines) that sometimes have advantages in competition with European Airlines because they profit from subsidies infrastructure fees at their home base or fuel prices below market prices, the free allowances give a certain buffer against this unfair advantages in competition of Non-European Airlines. Non-European Airlines entering or growing clearly in the European market need to buy emission allowances for all of the emissions of their flights. But the buffer through the free allowances is relatively small in comparison with the advantages of the growing competition from East.

Argumentation B: pass on of opportunity costs in the aviation market

One may assume that the unit of production in aviation is a flight because an airline can decide about adding or removing a flight, but cannot decide how many passengers will be on it (although of course its pricing strategy will be aimed at attracting the optimal number of passengers for each flight). Adding a marginal unit involves buying a sufficient amount of allowances to cover all the emissions of this flight in the scope of the EU ETS. Because free allowances are calculated on the basis of historical output, an airline will not receive free allowances if it adds a flight and hence it has to buy all the allowances. Neither does it have to return allowances when it discontinues a flight (unless it stops operating altogether, which we consider to be a special case). This means that the revenues that this additional flight needs to generate in order to break even will include the full carbon costs of that flight.

In aviation, markets are mostly city pairs. Many city pairs are connected by one or a few airlines, suggesting a monopolistic or oligopolistic market structure. In reality, however, most markets are competitive because of the relative ease of entry and exit from the market, or the oligopoly is a Bertrand-type oligopoly, where firms compete for market share and prices reflect marginal costs, rather than Cournot-type oligopolies where oligopoly rents are earned (Forsyth 2008). Even at slot constrained airports markets can be competitive when they share a catchment area with non-constrained airports.

Because the market is competitive and the marginal costs include in the long run – meaning a period of at least five years – the full carbon costs, the long run supply curve is raised by the costs of carbon. If the supply curve is horizontal, as some assume (see e.g.

Forsyth 2008), this means that 100% of the carbon costs are passed on, including opportunity costs. If, on the other hand the supply curve is sloping upwards, a share of the costs are passed on, the share being determined by the elasticities of supply and demand. The fact that airline profits vary suggests that the supply curve could be sloping upward. However, there is some evidence that cost increases like fuel price increases are passed on completely, albeit with a time lag (PWC 2005, Toru 2009, Özmen 2012). This would suggest a flat or almost flat supply curve.

If the supply curve would slope upward, the rational pass on of costs could coincidentally results in a full pass on of monetary costs (expenditures) and no pass on of opportunity costs. This would happen when the share of costs passed on equals the share of allowances that needs to be bought. We can calculate when this would occur from the following data:

- Table 12 shows that for the STC scope, the emissions in 2026 are 73 Mt, while the cap amounts to 62 Mt and the free allowances amount to 52 Mt. Hence, airlines need to buy 28% of their allowances.
- The elasticity of demand is approximately 1.
- The cost pass on is given by PES/(PES-PED) where PES is the price elasticity of supply and PED is the price elasticity of demand
- We have not found a value of the elasticity of supply in the literature, but we can estimate.

It can be shown that in this case, the pass on rate would equal 28% if the price elasticity of supply equals 0.38. In other words, when the elasticity of supply equals 0.38, then for this year, coincidentally the share of costs would be passed on that equals the share of allowances that airlines need to buy. In subsequent years, provided that emissions continue to grow, the pass on rate would no longer suffice to offset the expenditures on allowances.

How realistic is a elasticity of supply of 0.38? We don't know, but it seems to be higher than the value of 0 suggested by the fact that fuel prices are passed on completely. But in contrast to fuel prices the costs from EU ETS are not affecting all airlines worldwide in the same way. Still, there are a few situations in which costs may not be passed on:

- If airlines are not profit maximising but rather output maximising, they may pass on some of the value of the free allowances to their passengers. However, with the possible exception of some state-owned airlines, there is no reason to assume that airlines do not seek to maximise profits, since profits are essential for their survival.
- If airlines are operating in a monopoly or oligopoly market, e.g. because of very restrictive bilateral air service agreements or because they operate from a heavily congested airport with no uncongested airports in the vicinity, they may set their prices well below marginal costs. If the marginal cost plus the carbon costs is still below the price, the carbon costs will not be passed on.
- If an airline's emissions are below its amount of freely received allowances and is considering exiting the market completely, the situation changes because when it ceases operations it has to return the freely allocated allowances. In such a case an airline may choose to price below marginal costs as long as the total losses are offset by the benefits of the freely allocated allowances.

Conclusion cost pass on

In the shorter run, when the network mostly does not change a lot, the marginal carbon costs are the additional effective monetary costs an airline has to bear.

Airline may start to change their network every half year, so in a time period of a year or more, the marginal unit of production would be a flight. At this time horizon, there are two perspectives. One is that airlines are profit maximisers in which case the micro-economic perspective dictates that all costs are passed on to the customers, except when the elasticity of supply is high or in some particular circumstances that are not representative of the aviation market (heavily restricted markets or airline emissions below the baseline). The other is that airlines aim to maximise market share in which case they may choose to pass on some of the value of the free allowances to their customers. Lacking empirical data on the cost pass on rate, we cannot decide which view is closer to reality.

But the European aviation market is not a perfect market the theoretical argumentation of a full pass on of effective and opportunity cost presumes. The European Aviation market shows entry barriers (like grandfathering of slots, national economic policy aims, the logic of offering nets of intercontinental flights with regional feeder/defeeder and so on, national differencing prices for infrastructure or even fuel use, and so on). This leads to a situation that the development of the aviation market might as well be described for more than a flight schedule sequence. Additionally, all actors in the European Aviation market realize the discussions around ETS in aviation. Together with different options how the topic will be discussed at ICAO-level airlines may assume that the current system does not stay under unchanged rules in the coming years.

This means – except for the very short term which is in this study not of interest - a pass on of the effective costs from EU ETS may be taken as sure. In the short term (up to about two years) due to market imperfections[6] we assume no passing on of opportunity costs. In the long run (more than five years) depending on different circumstances (e.g. if airlines expect the system to be persistent) some pass on of opportunity costs is possible. The amount is impossible to forecast exactly. In the medium term we see a transition from the short to the long term behaviour.

In addition, it will be very hard to identify in an ex-post analysis whether and how much the pass on rate of the two cost elements were. The price signal from EU ETS is probably too low at the current and the further expected price level. It will be hard to differentiate the impact on aviation prices from EU ETS from all other influences European aviation is exposed to.

3.3.2 Crossfinancing

The first mechanism mentioned in the literature through which EU ETS might influence the competitive position of airlines is cross financing. It relates to the advantage that airlines may have by operating in two markets, which gives them an opportunity to compensate losses in one market with profits in another market.

[6] (Party) Passing on of opportunity costs gets possible if airlines may change their fleet, their destinations, their network structure, etc.. For half a year an airline is not able to change the flight plan. After this still an airline will not change drastically their structure of supply of flight services because on the one hand the starting and landing slots at European airports are allocated according to grandfathering rights and on the other hand airlines have a bloc of fixed costs they are not able to adjust in the short term.

Cross financing between markets and market segments

Crossfinancing takes place between different markets and market segments, for example between economy and premium passengers, or between direct routes and routes which require a transfer. The issue here is whether the additional costs incurred because of the EU ETS will give rise to additional cross financing. This would be cross financing between routes: airlines would compensate the higher costs of EU-flights due to EU ETS by increasing revenues on non-ETS flights. Airlines with a small share of flights in the scheme would then be able to undercut fares of airlines with a majority of flights under the scheme and gain market share (CE Delft and MVA, 2007; Ernst & Young and York Aviation 2007; Infras 2009, Scheelhaase et al. 2010; Netherlands Institute for Transport Policy Analysis, 2012). Although it has not been mentioned previously in the literature, the analysis in Section 3.3.1 opens another type of cross financing, if assuming that the opportunity costs of freely allocated allowances could be passed on in the long run. In that case, airlines that are exposed to the EU ETS would generate additional revenues in the EU ETS market which they could use to cross-subsidise activities outside the EU ETS.

In this study we will analyse the impact of the introduction of EU ETS on cross financing between market segments (routes) and on market actors (type of airline).

The impact on competitive markets depends on the scope of the system. The affected markets are markets where airlines with a large share of emissions in the scope of the system compete with airlines that have a small share of emissions under ETS. In the regular scope (all arriving and departing flights), which has been analysed in the literature, the additional cross-subsidisation would occur on intercontinental routes where EU airlines compete with non-EU airlines. These airlines would be network airlines, because they operate on intercontinental routes.

When evaluating the rationality of crossfinancing, the crucial question is whether airlines are able to increase their prices or lower their margins (temporarily) in market segments not covered in the EU ETS. Rational profit maximising airlines would allocate a relatively larger share of the costs to market segments with a lower elasticity of demand, and the price elasticity of demand is lower on intercontinental routes than on intra-EU routes. Again, the answer depends on the geographical scope. Below we discuss for both geographical scopes separately the opportunities for cross-subsidisation and the rationality. After this theoretical discussion, we analyse the evidence. An example of cross financing would be given by US airlines and European airlines that are both operating under ETS. American airlines have a relatively low share of flights under EU ETS and surrender emission allowances for up to 10 percent of the flights, based on the share of their total flights that land in and depart from EU+ countries. For European airlines, on the other hand, which for natural reasons perform an important share of their flights within European territory, this figure is 80 percent or higher. If additional cross financing occurs, US airlines increase their prices on the flights outside the EU ETS and use the additional revenues to compensate cost increases on flights to and from the EU. European airlines would have less opportunity to do the same and would therefore experience competitive disadvantage (CE Delft, 2011).

Stopping the Clock

In the stop the clock scenario, only intra-EU flights are included in the EU ETS. Regional airlines and European low cost carriers have the majority of flights in the scheme, whereas European network carriers have both flights outside and in the geographical scope of the scheme. Hence, if additional cross-subsidisation is to occur, it would occur on intra-EU routes where regional airlines or low cost carriers compete with network carriers.

In this scenario, it appears to be attractive to allocate the costs to intercontinental routes. EU network carriers would have greater opportunity to do so than regional airlines and low cost carriers. If network carriers allocate their costs to intercontinental routes, the cost increases on intra-EU routes would be lower, and EU network carriers could gain market share at the expense of low cost carriers. However, while the aggregate price elasticity on intercontinental routes may be lower, the price elasticity which individual airlines face may sometimes not: in a competitive market, there may be a high cross-price elasticity between airlines operating on the same route. Since most intercontinental routes are operated by at least two carriers from different continents, with a different exposure to the EU ETS, this crossfinancing strategy would unlikely yield benefits.

Only looking at European airlines, the European network carriers would have the largest possibility to cross-subsidise. They are also the carriers for which the cost increases are relatively the lowest, and hence they would already gain market share at the expense of low cost carriers.

European Airspace

The European airspace scenario has elements of both the STC scenario and the regular design of inclusion of aviation into EU ETS (all flights from/to EU). Because the geographical scope of EAS not only includes emissions on intra-EU flights but also on parts of the emissions on intercontinental flights, it affects both carriers that operate only on intercontinental routes, and both on intercontinental and EU routes, and only on intra-EU routes. Non-EU carriers could, according to the arguments put forward, cross-subsidise intercontinental routes in order to gain market share from EU network carriers. EU network carriers could cross-subsidise intra-EU routes in order to gain market share from low cost carriers and regional airlines.

In this scenario, apart from the cross-subsidisation option analysed above, non-EU network carriers could cross-subsidise their intercontinental routes by raising prices on routes outside the scope of the EU ETS (second type). Since price elasticities of demand on short haul routes outside the scope of the EU ETS are likely to be higher (because price elasticities for short haul flights are higher generally), this does not appear to be a rational strategy in short haul flights, unless the airline operates routes with a particularly low price elasticity of demand. It seems more rational for long haul flights.

The third type of cross-subsidisation would use of profits generated by passing on the opportunity costs of freely allocated allowances – if these occur – to lower prices on certain routes. Since the freely allocated allowances are not liked to particular routes or flights, airlines would not necessarily use the profits for certain routes. Instead, they could allocate them to the routes where they see the largest advantage in increasing market share, or use the profits for other purposes, e.g. to increase dividends. The scope for this type of cross-subsidisation would be relatively the largest for airlines with the largest share of emissions in the scope of the system, i.e. low cost carriers and regional airlines in both the STC and the EAS scenario.

Evidence on additional cross-subsidisation

In any case an airline will try to pass additional effective costs where the airline expects the lowest negative impact on earnings and profitability. So even EU carrier will not just allocate the effective cost of emissions to the flight causing them but do some kind of cross financing depending in the different price elasticities of demand per route.

There is weak empirical proof on the occurrence of the first type of cross-subsidisation as a result of the introduction of the EU ETS. However, cross-subsidisation can be modelled with SECAN-ET and this presents us with some interesting modelling results (see section 6). The results of our SECAN-ET model runs show that cross-subsidisation has a minor impact on the revenues of airlines, typically much smaller than 0.1%[7]. This implies that even if airlines would additionally cross-subsidise, it would not significantly change the competitive positions of airlines.

There is an equal lack of empirical evidence on the occurrence of windfall profits, which are a prerequisite for the third type of cross subsidisation. Our modelling results, both with AERO-MS and with SECAN-ET, show that if opportunity costs are passed on, airline profits would increase significantly, and that the impact on profits would be much larger for EU-based airlines than for non-EU based airlines. This implies that if opportunity costs would be passed on fully or partially, it would create opportunities for EU-based carriers to engage in additional cross-subsidisation.

3.3.3 Hub-effect

The second mechanism for competitive distortions is the hub effect, where airlines with a hub outside EU+ may get a competitive advantage over airlines with a hub within EU+ borders (Ernst & Young and York Aviation 2007, CE Delft and MVA 2007, Infras 2009, Netherlands Institute for Transport Policy Analysis, 2012).

For most destinations, there are direct flights available. In many cases these flights are operated in competition between carriers based at the two cities concerned. However, airlines may also offer alternative routings via a hub airport, where passengers must transfer (interchange) between flights. This is connected with a prolongation of travel time. Passengers between major cities typically have a choice between direct flights, transferring at an EU+ hub, or transferring at a non-EU+ hub.

Stopping the Clock

The importance of hub location depends on the geographical scope. For the STC scope, passengers coming from or flying to an EU destination will often have a choice between a direct flight, a transfer at a hub outside the EU or a hub in the EU. For passengers who transfer at EU+ hubs, the intra-EU leg will be subject to the EU ETS. In contrast, direct flights or flights via non-EU hubs will not be subject to the EU ETS. Therefore, airlines that offer direct flights to a destination outside the EU see their competitiveness improved. Airlines that have a hub airport just outside the EU+ borders might have a competitive advantage over airlines that have a transfer on a hub airport within EU+ borders.

European Airspace

For the European airspace scope, the situation is somewhat different as intercontinental flights are partly included – although the share of emissions in the EU ETS is still smaller when flying from a non-EU hub or a direct intercontinental flight. Moreover, also flights between two non-EU airports could be affected when they have a possible connection at an EU hub and a non-EU hub.

---

[7] Note that the Netherlands Institute for Transport Policy Analysis (2012) finds a slightly higher effect but they assume far higher levels of cross-subsidisation. Moreover, they analyse cross-subsidisation in the original geographical scope of the Directive (all arriving and departing flights), in which the opportunities for cross-subsidisation could be larger.

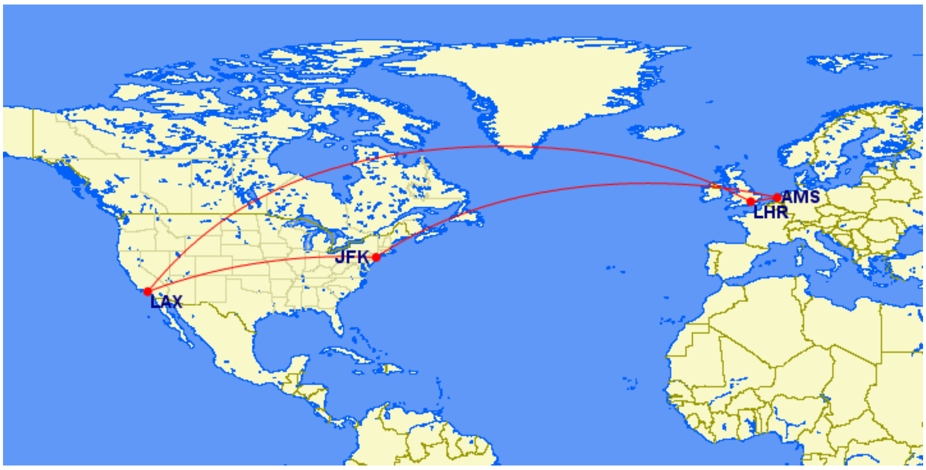
Table 6 shows an example of a hub effect on a flight from Amsterdam to Los Angeles (direct and indirect with EU and non-EU hub).

Table 6: Hub effect on flight between Los Angeles and Amsterdam for 2 scenarios (STC and EAS)

Los Angeles – Amsterdam	STC	EAS
Direct flight	not included	Small part included
Transfer London	one leg included	One leg partially included, one leg fully included
Transfer New York	not included	One leg partially included, one leg not included

When analysing the importance of the change from a direct to a transfer flight, time costs have also to be considered; when the choice is between two indirect flights. If the difference in time is limited, it has to be analysed, if there is a high enough passenger/cargo volume available, that leads to profits on the alternative route profitably in operation.

Figure 10: Hub effect on flight from Los Angeles (LAX) to Amsterdam (AMS) through non-EU hub JFK or EU-hub (London Heathrow)



Source: Great circle mapper (www.gcmap.com)

In both geographical scopes, the affected flights are intercontinental flights and the airlines are therefore network airlines. Network airlines with a hub in the EU are disadvantaged relative to network airlines with a hub outside the EU. However, not all routes are equally vulnerable to this type of avoidance because it requires a hub airport on the route.

The affected market segments from the hub-location and the extent to which airlines can benefit from a hub-effect depends mainly on geographical factors and are present only in the EAS. The most obvious routes that are likely to be affected by the hub effect are routes where an alternative stopover is possible. This would be hubs just outside Europe: hubs in the Middle East, North Africa, and East coast of the USA.

Table 7: Overview of routes and their possible hubs

From	To	Alternative hubs
EU+	West coast of N-America	East Coast of USA
EU+	South East Asia	Middle East, East/South Europe
EU+	Africa	North-Africa
EU+	Latin-America	East coast of USA
EU+	Australia	Middle-East, South-East Asia
N-America	Middle East	Indian subcontinent, South-East Asia
N-America	Southeast Asia	Middle East

On flights from the EU+ countries to the west coast of N-America, the presence of hubs on the east coast gives some opportunities to avoid an EU hub. Examples of large international hubs on the East coast are Atlanta, New York, Washington, Houston, Miami, and Florida.

In the Middle East the two fast growing airports Abu Dhabi and Dubai (United Arab Emirates) provide opportunities for hub transfers for flights from EU+ to Australia and to south east Asia. Also Doha (Qatar) experiences a rapid growth as an international hub.

Just outside Europe, the airport of Istanbul Ataturk (Turkey) is an important player in the field of international airport hubs. In East-Europe, the airport of Moscow is a large airport that may function as a hub transfer for flights to South-East Asia.

In North Africa there are currently no major hubs present, but this might change in the future.

Evidence on the hub effect

The models employed in this project do not allow for a quantification of the hub effect. The Netherlands Institute for Transport Policy Analysis (2012) has analysed the impacts for the regular scope of the ETS. With a relatively low allowance price of 10 € but full pass on of opportunity costs, it finds that the demand for transfer at EU hubs could decrease by 1% for flights from an EU destination to a non-EU destination to 5% for flights between two non-EU airports with a possible transfer in the EU. The latter market is smaller than the former. The effect in the regular design would have fallen almost completely on network carriers. In EAS and STC the impact is likely to be much smaller, because only a small part of the intercontinental flights is covered in EAS.

3.3.4 Profit margin (or volume effect)

Third, some studies argue that the higher costs that airlines face with the inclusion of aviation in the EU ETS would reduce the profit or profit margin of the airlines (Ernst and Young and York Aviation, 2007).

When airlines face higher costs due to the purchase of emission allowances under EU ETS, they may want to pass these costs on to the passengers by increasing the ticket prices.

However, increased prices may lead to a reduced demand for passengers and cargo, and hence a reduction in profits for airlines. In order to prevent the reduction in demand, airlines may opt to choose not to increase their prices, but to absorb the costs, which will reduce the profit margin of the airline.

In the case of a free allocation of emission allowances to the airlines, windfall profits would arise if airlines would be able to pass on the opportunity costs of these allowances to their passengers (CE Delft 2007). These windfall profits would not be equal for all airlines: since short haul flights have higher emissions per RTK, and since allowances are allocated on the basis of RTK, airlines with many short haul flights would have relatively fewer opportunities for realizing windfall profits than airlines with many long haul flights. Relatively the best off would be non-EU+ carriers that only fly long haul to EU+ countries (e.g. US carriers, south-east Asian carriers, Middle-Eastern carriers) (CE Delft and MVA 2007, Scheelhaase et al., 2010).

Stopping the Clock

In the Stopping the Clock scenario, only intra-EU flights are subject to the EU ETS. The increased effective costs due to the purchase of emission allowances may negatively affect the profit or profit margin of airlines operating in this market segment. Since European low cost airlines have a higher share of emissions within the stopping the clock scope than European network carriers, it is plausible that this type of airline will be mostly affected. EU+ based network carriers generally also operate on long haul distances, which are not subject to the EU ETS, and are therefore expected to be less harmed by STC. Conversely, European low cost carriers will receive more free allowances per unit of revenue than network carriers, and therefore would have a higher windfall profit if opportunity costs can be passed on.

European Airspace

In the European Airspace scenario, all flights arriving at/departing from EU+ airports are subject to the EU ETS. The purchase of emission allowances increases the effective costs of all airlines arriving or departing from an EU+ airport. Therefore, the market segment where reduced profit margin leads to distortive competition is most likely on intercontinental flights. The market actors that are most likely to be affected are the EU+ based airlines, since they have a larger share of their flights under the EU ETS, and therefore are expected to see their profit margin to be more reduced than non-EU+ based network carriers who have a large share of their flights (and profits) outside the EU ETS. The latter would also benefit more from free allowances if they could pass on (parts of) their opportunity costs to passengers (CE Delft 2007).

Evidence on the profit margin

Modelling with SECAN-ET shows that EU network carriers have ETS-related expenditures of 0.2% of revenues in the STC, while LCC have expenditures amounting to 0.8% of revenues. The value of the free allowances is 0.6% of revenues for network carriers to 2% for LCC, so that if these opportunity costs could be fully passed on, the profit margin of EU LCC would increase by 1% and of EU network carriers by 0.3% for non-EU carriers, the impacts on profits would be an order of magnitude smaller.

3.3.5 Exceptions for small aircraft: De-minimis rule

The fourth mechanism that could distort the competitive position of airlines in EU ETS is the de-minimis clause. According to this rule, airlines are exempted of EU ETS in the following cases:

- Commercial airlines with less than 243 EU flights for three consecutive four-month periods per year (less than 2 flights a day to or from an EU airport)
- Commercial airlines which emit less than 10,000 tonnes/CO2 annually

The purpose of the exemption of EU ETS by the De-minimis rule is to reduce the compliance and administrative costs for small airlines within EU ETS (EC, 2009). However, the exception of smaller airlines could lead to a deterioration of the competitive position of other airlines that compete with these exempted aircraft operators.

3.4 Conclusion

The impacts on competitiveness depend on the ability to pass on a) EU ETS related effective expenditures and b) the opportunity costs of freely allocated allowances. Moreover, in the European Airspace scenario and to a lesser extent in the Stopping the Clock scenario, the hub location is important.

Lacking a clear price signal in a stable regulatory environment, it is not possible to evaluate ex-post whether airlines are able to pass-on costs and opportunity costs. Hence, our conclusions on this subject are scenarios. If airlines are not able to pass on the EU ETS related effective expenditures, as could be the case in the short run, this would impact the profitability of European low cost carriers more than European network carriers. Non-European carriers would hardly be affected. As a result, the ability of low cost carriers to invest in new routes or attract capital would be diminished and their competitive position would deteriorate relative to European network carriers, which, in turn, would see their competitiveness, deteriorate relative to foreign network carriers. This would be irrespective of the geographical scope, but it would a transitory effect.

If airlines could pass on the EU ETS related expenditures, but not the opportunity costs of free allowances, their profit margins would not change and their total profits would decrease somewhat as a result of lower demand. LCC would be worse affected than network carriers because of the larger share of flights affected.

If airlines would be able in the long run to pass on effective expenditures and (to a smaller or larger extent) opportunity costs, the opposite would occur. LCC would see their profit margins grow more than European network carriers and much more than foreign network carriers. As a result, their ability to compete would improve.

On the related issue of cross-subsidisation, there has been, and continues to be, much debate about whether airlines are able to cross-subsidise EU ETS flights with additional revenues generated on flights outside the scope of the EU ETS. Our model results show that even if this is possible, the benefits for airlines will be minimal.

On intercontinental routes, and especially for flights that involve a transfer, the location of the hub airport has an impact on the competitiveness. Hubs outside the EU (e.g. on the east coast of North America, and in the Middle East) become more attractive for a transfer than hubs in the EU. In the STC scope, this is only the case for flights from the EU to non-EU destinations involving a transfer. For the EAS scope, this involves all intercontinental flights. It would result in a deterioration of the competitiveness of EU network carriers and an improvement of non-EU carriers, although at current price levels, it would only be a marginal effect. But the potential hub effect has to be put in context of the resulting change travel time, especially if demand for flights for business purpose is looked at.

4 Cost functions

An important indication for the impact of the EU ETS is the shape of cost functions of different airline types. In this chapter the cost functions provided by AERO-MS are presented. These cost functions are challenged with real cost data based on actual annual reports of airlines.

4.1 AERO-MS cost functions

4.1.1 Cost categories in AERO-MS

The AERO-MS considers the following variable aircraft operating costs (or direct operating costs) components:

1. Cabin crew costs;
2. Capital costs;
3. Finance costs;
4. Flight crew costs;
5. Fuel costs;
6. Maintenance costs;
7. Landing costs;
8. En route navigation costs.

In a first step the AERO-MS calculates the cost per physical unit for each variable cost component at a route group level. Physical unit can be a cycle (a single flight), distance or block time, depending upon the variable cost component, as set out in table 8 below. In a second step for each variable cost component, total costs are computed by multiplying the costs per physical unit with the number of physical units.

The AERO-MS is primarily concerned with the operating cost changes which affect whether an airline would choose (in the long term) to adapt the aircraft types used to meet demand as a result of policy measures to reduce aircraft emissions. The variable operating costs, included in the AERO-MS, are therefore those that vary significantly by aircraft type and technology level.

The various variable costs components of air transport are modelled as follows:

1. Cabin and flight crew costs are calculated from salary costs per flight hour and the number of crew members. Salary costs vary by the region of carrier registration. Total cabin and flight crew costs are computed by multiplying the salary costs per crew member per flight hour with the number of crew members (varying by aircraft type) and the number of block (or flight) hours.
2. Capital costs represent the loss in value of aircraft through ageing. Analysis of market values for different ages of aircraft of the same type indicates that aircraft typically

depreciate at about 6% of their residual value (in real terms) per annum. This is incorporated in an annual depreciation function, which varies with age around the 6% figure. The depreciation function allows a weighted average annual depreciation cost to be calculated for each generic aircraft type/technology level. This is divided by the average annual aircraft utilisation for the generic aircraft type and technology level to calculate the capital costs per block hour. Total capital costs are computed by multiplying the capital costs per block hour with the number of block hours

3. Finance costs are the opportunity costs of capital tied up in the purchase of aircraft. Finance costs are represented in the AERO-MS by interest on the residual (non-depreciated) value of the aircraft fleet. Finance costs are calculated by multiplying the average residual value of each generic aircraft type/technology level by a real interest rate. The resulting interest burden for each generic aircraft type/technology level is divided by the annual utilisation to obtain finance costs per block hour. Total finance costs are computed by multiplying the finance costs per block hour with the number of block hours.
4. Fuel consumption and cost are computed on the basis of the Landing-and-TakeOff (LTO) related fuel use and a specific fuel use per km, by aircraft type, technology level and distance band, taking into account the fuel use characteristics by aircraft type and technology level and the aircraft weight (based on empty weight, average payload and fuel required for the flight). Total fuel consumption is computed by (per aircraft type) multiplying the fuel use per km with the number of flight km, and multiplying the fuel use per LTO cycle with the number LTO cycles. Total fuel costs are computed by multiplying fuel consumption (in kg) with the kerosene price per kg.
5. Landing costs are computed on the basis of landing costs per LTO cycle which vary by aircraft type and region. Total landing costs are computed by multiplying the landing costs per LTO cycle with the number of LTO cycles.
6. Maintenance costs are calculated from maintenance costs per hour and the number of maintenance hours per flight hour. Calculations are made by aircraft type and technology level. Maintenance costs per hour also vary by the region of carrier registration, taking into account that maintenance partly takes place in regions with lower salary cost levels (which lowers the hourly maintenance costs for regions with relatively high salary costs). Total maintenance costs are computed by multiplying the maintenance costs per block hour with the number of block hours.
7. En route navigation costs are calculated from route costs per km which vary by aircraft type and route group. Total en route navigation costs are computed by multiplying the route costs per km with the number of flight km.

In addition to the variable cost components, the AERO-MS takes into account other (non-flight related) costs, such as the costs of ground handling, sales, ground facilities (buildings) and overhead. These costs are considered as a single cost by flight type (scheduled versus LCC/non-scheduled and passenger operations versus full freighters) and AERO-MS route group.

Table 8: AERO-MS variable cost components by physical unit

Cost component	Cycle-related	Distance-related	Block hour-related
Cabin crew costs			*
Capital costs			*
Finance costs			*
Flight crew costs			*
Fuel costs	*	*	
Maintenance costs			*
Landing costs	*		
En route navigation costs		*	

4.1.2 EU ETS related route groups for which cost functions are provided

A distinction is made between three different flight types for which AERO-MS cost functions are provided:

- Scheduled passenger operations by network carriers;
- Low Cost Carrier (LCC) and non-scheduled passenger operations;
- Full freighter operations.

In addition a distinction is made between different EU ETS related route groups. These route groups are presented in table 9 with an indication of the number of airport pairs within a route group and the average flight distance.

Table 9: Route groups for which cost functions are provided

Route Group	Nr of airport pairs	Average flight distance (km)
Intra EU+*	36319	852
Between EU+ and North America	1615	7187
Between EU+ and Rest of Asia / Pacific	802	8041
Between EU+ and Latin America / Caribbean	726	8029
Between EU+ and Middle East	1207	4258
Between EU+ and Africa	3112	3143
Between EU+ and Australia/New Zealand/Japan/South Korea	102	10121
Between EU+ and Rest of Europe	3977	2000

* EU+ refers to EU28 plus Norway, Iceland, Liechtenstein, Switzerland and the outermost regions

Hence for 24 markets (3 flight types and 8 EU ETS related route groups) cost functions are provided below.

The route group Intra EU+ relates to the coverage of the stopping the clock EU ETS options (see figure 1). The other route groups are also included in the regular design of the EU ETS.

In order to get an idea on the relative importance of the various markets for which cost functions are provided, an overview of the number of Revenue Tonne Km (RTK) per market is provided in figure 11.

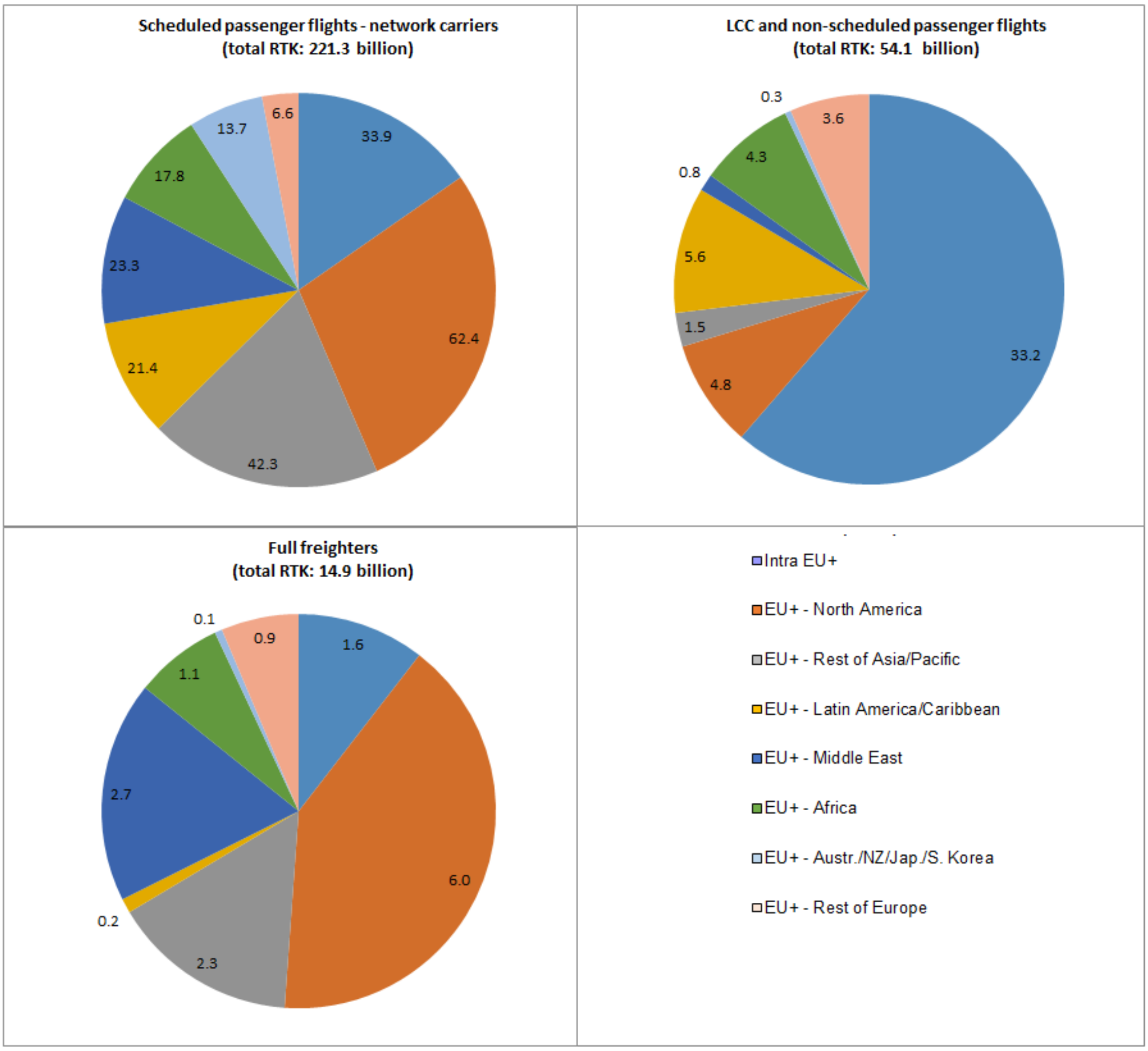
Figure 11 shows that scheduled passenger operations by network carriers are most important in terms of the total number of RTKs (221.3 billion RTK in 2012). Hereby it is noted that about 25% of total RTKs carried by this flight type relates to cargo (belly hold). Figure 11 furthermore shows that the most important intercontinental route groups are between EU+ and North America (62.4 billion RTK) and between EU+ and the Rest of Asia (42.3 billion RTK).

The total number of RTKs carried by LCC and non-scheduled passenger operations is 54.1 billion RTKs. Figure 11 shows that the larger part of the RTKs relates to the Intra EU+ route group (33.2 billion RTK).

For full freighters, only a small proportion of the RTKs is performed on the Intra EU+ route group (1.6 billion RTK out of the total of 14.9 billion). This small proportion follows from the strong competition from surface transport modes for cargo transport on intra European routes. A large proportion of cargo transport by full freighters is related to flights between the EU+ and North America (6 billion RTK).

Note that passenger aircraft take account of over 50 billion RTK of cargo transport, whereas the total cargo transport by full freighters on EU+ related routes is 14.9 billion RTK. Hence, on EU ETS related route, the larger part of cargo (in terms of RTKs) is transported by passenger aircraft in the belly hold.

Figure 11: Revenue Tonne Km (RTK) in 2012 for different flight types and EU related route groups*



* RTK are computed on the basis of an average weight of passengers (including baggage) of 90 kg.

4.1.3 AERO-MS cost functions for EU ETS related route groups

AERO-MS cost functions are provided for:

- Scheduled passenger operations by network carriers (figure 12);
- LCC and non-scheduled passenger operations (figure 13);
- Full freighter operations (figure 14).

In all 3 figures cost functions are provided for the 8 different EU ETS related route groups. The cost functions express the unit costs per RTK for the variable cost component considered in the AERO-MS. Unit costs are also provided for the other (non-flight related) costs. Hence the costs function also picture the total operation costs per RTK for the different flight types and EU ETS related route groups.

Figure 12 shows that for scheduled passenger operations by network carriers the unit cost levels are clearly highest for the Intra EU+ route group. These higher cost levels follow from the shorter flight distances and smaller aircraft which operate on Intra EU+ routes (smaller aircraft generally have higher costs per RTK).

The unit cost levels for the route group EU+ to the Rest of Europe are in between the cost levels for the Intra EU+ routes and the intercontinental routes. Cost levels between the EU and various other continents are fairly comparable as all of these routes mainly consist of long haul flights operated by larger aircraft.

Fuel cost is clearly the most significant variable cost component. For Intra EU+ scheduled passenger operations by network carriers fuel costs are 0.36 US$ per RTK. This is about 35% of the overall variable costs. For intercontinental flights fuel costs per RTK - like the unit costs for other variable cost components - are lower compared with the unit costs on Intra EU+ routes. For flights between EU+ and North America fuel costs are 0.22 US$ per RTK. However, on intercontinental routes fuel costs take account of a larger proportion of the overall variable costs (typically around 45%).

Figure 12 also shows that network carriers with scheduled passenger operations have relatively high levels of other (non-flight related) costs.

For LCC and non-scheduled passenger operations, cost levels are generally significantly lower compared with the cost levels of network carriers (compare cost functions in figure 13 with cost functions in figure 12). This is especially true for the Intra EU+ route group which, in terms of RTKs, is by far the most important EU ETS related route group for LCC and non-scheduled passenger operations (see figure 11). Overall variable costs on Intra EU+ routes are 0.68 US$ per RTK for LCC and non-scheduled passenger operations (see figure 13) versus 1.05 US$ per RTK for network carriers (see figure 12). If the other (non-flight related) costs are also taken into account, the difference is even larger (0.74 US$ per RTK for LCC/non-scheduled versus 1.67 US$ per RTK for network carriers). The lower costs per RTK for LCC/non-scheduled operations not only follow from lower cost levels, but also from higher load factors.

Also for full freighter operations, the unit cost levels are highest on Intra EU+ operations (see figure 14). Furthermore, cost levels on the intercontinental route groups vary significantly, with highest cost levels for the route group between EU+ and Australia, New Zealand, Japan and South Kora. The variation in cost levels across various intercontinental route groups for full freighter operations is especially due to a significant variation in load factors.

Figure 12: AERO-MS cost functions scheduled passenger flights by network carriers.

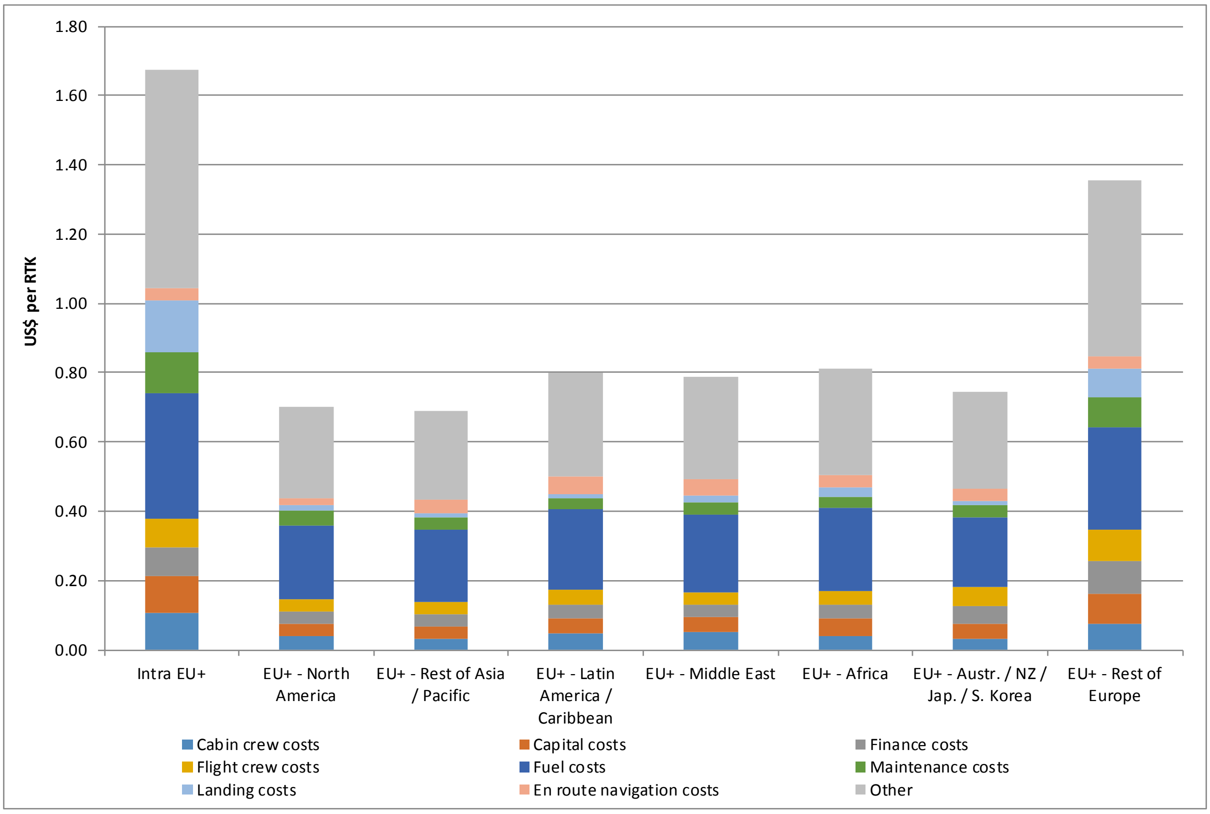


Figure 13: AERO-MS cost functions LCC and non-scheduled passenger flights.

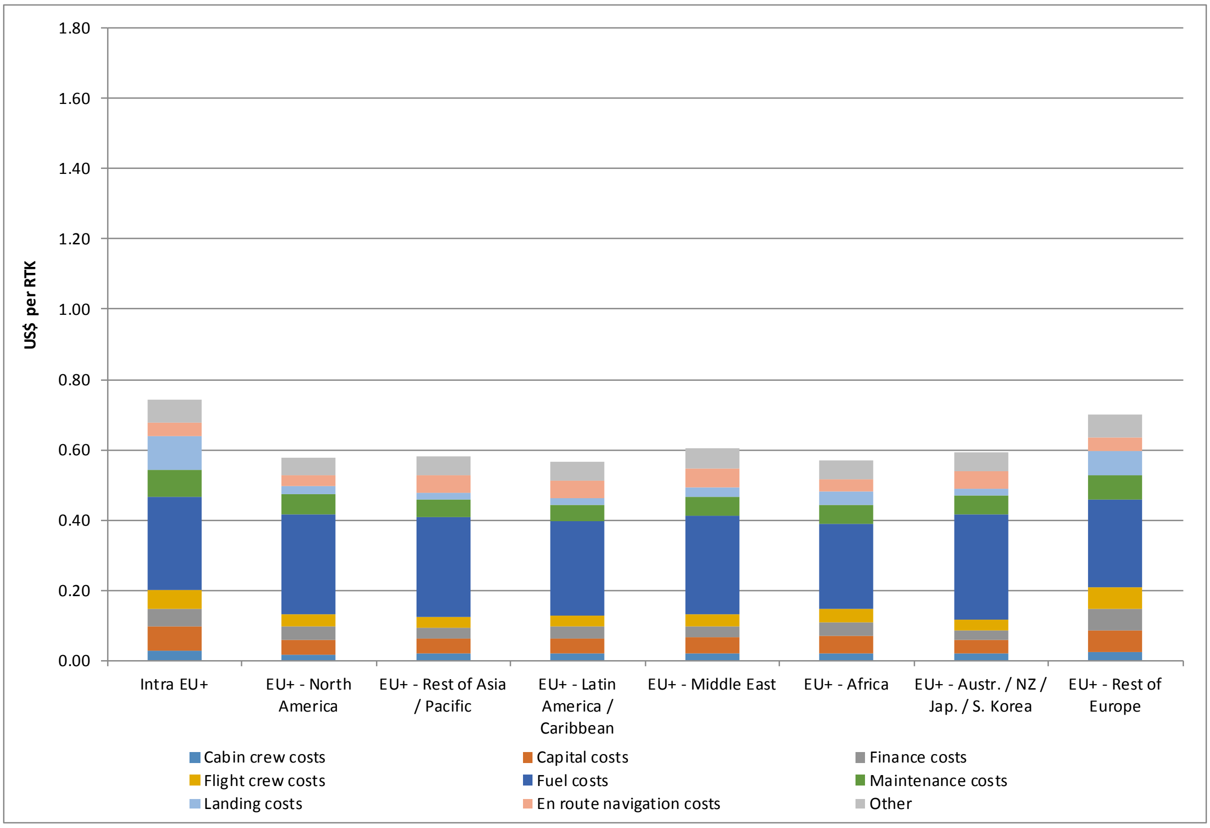
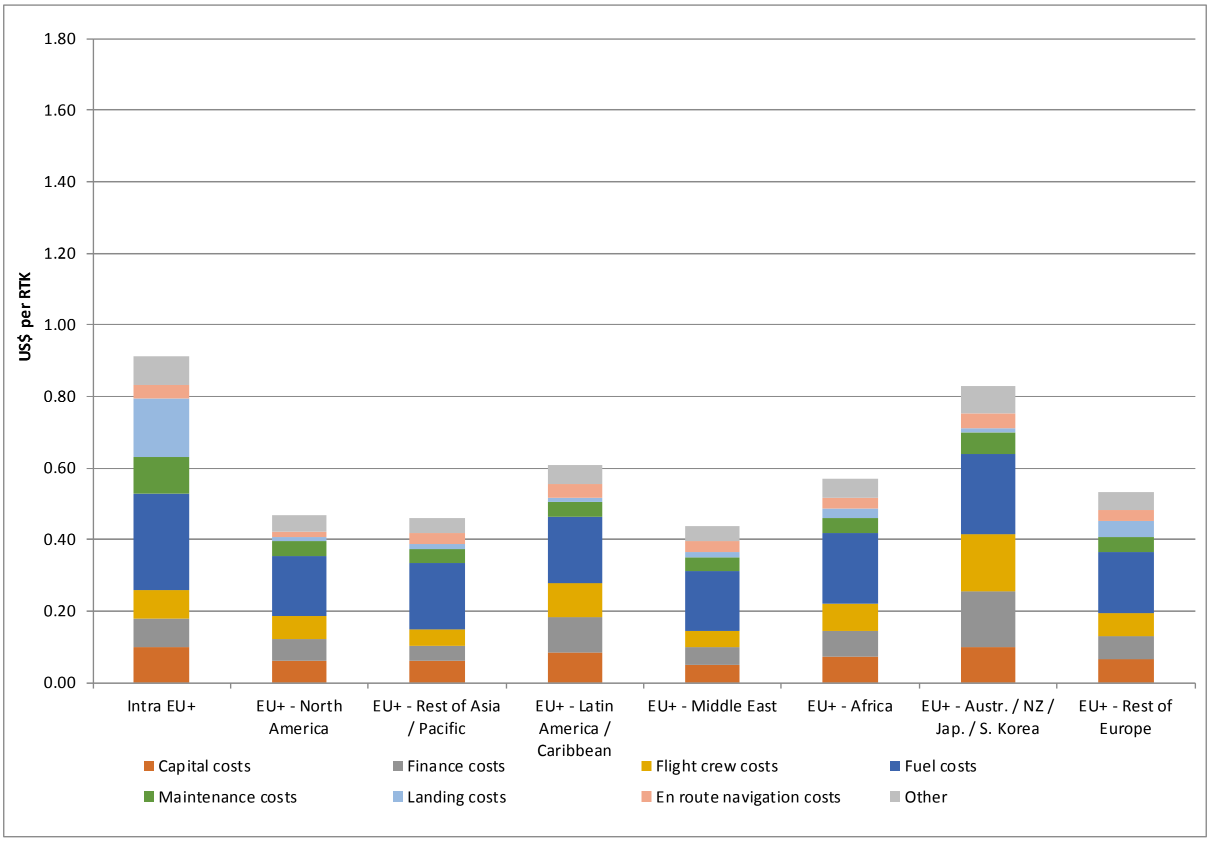


Figure 14: AERO-MS cost functions full freighter operations



4.1.4 Cost effect of EU ETS following from AERO-MS cost functions

Chapter 7 is involved with the analysis of the overall effects of EU ETS options using the AERO-MS. This section shows the cost effects of EU ETS following from cost functions in the AERO-MS. This is done for passenger flights on the Intra EU+ route group which are served by both network carriers and LCC carriers (with different cost structures).

The first part of table 10 provides the relevant AERO-MS data. First the fuel cost and total operating cost per RTK (following from the cost functions provided in section 4.1.3) are presented. As discussed in section 4.1.3, the total operating cost per RTK are lower for LCC and non-scheduled operations. Also fuel costs per RTK are lower (0.36 US$ per RTK for network carriers versus 0.26 US$ per RTK for LCC). Hence, on Intra EU+ routes unit fuel costs are about 27% lower for Low Cost Carriers.

Fuel use per RTK - as computed by the AERO-MS - for Intra EU+ flights is 0.41 kg per RTK for network carriers versus 0.30 kg per RTK for LCC. Hence the difference in unit fuel costs is due to a difference in fuel efficiency. The price per kg of fuel for network carriers and LCC is the same. The higher fuel efficiency for LCC carriers is mainly due to higher load factors.

Fuel per RTK can be translated into CO_2 per RTK (3.15 kg of CO_2 emission per kg fuel use). CO_2 emissions per RTK on Intra EU+ flights are 1.28 kg per RTK for network carriers versus 0.94 kg per RTK for LCC.

The second part of table 10 shows what the cost effect is in case of the EU ETS assuming a price of 10 € per ton of CO_2 (or 13.2 US$ per ton). Following from the AERO-MS computed CO_2 emissions per RTK, the cost per RTK following from this CO_2 price level would be 1.7 US$c per RTK for network carriers and 1.2 US$c per RTK for LCC.

For both network carriers and LCC, the CO_2 cost per RTK equals an increase in fuel costs by 4.7%. However, because fuel cost are a larger proportion of total operating costs for LCC, the percentage increase of total operating costs is larger for LCC (1.7% versus 1.0% for network carriers).

Assuming all cost increases would be passed on into higher fares, and assuming that possibilities for mitigating cost effects by supply side responses are limited, the percentage effects for fares would be comparable to the percentage effects on total operating costs. Hence, for LCC, the percentage effect on fares will be about 1.7% in case of an EU ETS price of 10 € per ton of CO_2. For network carriers the fare increase will be about 1%. Naturally, this percentage price effect would double if the CO_2 price would double.

Note that differences in the effects for operations by network versus LCC carriers are not only related to differences in cost structures, but - for example - also to differences in price elasticities of demand. The analysis of the overall differences in effects of EU ETS between various flight types is presented in chapter 7.

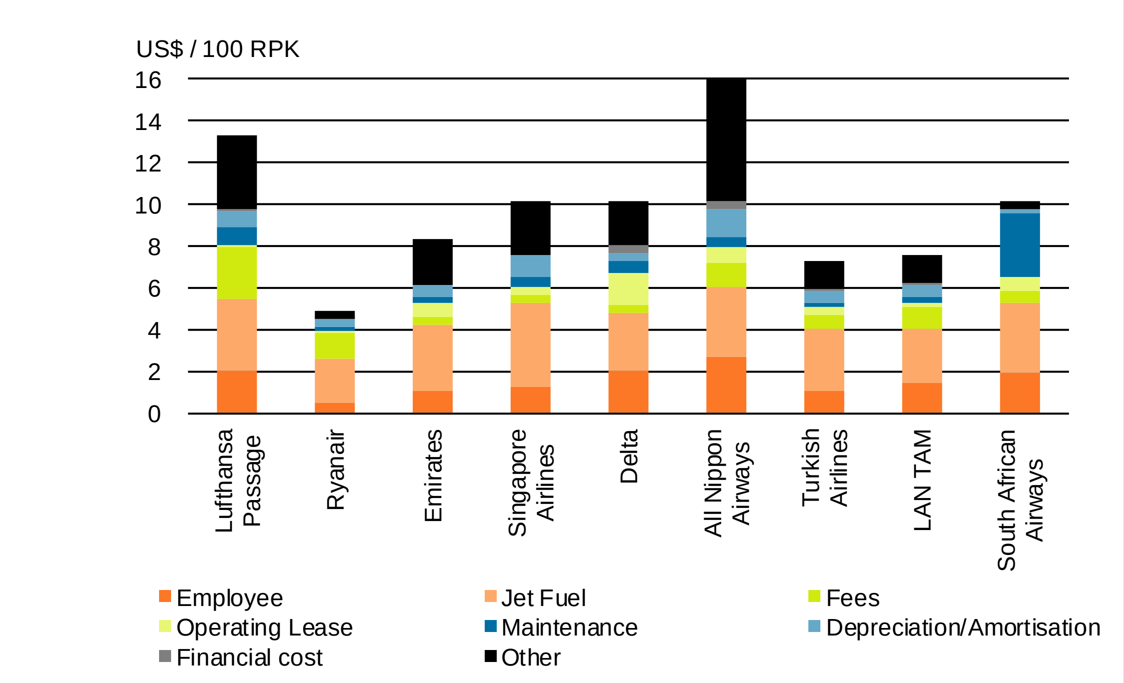
Table 10: Cost effect of EU ETS for Intra EU+ passenger flights.

Indicator	Unit	Scheduled passenger operations by network carriers	LCC and non-scheduled passenger operations
AERO-MS data			
Fuel costs per RTK	US$ per RTK	0.36	0.26
Total operating costs per RTK	US$ per RTK	1.67	0.74
Fuel use per RTK	kg per RTK	0.41	0.30
CO_2 per RTK	kg per RTK	1.28	0.94
Cost effect in case of EU ETS CO_2 price of 10 € per ton			
Costs of CO_2 per RTK	US$ per RTK	0.017	0.012
Increase fuel costs*	%	4.7%	4.7%
Increase total operating costs	%	1.0%	1.7%
* Costs for CO_2 allowances are assumed to be treated as fuel costs (and can therefore be added to fuel costs)			

4.2 Comparison with annual report data of the year 2012

To check the validity of the AERO-MS cost data, a comparison is made with annual report data of different airlines for the year 2012. The following figure shows the cost structures of airlines from different parts of the world in relation to revenue passenger km (RPK):

Figure 15: Cost structure of different Airlines per RPK



Source: INFRAS

According to the AERO-MS the cost per RTK of network carrier varies for different relation groups between 0.7 and 1.7 US$ per RTK. The annual report data shows for network carriers average cost per RPK in the range of 7 to 16 US$ per 100 RPK. Assuming that one passenger with baggage has an average weight of 90 kg this is 0.7 to 1.4 US$ per RTK. This lies within the range of the AERO-MS data.[8]

For low cost carriers, according to the AERO-MS data, the average cost per RTK are between 0.55 and 0.75 US$. Ryanair lies with cost of 5 US$ per 100 RPK at the lower bound of the range. Knowing that Ryanair has the most fuel efficient aircraft fleet in Europe and that fuel costs cause 30% to 50% of all LCC cost, the data of the AERO-MS seems plausible.

All in all it is concluded the AERO-MS cost data are in line with annual report data.

The figure above does not allow to judge about the efficiency of different airlines. As we have seen in the analysis of the AERO-MS data, the average cost per unit depends strongly on the flight distance. Therefore higher costs per unit can rely on less efficient production structure but also on a different relation between short and long haul flights. Hence, to assess the efficiency of an airline, information about their route net is necessary.

8 On the basis of the annual reports the calculation of costs per RTK was not possible since not all airlines publish data about their cargo ton-km. Nevertheless we checked the differences for those airlines which have official data about cargo ton-km. There is no effect which questions the plausibility of the AERO-MS data.

5 General aspects about the modulation

5.1 Interaction of the SECAN-ET and AERO-MS

For the quantitative analyses use is made of two aviation models. The models have different focuses and complement one another. To understand, how the models interact, it is important to understand the potential responses of all affected actors to the implementation of the EU ETS. Actor responses are measures that can be taken by the various actors in the air transport sector (basically: airlines and consumers). They can be categorised as follows:

- Supply side responses;
- Fare and demand responses;
- Evasive responses.

Supply side responses are to be regarded as (desired) responses aiming to reduce fuel use and emissions. The fare and demand responses relate to the change in fares by airlines in relation to cost changes and the change in demand from airline consumers in relation to fare changes imposed by airlines. Demand responses are desired responses as the price increase reflects an internalization of external costs. Not intended demand responses are also possible. For example competitive distortions due to different levels of internalization by different airline types. Evasive responses relate to options for airlines and consumers to avoid negative effects of the EU ETS from the viewpoint of the costs and benefits of these actors. Since evasive responses are not aimed at achieving environmental improvement they may to some extent counteract the intended effects of the EU ETS or lead to other undesired effects (such as economic distortions).

In relation to the EU ETS the following supply side responses are considered:

- New aircraft technology shift: change in purchase behavior of airlines towards (available) environmentally more efficient new aircraft.
- Accelerated fleet renewal: replacing the older part of the fleet earlier than in the situation without the EU-ETS, based on financial considerations of airlines.
- New aircraft capacity shift: adjustment of mission capabilities to allow for more efficient aircraft operation in view of anticipated EU-ETS effects on transport flows.

Within fare and demand responses a distinction is made between:

- Airlines: Adjustment of fares to cost increases: adjustment of fares to an given increase in total operating cost following from the introduction of the EU ETS;
- Consumers: Demand response to fare change: reduction of air transport demand following from increases in fares.

Potential evasive responses to the EU ETS include:

- Cross financing of flights under the EU ETS with flights not covered by the EU ETS: Additional cross financing of flights under the EU ETS with income earned with flights not covered by the EU ETS.
- Cross financing economy class tickets: Additional cross financing of economy class tickets by passing on a relatively large share of the EU ETS related cost increases into business class fares.
- Destination switching: passengers departing from EU+ replace destinations in EU+ by destinations in non-EU+ countries (f.e. Turkey as a destination instead of Greece for Western European tourists). This response is potentially taken in the case of the “Stopping the Clock” option.
- Additional stopovers: Include additional stopovers in flight schedules to reduce the amount of emissions for which allowances have to be surrendered. Also this response is potentially taken in the case of the “Stopping the Clock” option.

Table 11 shows an overview of the actor responses to the EU ETS. The table indicates which of the responses are covered in both the AERO-MS and the SECAN-ET model. It can be seen that:

- Supply side responses are covered in the AERO-MS but not the SECAN-ET model;
- Fare and demand responses are covered by both models;
- Evasive responses are covered in the SECAN-ET model but not in the AERO-MS.

The table also shows which responses are short term or long term responses. Short term responses will take place directly after the EU ETS is enforced. Fare and demand responses and evasive responses can be considered as short term responses. The supply side responses, which are basically related to adjusting the aircraft fleet in response to the introduction of the EU-ETS, are clearly long term responses.

Because the AERO-MS takes into account the long term supply side responses, the analysis of the EU ETS with the AERO-MS is done for a future year so that the supply side responses are fully taken into account. The impact assessment of the EU ETS options with the AERO-MS will be made relative to a Business as Usual (BaU) scenario. The scenario to be used is the CAEP/8 Medium Growth scenario for the year 2026. A further specification of this scenario is provided in chapter 7 of this document.

The SECAN-ET model considers short term responses. Therefore the year 2012 will be the main analysis year for the impact assessment carried out with the SECAN-ET model.

Table 11: Overview of the applied models to analyse the different responses

Actor Responses to EU ETS	Actor	Long Term (LT) or Short Term (ST)	Included in AERO-MS (Yes/No)	Included in SECAN-ET (Yes/No)
Supply side responses				
New aircraft technology shift	Airlines	LT	Yes	No
Accelerated fleet renewal	Airlines	LT	Yes	No
New aircraft capacity shift	Airlines	LT	Yes	No
Fare and demand responses				
Adjustment of fares to cost increase	Airlines	ST	Yes	Yes
Demand response to fare change	Consumers	ST	Yes	Yes
Evasive responses				
Cross financing flights under ETS	Airlines	ST	No	Yes
Cross financing economy class tickets	Airlines	ST	No	Yes
Destination switching	Consumers	ST	No	No (qualitative analysis)
Additional stopovers	Airlines	ST	No	No (qualitative analysis)
Results				
Shift in passenger volumes	Consumers	LT/ST	Yes, LT	Yes, ST
Shift in freight volumes	Consumers	LT/ST	Yes, LT	Yes, ST
Shifts of passengers and freight between airline types	Consumers	ST	No	Yes
Shift in fuel use	Airlines	LT/ST	Yes, LT	Yes (in less detail than in AERO), ST
Shifts in costs and revenues (per airline type)	Airlines	LT/ST	Yes, LT	Yes, ST

In order to come up with a coherent analysis, data and modelling assumptions between the AERO-MS and SECAN-ET model are harmonized. For example price elasticities of demand and assumptions regarding the pass on of the EU ETS induced cost increases are harmonized. Table 12 contains the price elasticities of demand for Europe related route groups which have been applied in the analysis of EU ETS scenario by both SECAN-ET and the AERO-MS. Elasticities are based on an IATA study from 2008 (IATA, 2008), and vary across route groups. It can be seen, that following from the IATA study, intra European demand is more price sensitive compared to intercontinental demand. Hence, on average demand on the flights covered by the STC scenario is somewhat more price sensitive compared to demand on flights covered by the EAS scenario. Table 12 also shows different values for business versus leisure passenger demand. Where compared to network carriers, low cost carries have a larger proportion of leisure purpose passengers, on average demand for low cost carriers is more price elastic in comparison to passenger demand for network carriers.

Table 12: Price elasticities for passenger demand applied in the analysis.

Route Group	Passenger Purpose	
	Business	Leisure
Intra Europe	-0.60	-1.20
Europe - North America	-0.48	-1.08
Europe - Latin America	-0.48	-1.08
Europe - Africa	-0.35	-0.95
Europe - Middle East	-0.29	-0.89
Europe - Asia	-0.29	-0.89

Data of the situation without the EU ETS are also harmonised (basically numbers of passengers and freight volume on aggregated route groups). The harmonization assures that we have in both models the same underlying assumptions for the assessment of the impacts of the fare and demand responses.

An important issue in relation to the application of AERO-MS data in SECAN-ET is that in AERO-MS the base year is 2006. Hence the starting point of the AERO-MS is a database with all the flights by airport pair for the year 2006 (global coverage with over 123000 airport pairs). In order to come up with 2012 related data, a 'forecast' for the year 2012 is made whereby use is made of annual % changes in passenger km and freight tonne km over the period 2006-2012. For this purpose we have used IATA data. These data include annual changes in passenger km and freight tonne km for 6 groups of carriers. The data are included in the table 13 below.

Table 13: Annual growth in passenger and cargo aviation transport by region of carrier registration (2007-2012).

Annual growth in Revenue Passenger Km (RPK) - percentage change relative to previous year							
Region of carrier registration		2007	2008	2009	2010	2011	2012
1	Africa	8.0%	-4.0%	-2.0%	12.9%	0.3%	7.3%
2	Asia/Pacific	7.3%	-1.5%	-4.6%	9.0%	5.4%	6.1%
3	Europe	6.0%	1.8%	-3.3%	5.0%	9.0%	5.1%
4	Latin America	8.4%	10.2%	0.0%	13.2%	11.4%	9.6%
5	Middle East	18.1%	7.0%	11.2%	17.8%	8.5%	15.2%
6	North America	5.5%	2.9%	-5.2%	7.4%	2.3%	1.3%
	World	7.4%	1.6%	-2.5%	8.3%	5.9%	5.3%
Annual growth in Freight Tonne Km (FTK) - percentage change relative to previous year							
Region of carrier registration		2007	2008	2009	2010	2011	2012
1	Africa	-6.0%	-2.5%	-9.2%	23.5%	-2.1%	5.8%
2	Asia/Pacific	6.5%	-6.6%	-9.1%	24.0%	-4.4%	-5.5%
3	Europe	2.7%	-2.8%	-16.1%	10.8%	1.3%	-2.9%
4	Latin America	-5.4%	-13.5%	-4.0%	29.6%	6.0%	-1.1%
5	Middle East	10.1%	6.3%	3.9%	27.6%	8.2%	14.7%
6	North America	0.7%	-1.9%	-10.8%	22.9%	0.2%	-0.7%
	World	4.3%	-4.0%	-10.1%	20.8%	-0.6%	-1.5%

Source: IATA (see: http://www.iata.org/publications/economics/Pages/mtaarchives.aspx)

5.2 Similarities and differences between SECAN-ET and AERO-MS

This section provides a summary of the main similarities and differences between the two aviation models used for the quantitative analysis.

The main similarities between the SECAN-ET and AERO-MS are:

- Both models compute the effects of two different situations. The first situation is the baseline computation. The baseline computes the effect without taking into account a GHG-emission reduction policy (in this study EU ETS scenarios). The second computation takes into account the same baseline situation but then with an EU ETS scenario. By comparing the results of the two computations the effects of the EU ETS scenario can be analyzed. For SECAN-ET and the AERO-MS this analysis principle is reflected in respectively figure 18 and figure A2 in Annex A.

- As described in section 5.1 and indicated in table 11, both models take into account fare and demand responses.

- In order to assess fare and demand responses in both models the same steps are taken. First the EU ETS related CO_2 allowance price is translated into a cost change per unit of demand. The cost change per unit of demand can be different for different airline types (see also table 10). In a second step the changes in unit costs are translated into changes in fares. Following from the fare changes, in the last step changes in demand are computed using the price elasticities of demand.

- In both models it is assumed that all the real cost increases for airlines following from the introduction of the EU ETS are passed on into higher passenger fares and freight rates. The underlying assumption is that if airlines would not be able to pass on real cost increases of policy induced cost increases, there would be no sustainable business model for airlines.

- In both models the demand responses follows from the price elasticities of demand which are presented in table 12 and are based on an IATA study from 2008.

- Assumptions with respect to the extent by which opportunity costs for the benchmarked allowances are passed on to consumers can be varied in both models. In both models two alternative assumptions have been tested: i) none of the opportunity costs are passed on; and ii) all of the opportunity costs are passed on. As described in Chapter 3, we expect for the short term (up to about two years), that no opportunity costs are passed on. In the long term (more than five years) if airlines expect the system to be persistent at least a part of opportunity costs is passed on. Since the EU ETS could in the long term be replaced by a global scheme, the short term impacts are in the main focus of this study.

The main differences between the SECAN-ET and AERO-MS are:

- The basis of the AERO-MS is the Unified Database (UD). The UD includes the EUROCONTROL WISDOM Operations Database which contains a detailed record of aviation movements for the Base Year 2006. The UD has a global coverage and records over 123,000 airport-pairs. Each airport pair in the Unified Database is described in terms of its passenger and cargo demand, and the number of flight by generic aircraft type. SECAN-ET includes demand on the level of aggregated route groups, whereby the focus is on Europe related route groups.

- The AERO-MS takes into account long term supply side effects, which are basically changes to the fleet composition, following from GHG-emission reduction policies (see also section 5.1). Changes to the fleet can lead to changes in fuel use and emissions. SECAN-ET is focused on the short term and thus does not take into account effects on fleet composition.

- In order to take into account the supply side effects, the AERO-MS assesses the effects of GHG-emission reduction policies on the longer term. In the present study effects for the year 2026 are computed. SECAN-ET computes effects on the short term. In the present study effects for the year 2012 are computed.

- The SECAN-ET takes into account the effects of cross financing, whereby the AERO-MS does not.

- AERO-MS analyses impacts on markets. It shows changes relative to the total market volume (e.g. decline of demand for intra-EU flight operated by LCC airlines). In contrast SECAN-ET analyses impacts on airline types. It shows changes relative to the volume of an airline type (e.g. decline of demand for flights operated by European LCC)

5.3 Definition of the model runs

The effects of the EU ETS policy options in SECAN-ET are computed for the year 2012. The effects in the AERO-MS are computed for the year 2026, in order to take into account more long term supply side responses (see also table 1 of draft report). The Business as Usual scenario to be used in the AERO-MS is the CAEP/8 Medium Growth scenario for the year 2026.

In order to model the EU ETS options, specifications have to be made in relation to

- Allowances prices per ton of CO_2;
- Emission cap and proportion of allowances under the cap which are auctioned;
- Assumptions with respect to passing on opportunity costs.

Allowance price

The allowances price reflects a major uncertainty. As the aviation industry is expected to be a net buyer of allowances the question is at what prices other economic sectors included the EU ETS will be able to provide allowances. The prices reflect the marginal abatement costs in these other economic sectors. In 2012 the allowance price varied between 5€ and 10€ per ton of CO_2. It is expected that future prices will be higher. In the impact assessment of different EU ETS options of the EC (SWD2013 430) a price of 10€ in 2020 and 35€ in 2030 has been assumed (assuming linear interpolation for 2026 this implies a price of 25€). In the EC impact assessments, also a doubling of the prices has been considered as a sensitivity test. Because of the uncertainly with respect to allowances prices, it is proposed to in each of the two models consider 2 different prices per ton of

CO_2. Taking into account the above, the following prices are assumed in the present study:

- In SECAN-ET (2012) consider prices of 10€ and 25€ per ton of CO_2.
- In AERO-MS (2026) consider prices of 25€ and 50€ per ton of CO_2.

The main assumption for both models is a price of 25€ per ton of CO_2. The prices of respectively 10€ and 50€ represent sensitivities.

Emission cap and proportion of allowances under the cap which are auctioned

In line with the current EU legislation, for all model runs it will be assumed that the emission cap is set to 97% in the year 2012 respectively 95% departing from 2013 of the average CO_2 emissions in the years 2004-2006 of the flights (or flight parts through EEA airspace) covered and that 15% of the allowances under the cap will be auctioned. Moreover, 3% is reserved for new entrants. It is assumed that the new entrance reserve will not yet be used in the year 2012. Due to the market growth and structural changes in the year 2026 the new entrance reserve is allocated to the market actors free of charge. The remaining 82% will be benchmarked free of charge.

For modelling purposes, in SECAN-ET and AERO-MS the free emission rights are allocated to airline types proportionally to their share in total aviation emissions within the scope of EU ETS. However, according to the current EU legislation free emission rights are allocated proportionally to Revenue Tonne Km in 2010. Because LCC have a larger share in RTK compared to their share in CO_2 emissions, the number of free emission rights for LCC is underestimated. For the model runs where it is assumed that the opportunity costs for free emission rights are assumed not to be passed on, this implies that for LCC the costs increases passed on to consumers are somewhat overestimated.

However, on the other hand airlines with less than average CO_2 emissions per RTK (like LCC) generally have higher growth rates which is not taken into account in the AERO-MS scenario specification as CAEP does not forecast separate growth rates for scheduled network carriers versus LCC. This implies that for LCC the share of emissions for which permits have to be bought from other economic sectors is somewhat underestimated. Hence for LCC from this perspective the cost increases passed on to consumers – if it is assumed that the opportunity costs for free emission rights are not passed on - are somewhat underestimated.

As the two above described issues work in opposite directions, it can be assumed that the magnitude of the cost increases for LCC – and hence the demand effects – as computed by the SECAN ET and AERO-MS is correct.

Also note that for cases where opportunity costs are assumed to be fully passed on, the assumptions with respect to the allocation of free emission rights and the possible differences in growth rates for scheduled network carriers versus LCC are not of relevance. In these cases, by definition all airline types are assumed to pass on costs for all of their emissions under the scope of the EU ETS.

Assumptions with respect to passing on opportunity costs

Part of the allowances under the EU ETS cap are assumed to be made available free of charge. The use of allowances however implies opportunity costs, whether the allowances have been bought or obtained free of charge. In the first case, the opportunity costs are reflected in actual expenditures on allowances either from the purchase of allowances at an auction or at the ETS market. For these allowances in the model runs it is assumed that all costs are passed on by airlines to consumers (100% pass on of real cost increases). In the case of freely obtained allowances, the opportunity costs are not reflected in actual expenditures. However, instead of using allowances to cover for one's emissions, the allowances could have been sold against the market price. If the opportunity costs are passed on to consumers, this may lead to windfall profits for airlines. With respect to the extent by which opportunity costs are passed on to consumers two alternative assumptions are proposed to be tested:

- None of the opportunity costs for freely allocated allowances are passed on to consumers (0%). This assumption reflects the short term responses (cf. Chapter 3)
- All of the opportunity costs for freely allocated allowances are passed on to consumers (100%). This assumption reflects the maximum long term impact (cf. discussion about passing on opportunity costs in Chapter 3).

Overview of model runs

The above implies that the number of model runs with respect to the EU ETS scenarios is 8. In summary these runs are defined as follows:

Table 14: Overview of the model runs

Run	Scenario	Allowance price per ton of CO_2 (SECAN-ET / AERO-MS)	Opportunity costs for freely obtained allowances passed on
R1	Stopping the Clock	25€	0%
R2	Stopping the Clock	25€	100%
R3	European Air Space	25€	0%
R4	European Air Space	25€	100%
R5	Stopping the Clock	10€ / 50€	0%
R6	Stopping the Clock	10€ / 50€	100%
R7	European Air Space	10€ / 50€	0%
R8	European Air Space	10€ / 50€	100%

5.4 Preparatory steps to model the European Air Space scenario

In order to model the EAS scenario in the AERO-MS a number of preparatory steps have been taken:

1. Assess largest airport for EEA and included third countries.
2. Compose kml file European Regional Airspace.

3. Compute country pair distance factors.
4. Assign country pair distance factors to flight stages in AERO-MS.

(1) Assess largest airport for EEA and included third countries

We have used the AERO-MS database in order to assess the largest airport for EEA and included third countries. Table B1 in Annex B includes an overview of the largest airport (identified on the basis of the number of flights to/from third countries) for each of the 30 EEA countries.

An overview of the largest airport for the included third countries is provided in table B2 in Annex B. The included third countries are the third countries listed in Annex IIc of the EC proposal [EC, 2013a] with the exception of the 73 countries which are to be excluded according to Annex 5 of the FAQ document on the EC proposal [EC, 2013c]. The excluded countries are developing countries with less than 1% in international aviation activity.

Where an included third country is in multiple time zones, in line with the EC proposal (COM2013 – 722), for each of the time zones a largest airport is assessed. This leads to 94 Time Zone Country Combinations (TZCC) in table B2 for which the largest airport is assessed in terms of the number of flights to/from EEA countries.

The longitude and latitude coordinates of the 30 and 94 largest airport is provided as an input to step 3.

(2) Compose kml file EEA territory

A kml file[9] of the European Regional Airspace has been composed on the basis of files with respect to the borders of individual EEA countries, including the outermost regions of EEA countries. On the basis of this a kml file of the complete EEA territory is composed. Moreover the EEA territory is expanded with a 12 nautical miles zone where a country borders the sea.

(3) Compute country pair distance factors

A software script has been written in order to compute the country pair distance factors. Inputs are:

- The longitude and latitude coordinates for the 124 largest airports from step 1.
- The kml file with respect to the EEA territory from step 2.

For any flights between the largest airport in an EEA country and the largest airport in a third country, the software script computes:

[9] KML stands for Keyhole Markup Language (KML), It is a notation for expressing geographic annotation and visualization for maps. KML was developed for use with Google Earth.

- The Great Circle Distance (factor Z – see section 2.2).
- The distances over EEA territory using the kml file from step 2 (part of factor Y – see section 2.2).
- Distances over sea areas between EEA country territories. Distances of 400 nautical miles or less are included in factor Y, distances above 400 nautical miles are excluded in factor Y
- Distance factor X by dividing Y by Z (see section 2.2).

The output of this step is that for any country pair a distance factor is provided (total of 30 * 94 = 2820 country pairs). The country pair distance factors reflect the percentages of emissions applicable to the EU ETS in the EAS scenario for flights between EEA countries and third countries and are presented in Annex C.

(4) Assign country pair distance factors to flight stages in AERO-MS

In this step the country pair distance factors have been assigned to the individual flight stages (airport pairs) in the AERO-MS. Hence, in line with the EC proposal, all airport pairs belonging to a certain country pair between an EEA and third country make use of the same distance factor in the modeling of the EAS scenario in the AERO-MS.

5.5 Emission coverage of EU ETS scenarios

The CO_2 emissions covered by the Stopping the Clock and European Air Space scenario are presented in table 15. The table presents the emission coverage for the CAEP8-M scenario in 2026, but also shows the emissions under the cap (95% of the average emissions in the years 2004-2006) for the EU ETS scenarios. The emissions under the cap are based on the AERO-MS Base Year run for the year 2006, whereby the result is corrected for one year of emission growth (leading to data for the year 2005 reflecting the average of the years 2004-2006). The table also presents the emission coverage of the regular (full scope) EU ETS in order to get a picture to what extent emission coverage is reduced in case of respectively the Stopping the Clock and European Air Space scenario.

Table 15: CO_2 emissions covered by EU ETS scenarios

EU ETS scenario	Emission cap		Emissions covered by the EU ETS	
	2012: 97% of average emissions 2004-2006 Megaton (% of regular EU ETS)	2026: 95% of average emissions 2004-2006 Megaton (% of regular EU ETS)	CAEP8-M 2012 Megaton (% of regular EU ETS)	CAEP8-M 2026 Megaton (% of regular EU ETS)
Regular EU ETS	213,4 (100,0%)	209,8 (100,0%)	236,6 (100,0%)	426;3 (100,0%)
Stopping the Clock (STC)	63,0 (29,4%)	61,7 (29,4%)	72,9 (30,8%)	105,7 (24,8%)
European Air Space (EAS)	91,6 (42,8%)	89,8 (42,8%)	105,5 (44,6%)	166,6 (39,1%)

A first observation from table 15 is that the emission cap for the regular EU ETS (209.8 Megaton), as computed with the AERO-MS, is very much in line with the cap of 210.3 Megaton which has been computed for the EEA[10]. Table 15 further shows that the emissions under the cap are reduced to 29.4% and 42.8% of the cap for the regular EU ETS for respectively the Stopping the Clock and European Air Space scenario. Because of the expected relatively large growth of emissions on routes between EEA countries and third countries (compared to the intra EEA routes), the relative emission coverage of especially the Stopping the Clock scenario will reduce over time (24.8% of regular EU ETS emissions is expected to be covered in 2026).

Figure 16 graphically presents the CO_2 emissions per route group for both the emission cap and the CAEP8-M BaU scenario. The figure shows that in the case of the EAS scenario the emission coverage is especially reduced because the flight trajectories outside the European Airspace are excluded for flights between EEA countries and included third countries. As shown in figure 16 the emissions outside the European Airspace of these flights take about half of the emissions covered by the regular EU ETS. The effect of the full exclusion of emissions of flights between EEA countries and excluded countries (i.e. developing countries with less than 1% in international aviation activity) has a much smaller effect on the reduction of the emission coverage (see green part in figure 16).

[10] See EEA (2011) Decision of the EEA Joint Committee No. 93/2011

Figure 16: CO_2 emissions per route group in percent

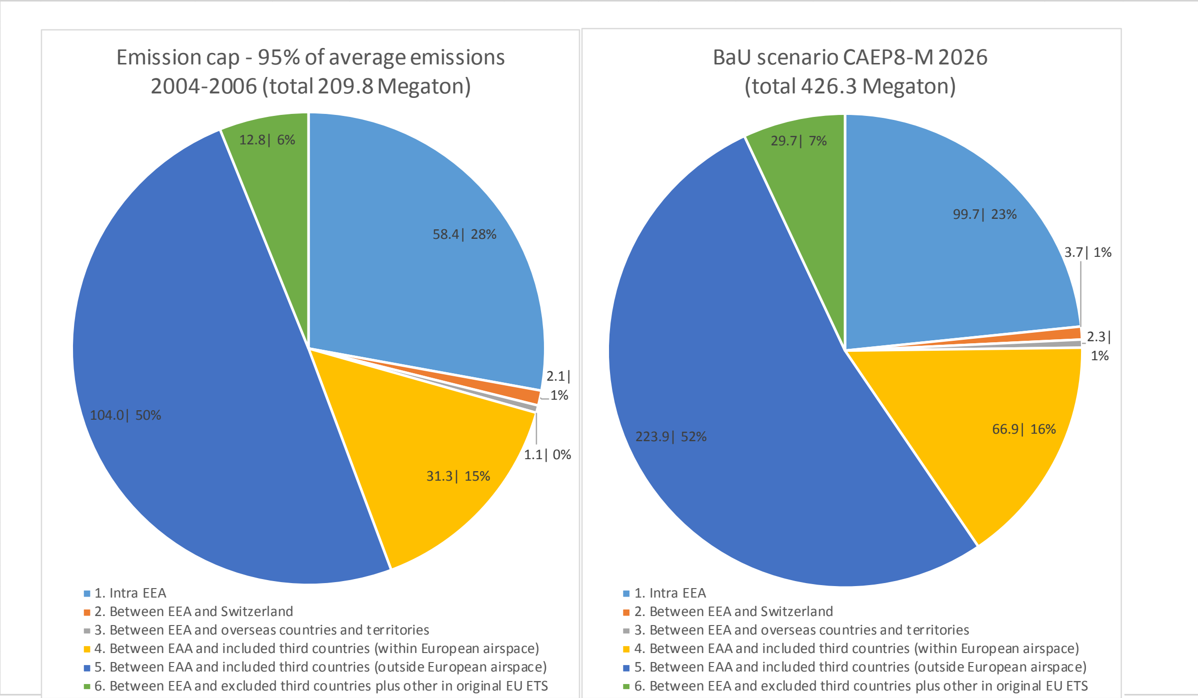
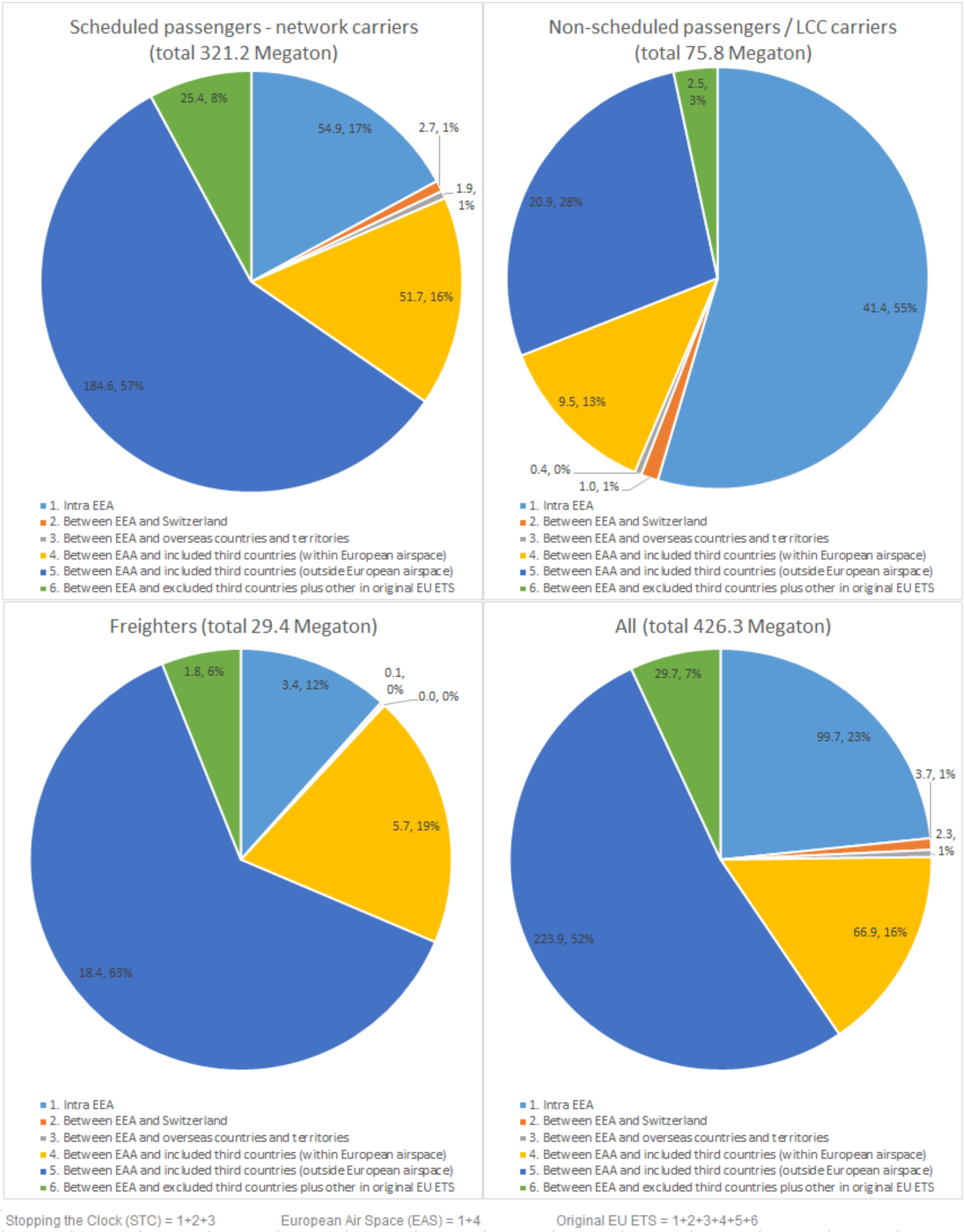


Figure 17 presents the CO_2 emissions per route group and flight type for the CAEP8-M BaU scenario. A first observation is that scheduled passenger network carrier operations take account of the vast majority of CO_2 emissions (321.2 Megaton - about 75% of the total). Charter and LCC carrier operations are responsible for about 18% (75.8 Megaton) of the CO_2 emissions, and the remaining 7% of emissions (29.4 Megaton) is related to freighter operations.

Another observation is that the distribution of emissions across route groups is very different for the various flight types. Hence the percentage of emissions covered in case of the Stopping the Clock and European Air Space scenario is very different for the various flight types. For scheduled passenger network carrier operations the emission coverage is reduced to 19% and 33% of the regular EU ETS for respectively the Stopping the Clock and European Air Space scenario. For charter and LCC operations the relative emission coverage is significantly larger (56% and 67% of the regular EU ETS emissions for respectively the STC and EAS scenario). Hence for both the STC and EAS scenario a significant larger proportion of the emissions of European charter/LCC operations is subject to emissions trading in comparison with the proportion of emissions - subject to emission trading - of European operations of (the competing) network carriers.

Figure 17: CO_2 emissions per route group and flight type in Megaton (BaU scenario CAEP8-M 2026).



For freighter operations the relative emission coverage for the STC and EAS scenarios is respectively 12% and 31% of the regular EU ETS emissions. This is lower compared to the passenger market because of the relatively unimportance of aviation activity on intra EEA routes in the freighter market (which follows from the strong surface competition for aviation cargo transport on intra EEA routes).

The percentages of CO_2 emissions covered for route groups between EEA countries and various world regions in case of the EAS scenario is presented in table 16. The table shows that a larger proportion of emissions is covered for shorter extra EEA flights (f.e. to/from Middle East and the rest of Europe) in comparison to longer extra EEA flights (f.e. to/from the Americas and Asia). The table also shows that overall about 20% of the CO_2 emissions on extra EEA flights is covered in case of the EAS scenario (this for both the emission cap and the CAEP8-M BaU scenario).

Table 16: Percentage of emissions covered by EAS scenario for Extra EEA route groups

Extra EEA route group	Emission cap (95% of 2004-2006)	CAEP8-M 2026
Between EEA and Africa	29.7%	30.0%
Between EEA and Asia	15.7%	15.6%
Between EEA and Europe (non EEA)	60.7%	61.9%
Between EEA and Latin America / Caribbean	8.1%	7.9%
Between EEA and Middle East	38.4%	38.3%
Between EEA and North America	13.9%	13.8%
Between EEA and third countries* from all regions	**20.3%**	**20.3%**

* Here third countries relate to both the included and excluded third countries.

6 Modulation with SECAN-ET

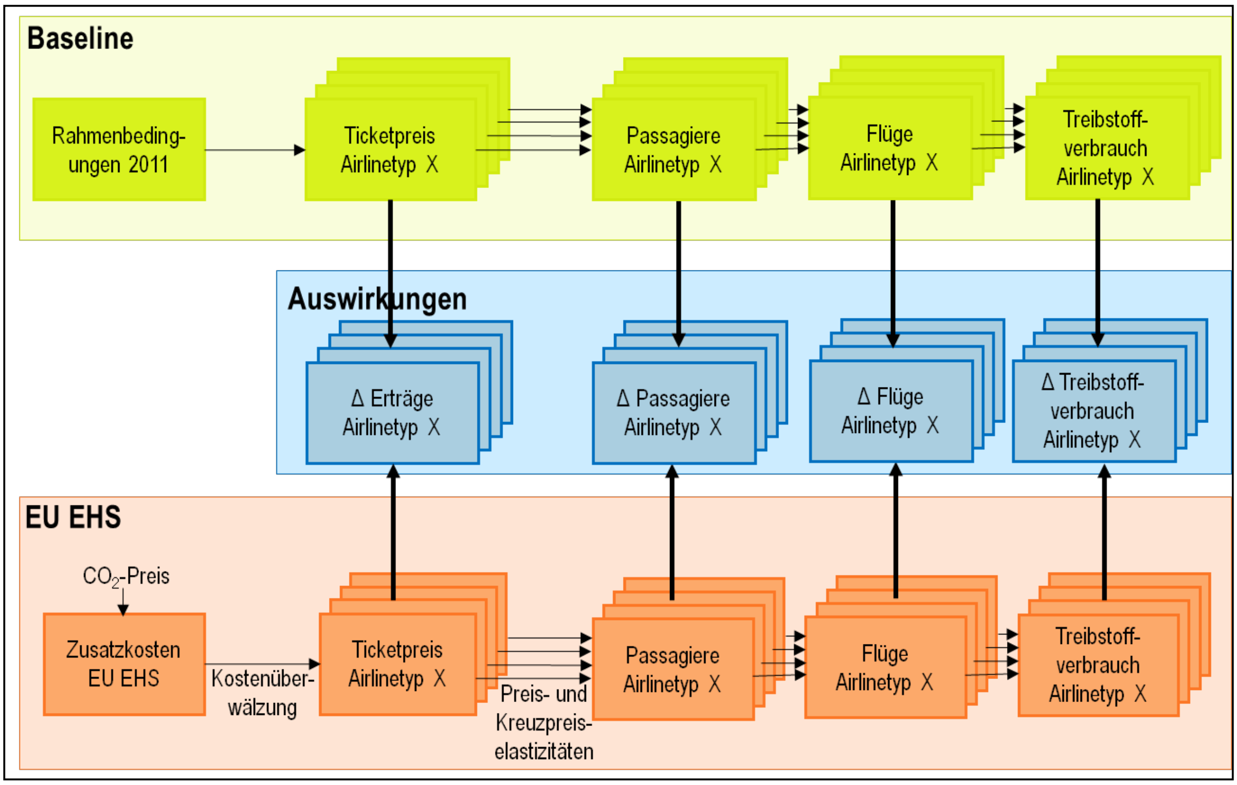
6.1 Model description

6.1.1 Overview

SECAN-ET models the impact of emission trading systems (or taxes) on airlines, emissions, value added and employment on a theoretical basis. For the mandate "Wettbewerbswirkung des EU EHS" only the modules "impact on airlines" and "impact on emissions" are used.

The basic functionality of SECAN-ET is shown in the figure below:

Figure 18: Functionality of SECAN-ET



Source:INFRAS

First, a baseline without emission trading is constructed. This baseline includes data about numbers of passengers/cargo and pkm/tonne-km cargo on different flight relations traveling in different airline types, revenues of the airlines and emissions (green box in Figure 18).

Then the situation with emission trading is deduced from the baseline. It is analysed, how the crucial sizes (ticket prices, pkm and cargo-km, revenues and emissions) change, if an emission trading system would be in place. Essential inputs are the CO_2-price and assumptions about the passing-on of costs as well as price elasticities of demand for flights (orange box in Figure 18).

In the third step, the baseline and the situation with EU ETS are compared. The difference between the baseline and the situation with EU ETS shows the impact of the emission trading (blue box in Figure 18).

In the following, the three steps (baseline, fictional situation with EU ETS, comparison) are discussed in more detail.

6.1.2 Baseline

In the first step a baseline including passengers and cargo, passenger- and cargo-km, airline revenues and fuel consumption per relation group and airline type is established. The passengers are subdivided in economy- and business-/first-class passengers and according to the purpose of their travel (leisure/business).

The following relation groups are analysed:

- EU+ – EU+
- EU+ – Switzerland
- EU+ – EEA's States overseas countries and territories
- EU+ - Rest of Europe
- EU+ - Rest of the world (ROW)
- ROW - ROW

The airlines are divided into the following types:

- Network airlines with homeland within EU+
- Network airlines with homeland "rest of the world"
- Charter/low cost carrier with homeland within EU+
- Charter/low cost carrier with homeland "rest of the world"
- Scheduled and non-scheduled freight airlines with homeland EU+
- Scheduled and non-scheduled freight airlines with homeland "rest of the world"

The result of the first step is the baseline. Its shape is shown in Annex D. In general the inputs for the baseline come from the AERO-MS. The Baseline is designed for the year 2012. Since the AERO-MS data are a projection starting from the data for the year 2006, the effect of the EU ETS on aviation are not reflected in the baseline.

To drive a complete baseline set some additional assumptions to the AERO-MS baseline were required. They are shown in the table 17. The chosen assumptions relay on common values in the context on aviation.

Table 17: Assumptions with respect to the baseline

Issue	Assumption
Ticket prices business class	The average ticket price in the business class is three times higher than the average economy class ticket price.
Belly freight revenue	The revenue per tkm belly freight on a specific relation group is the same as the revenue per pkm of freighter on the regarded relation group.
Profit	In average profit is 3% of revenue. The yield of intercontinental flights is 20% higher than the yield of continental flights.
CO_2 emissions	3.157 kg CO_2 per kg fuel use.
CO_2 emissions of belly freight	The division of CO_2 emission between passenger and belly freight is made according to weight. It is assumed that a passenger including baggage weights 90 kg.

Source: INFRAS

6.1.3 Situation with ETS

The second step contains the construction of the situation with emission trading. The basis for the construction is the baseline. First, the price increase per passenger type and relation group due to the EU ETS is calculated. This price increase is multiplied by the price elasticity of the respective customer. The result is an adjustment of the demand for air travel services, which leads to an adjustment of revenues.

The following table shows the assumption for the calculation of the situation with EU ETS.

Table 18: Modulation assumptions

	Assumption STC scenario	Assumption EAS scenario	Source
Emission growth within EU ETS since the base years period (2004-2006)	+12,9%	+12,1%	AERO-MS
Emission cap	97% of the emission in the base years period	97% of the emission in the base years period	c.f. chapter 5.2
New entrance reserve	3%	3%	c.f. chapter 5.2
Percentage of auctioned emission certificates	15%	15%	c.f. chapter 5.2
Price of emission certificates	25 EUR/t CO_2 (sensitivity with 10 EUR/t CO_2)	25 EUR/t CO_2 CO_2 (sensitivity with 10 EUR/t CO_2)	c.f. chapter 5.2
Cost pass on	Effective costs: 100% Opportunity costs: One scenario with 0% (short term impact) and one with 100% (maximum long term impact)	Effective costs: 100% Opportunity costs: One scenario with 0% (short term impact) and one with 100% (maximum long term impact)	c.f. chapter 3.3.1

	Assumption STC scenario	Assumption EAS scenario	Source
Cross financing long/short haul	20% of the effective EU ETS costs for passengers are shifted to intercontinental flights In the field of cargo there is no cross financing.[11]	20% of the effective EU ETS costs on continental flights for passengers are shifted to intercontinental flights. In the field of cargo there is no cross financing.	Assumption checked by SECAN-ET model iteration and plausibility checks
Price elasticities	continental flights: - leisure: -1.2 - business: -0.6 - cargo: -0.7 intercontinental flights: - leisure: -0.9 - business: -0.3 - cargo: -0.7	continental flights: - leisure: -1.2 - business: -0.6 - cargo: -0.7 intercontinental flights: - leisure: -0.9 - business: -0.3 - cargo: -0.7	IATA 2008, Brons et al 2001
Cross-price elasticities	30% higher than the respective price elasticity	30% higher than the respective price elasticity	based on IATA 2008[12]

Source: INFRAS

6.1.4 Comparison

In the third step, the baseline is compared with the situation considering the EU ETS. The main figures compared are the demand measured in pkm and tkm and the difference in revenues. Moreover the environmental impact, in terms of a reduction in CO_2 emissions, is shown.

6.2 Results

In this chapter we first show the results for the STC scenario and then for the EAS scenario. In both scenarios we assume that the CO2 price is 25 EUR/tCO2. Price sensitivities are showed in Annex E. For each scenario we show one model run where we expect that no opportunity costs are passed on and one where we assume that all opportunity costs are passed on. As discussed in Chapter 3.3.1 in the short term (up to about two years) we expect no passing on of opportunity costs and in the long term (more than 5 years) at least a partial passing on of opportunity costs is likely. In this sense the

11 Short haul cargo transport have only a share of 2% -3% of all cargo transport. Therefore the potential for cross financing is very limited.

12 IATA 2008 states, that price elasticities are 30% higher for price increases on national level than for price increases seen on supranational level. We assume that this factor corresponds to cross-price elasticities.

scenario with passing on of opportunity costs is a "what- -if-scenario" and not a scenario which shows the real impact of the EU ETS in the year 2012.

6.2.1 Results STC scenario

In this part the results of the modulation of the STC scenario are presented. Thereby the following relation groups are summed up:

- EU+ – EU+ and EU+ – Switzerland under the name EU+/CH – EU+/CH
- EU+ - Rest of Europe, EU+ - OT, EU+ - ROW and ROW – ROW under the name ROW – ROW.

EAS Scenario:

- EU+ – Switzerland and EU+ - Rest of Europe under the name EU+ - Rest Europe
- EU+ – EEA's States overseas countries and territories and EU+ - ROW under the name EU+ - ROW.

Costs of the EU ETS

Assuming a price of 25 EUR, the EU ETS increases the operating cost for European Networker by 293 m. € (0.2% of total revenue) and for European LCC by 212 m. € (0.8% of total revenue). Freighters are faced with 8 m. € additional costs (0.4% of total revenue). Non-European airlines have to pay 4 m. € for emission allowances. Compared to their total revenues this is a marginal amount.

The value of the emission certificates received for free (opportunity costs) is about 2.4 times higher than the effective costs. In a persistent system in the long run it is likely that (a part) of the opportunity costs will be passed on and increases revenues without a corresponding increase in costs. In this way freely allocated emission certificates can have the same impact as a subsidy.

Table 19: Cost of the EU ETS in the STC scenario

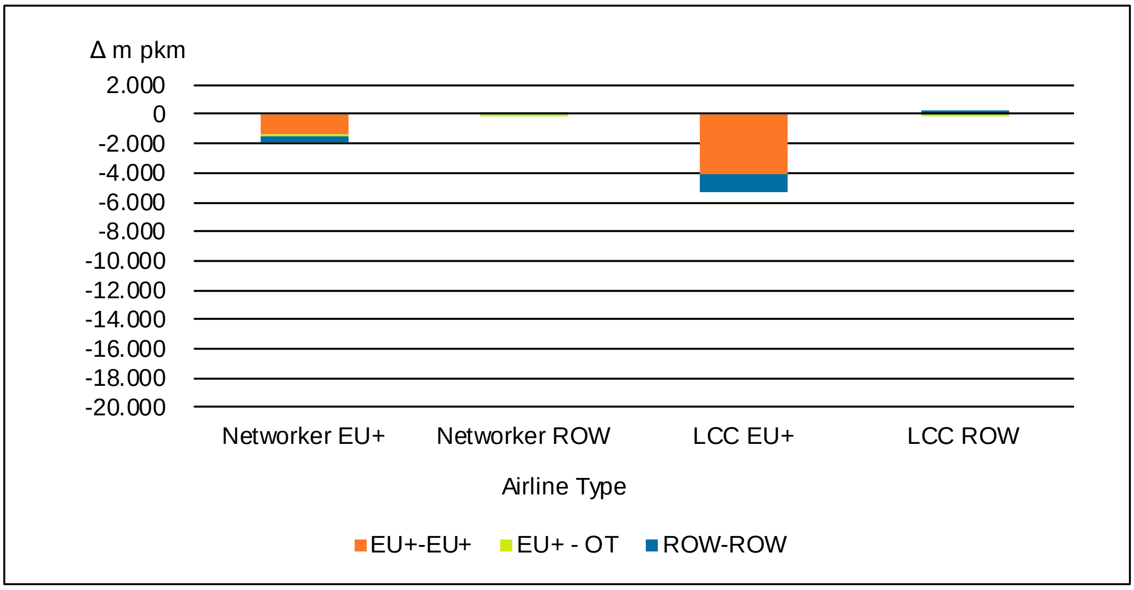
	Network Carriers		LCC		Freighter	
in m. €	EU+	ROW	EU+	ROW	EU+	ROW
Effective cost	293	2	212	0	8	2
Opportunity cost	709	4	512	1	20	5
Baseline Revenue	125.000	330.000	26.400	21.700	2.420	22.400
Effective cost relative to baseline revenue	0.23%	0.00%	0.80%	0.00%	0.35%	0.01%

Source: INFRAS

Impact on passenger demand

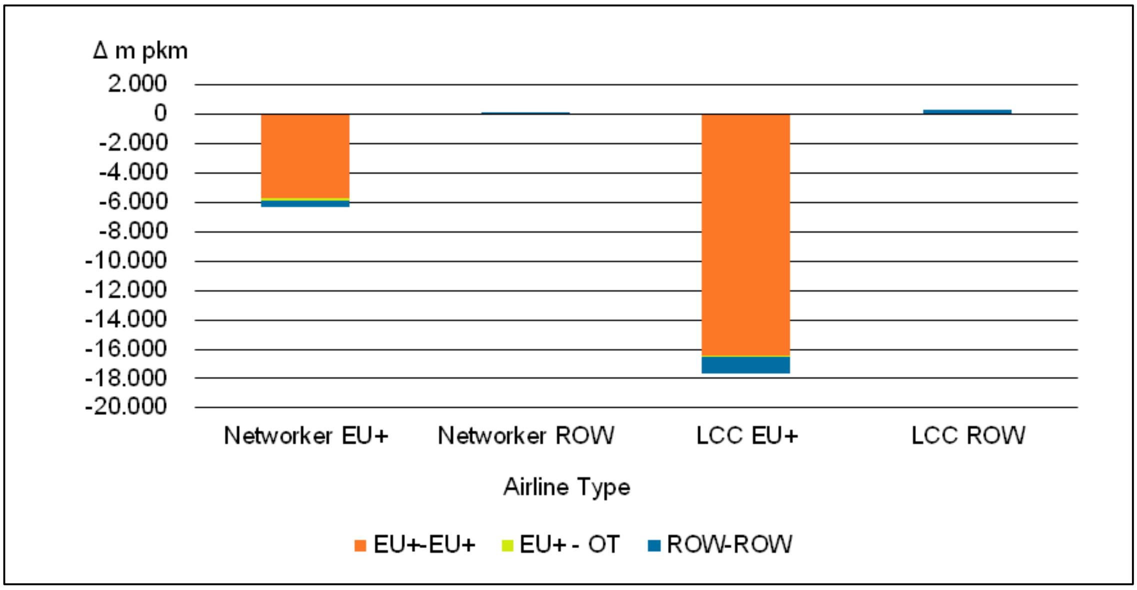
The following figures and table shows the impact of the EU ETS on passenger demand:

Figure 19: Impact on passenger demand STC without passing on of opportunity costs (short term)



Source: INFRAS

Figure 20: Impact on passenger demand STC with full passing on of opportunity costs (maximum long term)



Source: INFRAS

Table 20: Impact on passenger demand in m. pkm

in m. pkm	Without passing on opportunity costs*				Full passing on opportunity costs*			
Airline type	Network Carriers		LCC		Network Carriers		LCC	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW	EU+	ROW
EU+/CH-EU+/CH	-1.400		-4.100		-5.700		-16.500	
EU+ - OT	-40	-10	-30	-10	-150	-40	-100	-20
ROW-ROW	-500	120	-1.100	270	-500	120	-1.100	250
Total impact	-1.940	110	-5.230	-260	-6.350	80	-17.700	230
pkm before EU ETS	1.200.000	3.700.000	620.000	450.000	1.200.000	3.700.000	620.000	450.000
Total impact in %	-0,16%	0,00%	-0,85%	0,06%	-0,53%	0,00%	-2,84%	0,05%

Source INFRAS. * We expect in the short term no passing on of opportunity costs. In the long term at least partial passing on of opportunity costs is possible.

In the situation without passing on opportunity costs network airlines with homeland EU+ lose almost 2 bn pkm. The biggest impact is seen on the relation EU+/CH – EU+/CH. Due to cross financing strategies there is also a loss in pkm at relations not directly affected by the EU ETS (ROW – ROW). Since on those relations the relative price of EU+ airlines compared to airlines with homeland ROW get worse, some passengers change airline and networker from ROW gain about 100m pkm from airlines with homeland EU+ on the ROW-ROW relations. Networker from ROW loses some pkm at EU+ - OT relations, but this decrease is lower than the increase at the ROW-ROW relations. In relative terms network airlines with homeland EU+ loose about 0.2% of their pkm. For network airlines with homeland ROW the changes stay at marginal levels.

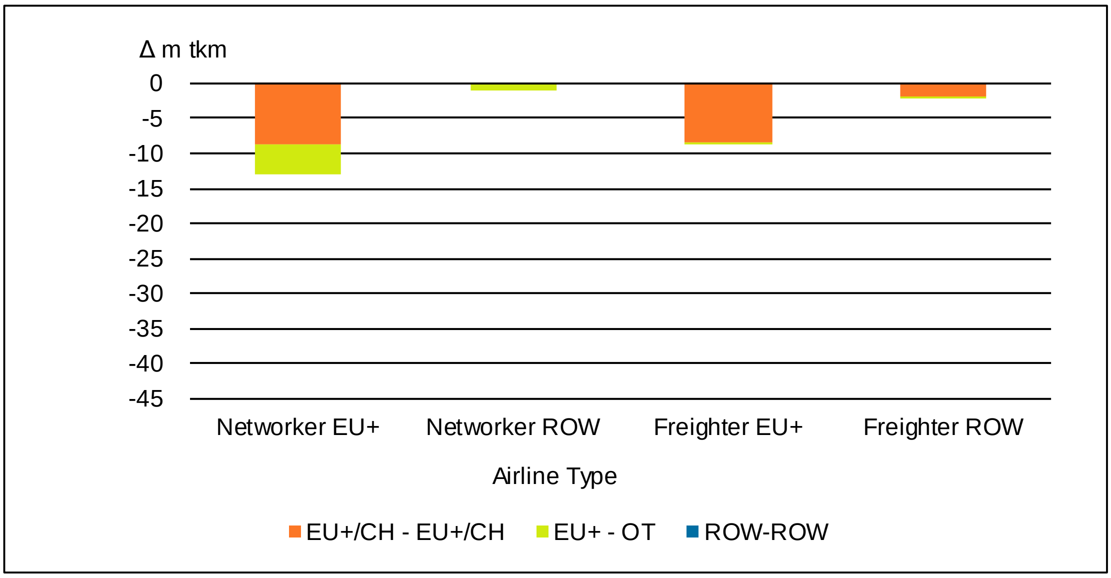
The impact of the EU ETS on LCC with homeland EU+ is in relative terms about 5 times higher than the impact on network airlines from EU+. They lose about 0.9% of their pkm. The higher impact has two reasons. First, passengers of LCC airlines have on average a higher price-elasticity than those of network airlines, since the share of business passenger (for which demand is less price elastic) is lower. The reaction on price increases is therefore stronger. Second, since the initial ticket price of LCC airlines is lower than that of network airlines the same absolute price increase results in a higher relative price increase. The relative price increase on ROW – ROW relation with respect to LCC from ROW lead for those airlines to a pkm increase of about 0.06%.

For airlines with homeland EU+ the impact of the EU ETS is about three times higher, when opportunity costs are passed on completely. LCC with homeland ROW profit somewhat less than in the situation without passing on of opportunity costs. We expect in the short term no passing on of opportunity costs. In the long run in a persistent system at least partial passing on of opportunity costs is likely.

Impact on cargo demand

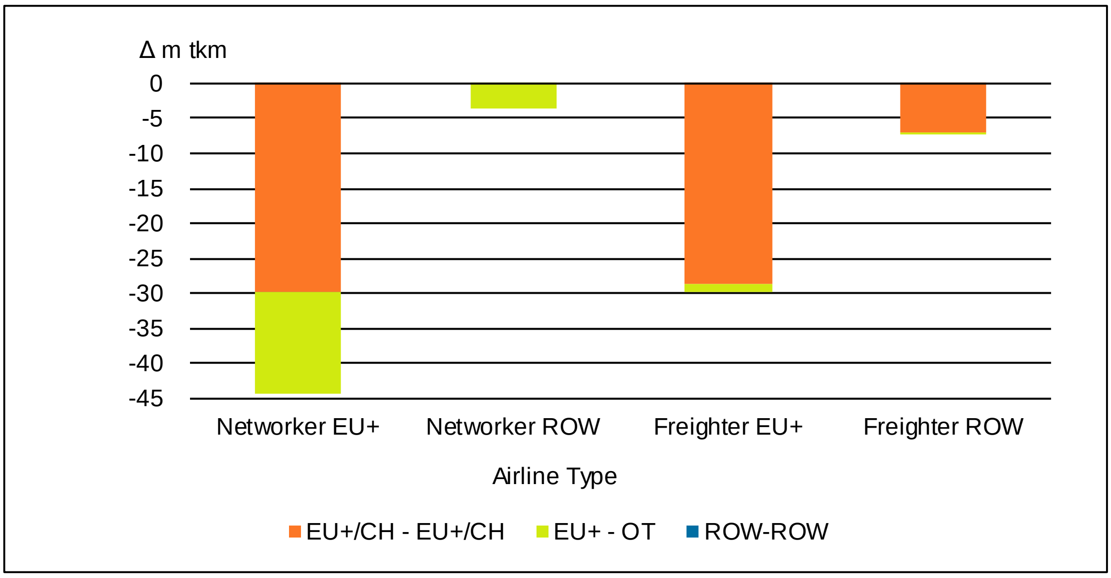
The following figures and table show the impact of the EU ETS on cargo demand:

Figure 21: Impact on cargo demand STC without passing on of opportunity costs (short term)



Source:INFRAS

Figure 22: Impact on cargo demand STC with full passing on of opportunity costs (maximum long term)



Source INFRAS

Table 21: Impact on cargo demand in m tkm

in m tkm	Without passing on opportunity costs*				Full passing on opportunity costs*			
Airline type	Network Carriers		Freighter		Network Carriers		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW	EU+	ROW
EU+/CH-EU+/CH	-8,7		-8,4	-2,0	-29,8		-28,6	-6,9
EU+ - OT	-4,2	-1,1	-0,3	-0,1	-14,4	-3,6	-1,0	-0,3
ROW-ROW	-	-	-	-	-	-	-	-
Total impact	-13,0	-1,1	-8,7	-2,1	-44,3	-3,6	-29,7	-7,1
m tkm before EU ETS	29.500	92.200	5.800	51.500	29.500	92.200	5.800	51.500
Total impact in %	-0,04%	0,00%	-0,15%	0,00%	-0,15%	0,00%	-0,51%	-0,01%

Source INFRAS. * We expect in the short term no passing on of opportunity costs. In the long term at least partial passing on of opportunity costs is possible.

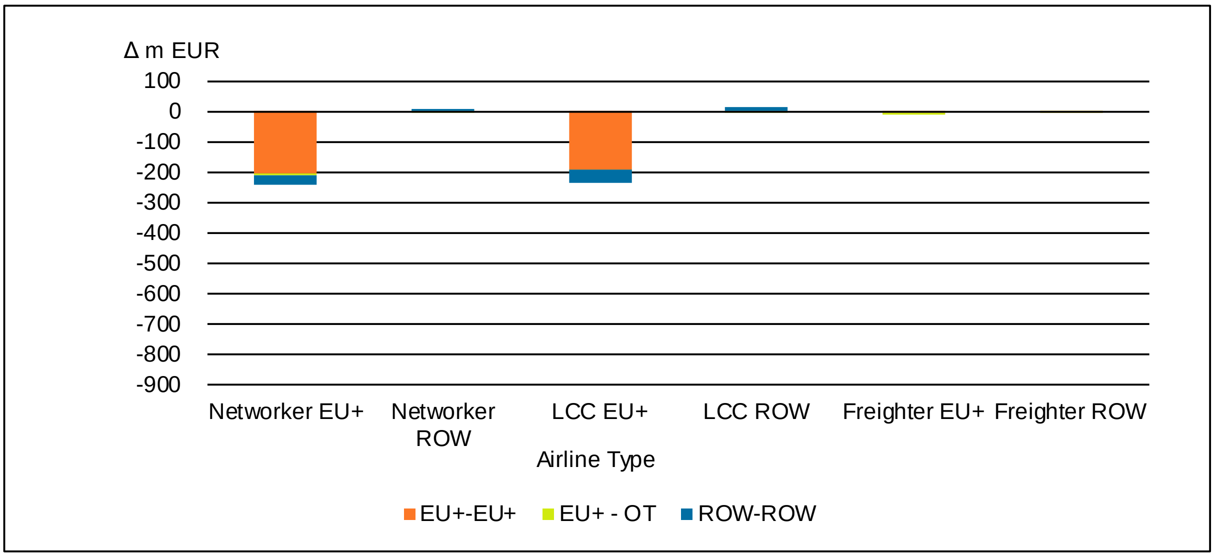
The impact of the EU ETS on cargo demand measured in relative terms is less strong than on passenger demand. Freighter airlines from ROW are hardly affected. Assuming no passing on of opportunity costs network airlines from EU+ lose 0.04% of their tkm and freighter airlines from EU+ 0.15% of their tkm. Assuming opportunity costs are passed on, these effects increase to respectively 0.15% and 0.51%. Because of the limited potential for cross financing on the cargo market, cargo transport on ROW-ROW relations is not affected. We expect in the short term no passing on of opportunity costs. In the long run in a persistent system at least partial passing on of opportunity costs is likely.

Impact on revenues

The following figures and tables show the impact of the demand reduction due to the EU ETS on revenues:[13]

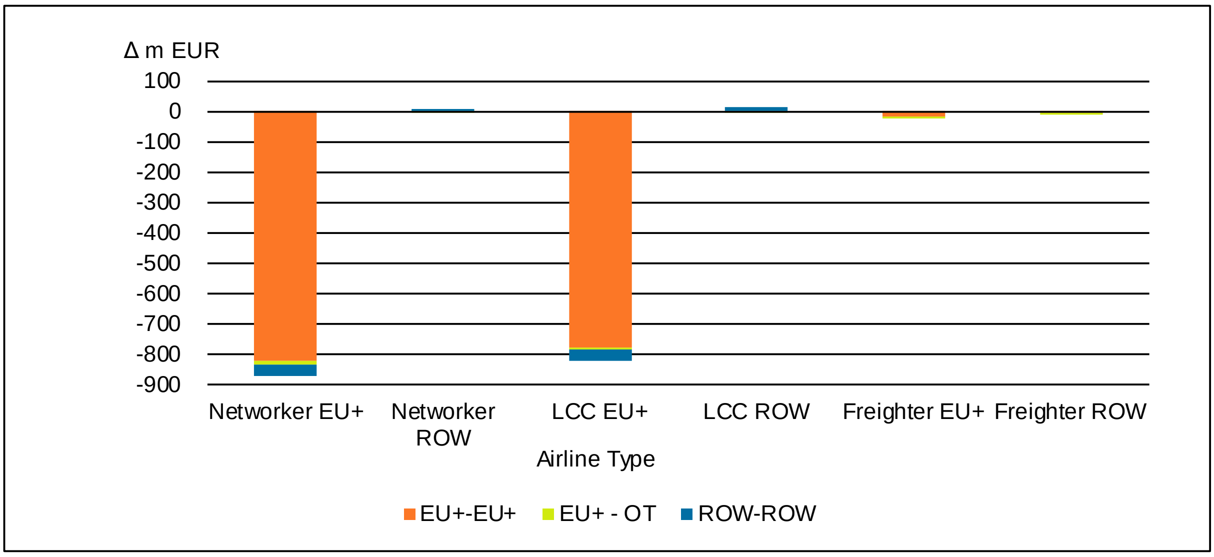
[13] Increases in fares to compensate the EU ETS costs are not considered.

Figure 23: Impact on revenues in the STC scenario without passing on of opportunity costs (short term)



Source INFRAS

Figure 24: Impact on revenues in the STC scenario with full passing on of opportunity costs (maximum long term)



Source INFRAS

Table 22: Impact on revenues STC scenario without passing on opportunity costs in m EUR

in m €	Without passing on opportunity costs*					
Airline type	Network Carriers		LCC		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW
EU+/CH-EU+/CH	-205		-195		-6	-1
EU+ - OT	-5	-1	-1	-1	0	0
ROW-ROW	-35	9	-40	13	0	0
Total impact	-245	8	-236	12	-6	-1
Revenue before EU ETS	125.000	330.000	26.400	21.700	2.420	22.400
Total impact in %	-0,20%	0,00%	-0,89%	0,06%	-0,25%	-0,01%

Source INFRAS. * We expect in the short term no passing on of opportunity costs. In the long term at least partial passing on of opportunity costs is possible.

Table 23: Impact on revenues STC scenario with full passing on opportunity costs in m EUR

in m €	Full passing on opportunity costs*					
Airline type	Network Carriers		LCC		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW
EU+/CH-EU+/CH	-820		-780		-20	-5
EU+ - OT	-10	-5	-5	-1		
ROW-ROW	-40	10	-35	12		
Total impact	-870	5	-820	11	-20	-5
Revenue before EU ETS	125.000	330.000	26.400	21.700	2.420	22.400
Total impact in %	-0,69%	0,00%	-3,11%	0,05%	-0,85%	-0,02%

Source INFRAS. * We expect in the short term no passing on of opportunity costs. In the long term at least partial passing on of opportunity costs is possible.

Assuming opportunity costs are not passed on, the EU ETS reduce revenues of network airlines with homeland EU+ by 0.2%. The effect on LCC from EU+ is with a loss in revenue of 0.9% about 4.5 times higher. For EU+ freighters the effect is about 25% higher as for networker. This follows from a higher share of fuel costs in total operating costs.

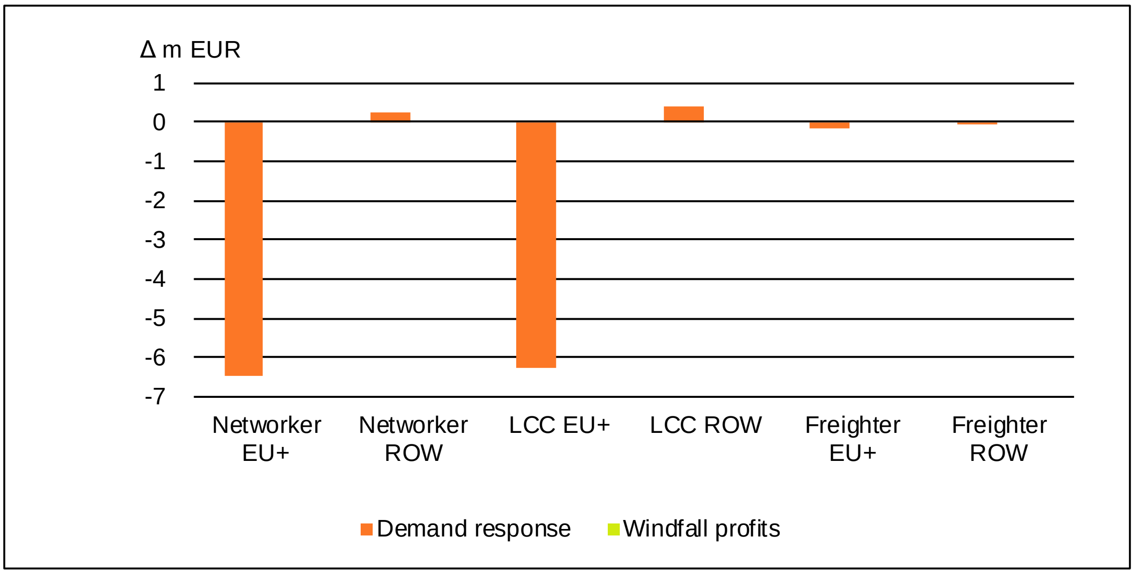
Airlines with homeland ROW are only very slightly affected. The strongest effect is seen for LCC They profit slightly from the price increase of their European competitor on ROW-ROW relations.

If opportunity costs are fully passed on, the relative effects on European airlines are multiplied by a factor of about 3.5. We expect in the short term no passing on of opportunity costs. In the long run in a persistent system at least partial passing on of opportunity costs is likely.

Impact on profits

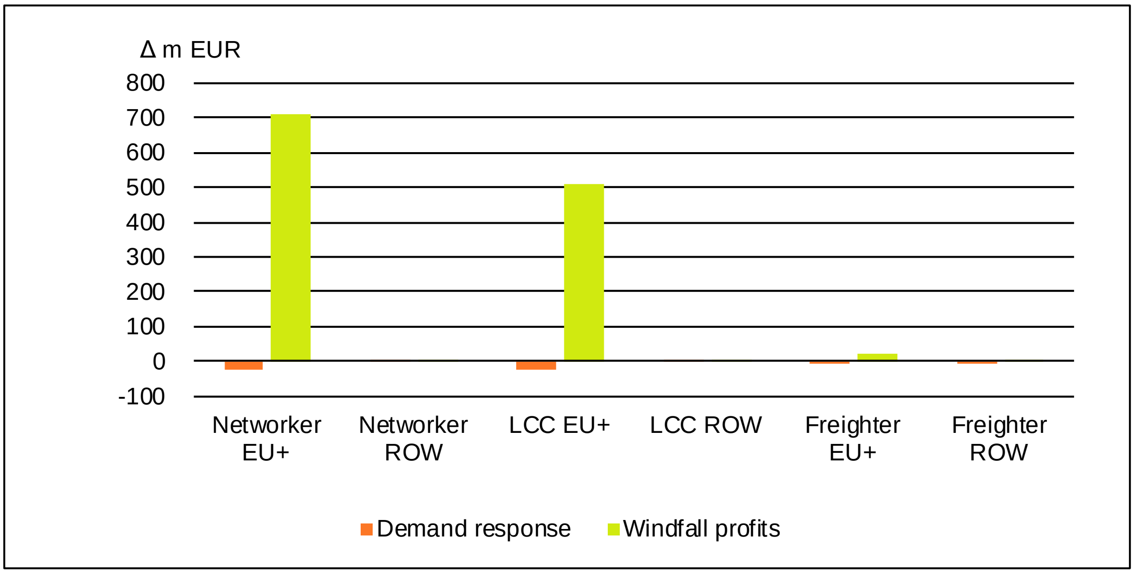
The following figures and tables show the impact of the EU ETS on profits:

Figure 25: Impact on profits in the STC scenario without passing on of opportunity costs (short term)



Source INFRAS

Figure 26: Impact on profits in the STC scenario with full passing on of opportunity costs (maximum long term)



Source: INFRAS

Table 24: Impact on profits STC scenario without passing on opportunity costs in m EUR

in m €	Without passing on opportunity costs*					
Airline type	Network Carriers		LCC		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW
Demand response	-6,5	0,2	-6,2	0,4	-0,15	0,0
Windfall profits	0,0	0,0	0,0	0,0	0,0	0,0
Total impact	-6,5	0,2	-6,2	0,4	-0,15	0,0
Profit before EU ETS	3.600	10.100	720	660	70	690
Total impact in %	-0,2%	0,00%	-0,9%	0,1%	-0,2%	-0,0%

Source INFRAS. * We expect in the short term no passing on of opportunity costs. In the long term at least partial passing on of opportunity costs is possible.

Table 25: Impact on profits STC scenario with full passing on opportunity costs in m EUR

in m €	Full passing on opportunity costs*					
Airline type	Network Carriers		LCC		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW
Demand response	-25	0	-20	0	0	0
Windfall profits	710	5	510	1	20	5
Total impact	685	5	490	1	20	5
Profit before EU ETS	3.600	10.100	720	660	70	690
Total impact in %	19%	0%	67%	0%	28%	1%

Source INFRAS. * We expect in the short term no passing on of opportunity costs. In the long term at least partial passing on of opportunity costs is possible.

Assuming opportunity costs are not passed on, the impact of EU ETS on the absolute profit level is about the same as the impact on revenue. Profit margins stay constant.

If opportunity costs are completely passed on, European airlines can raise their profits significantly (19% to 28%). Profit margins increase as well. The impact on the profit level for airlines from ROW is 1% in the maximum.

We expect in the short term no passing on of opportunity costs. In the long run in a persistent system at least partial passing on of opportunity costs is likely.

Impact on CO_2 emissions

Assuming opportunity costs are not passed on the STC scenario reduces CO_2 emissions in the year 2012 by 0,6 mt CO_2 compared to a situation without EU ETS. On a global level 0.1% of aviation emissions are reduced. Emissions covered by EU ETS are reduced by 0.9%.

A further 11,1 mt CO_2 is reduced in other industries by buying CO_2 certificates. Hence, the main environmental impact is seen in industries other than aviation.

Assuming opportunity costs are passed on, 2,2 mt CO_2 is reduced within the aviation sector and for afurther 9,5 mt CO_2 emission rights are bought from other economic sectors. We expect in the short term no passing on of opportunity costs. In the long run in a persistent system at least partial passing on of opportunity costs is likely.

6.2.2 Results EAS scenario

In this part the results of the modulation of the EAS scenario are presented. Thereby the following relation groups are summed up:

- EU+ - EU+;
- EU+ – Switzerland and EU+ - Rest of Europe under the name EU+ - Rest Europe/CH;
- EU+ – EEA's States overseas countries and territories and EU+ - ROW under the name EU+ - ROW;
- ROW – ROW.

Costs of the EU ETS

Assuming a price of 25 EUR, the EU ETS increases the operating cost for European Network Carriers by 824 m. € (0.7% of total revenue in the baseline) and for European LCC by 476 m. € (1.1% of total revenue in the baseline). European freighter airlines have to by emission rights for 21 m. € (0.8% of total revenue in the baseline).

In the EAS scenario non-European airlines have to bear additional costs as well. Under the assumption of a CO_2-price of 25 EUR/tCO_2, they would pay in total about 530 m. € for emission allowances. In relation to theyr baseline revenue this is 0.1% for Network Carriers and LCC and 0.2% for freighter airlines.

The value of the freely allocated emission certificates is nearly 2.4 times higher than the effective costs.

Table 26: Cost of the EU ETS in the EAS scenario

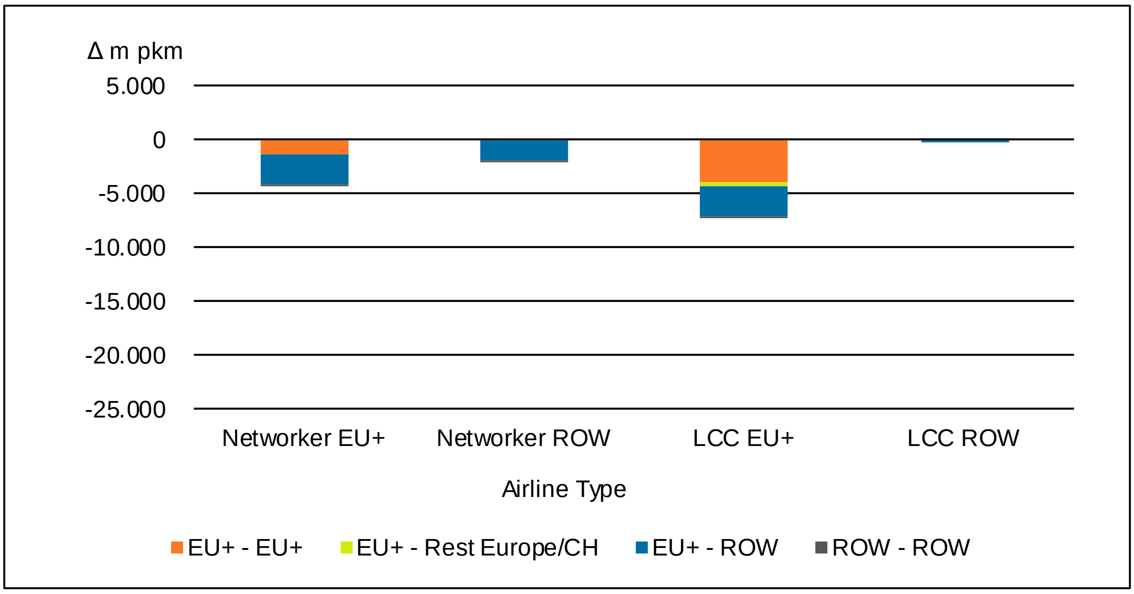
	Network Carriers		LCC		Freighter	
in m. €	EU+	ROW	EU+	ROW	EU+	ROW
Effective cost	824	476	288	15	21	38
Opportunity cost	1'993	1'151	698	37	50	91
Baseline revenue	125.000	330.000	26.400	21.700	2.420	22.400
Effective cost relative to baseline revenue	0.7%	0.1%	1.1%	0.1%	0.8%	0.2%

Source INFRAS

Impact on passenger demand

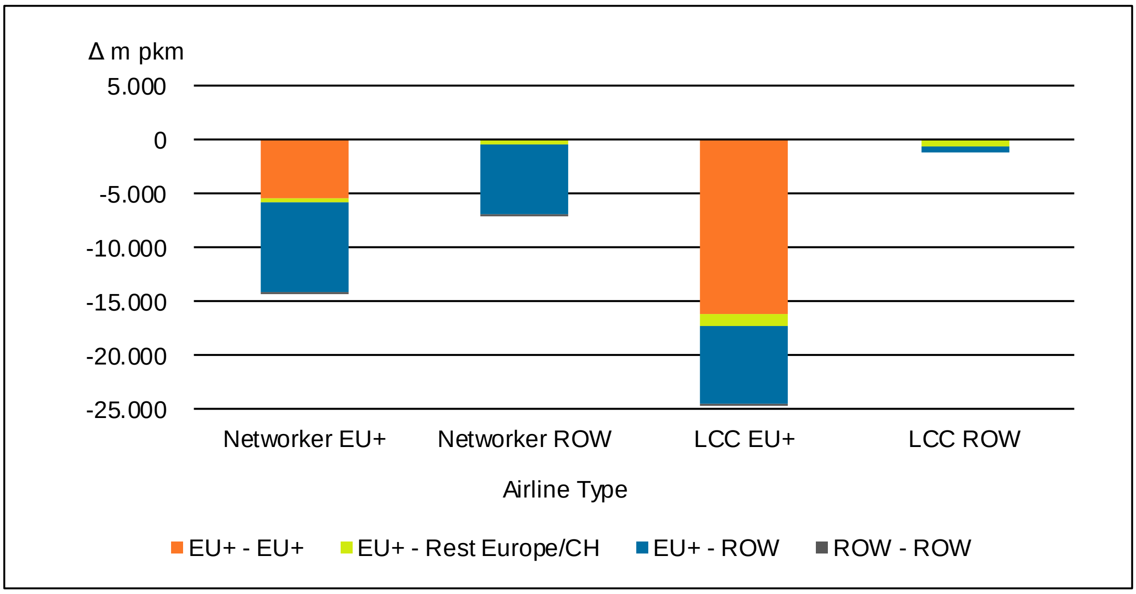
The following figures and table show the impact of the EU ETS in the EAS scenario on passenger demand:

Figure 27: Impact on passenger demand EAS without passing on of opportunity costs (short term)



Source INFRAS

Figure 28: Impact on passenger demand EAS with full passing on of opportunity costs (maximum long term)



Source INFRAS

Table 27: Impact on passenger demand EAS in m. pkm without passing on opportunity costs

in m. pkm	Without passing on opportunity costs			
Airline type	Network Carriers		LCC	
Homeland	EU+	ROW	EU+	ROW
EU+ - EU+	-1.360		-4.000	
EU+ - Rest Europe/CH	-100	-100	-280	-140
EU+ - ROW	-2.750	-1830	-2.770	-10
ROW - ROW	-40	-10	-300	+50
Total impact	-4.250	-1.940	-7.350	-100
pkm before EU ETS	1.200.000	3.700.000	620.000	450.000
Total impact in %	-0,36%	-0,05%	-1,19%	-0,02%

Source INFRAS. * We expect in the short term no passing on of opportunity costs. In the long term at least partial passing on of opportunity costs is possible.

Table 28: Impact on passenger demand EAS in m. pkm with full passing on opportunity costs

in m. pkm	Full passing on opportunity costs			
Airline type	Network Carriers		LCC	
Homeland	EU+	ROW	EU+	ROW
EU+ - EU+	-5.470		-16.120	
EU+ - Rest Europe/CH	-370	-410	-1.130	-590
EU+ - ROW	-8.220	-6520	-7.140	-540
ROW - ROW	-40	-10	-290	+50
Total impact	-14.100	-6.940	-24.680	-1.080
pkm before EU ETS	1.200.000	3.700.000	620.000	450.000
Total impact in %	-1,19%	-0,19%	-4,00%	-0,24%

Source INFRAS. * We expect in the short term no passing on of opportunity costs. In the long term at least partial passing on of opportunity costs is possible.

In the situation without passing on opportunity costs network airlines with homeland EU+ lose 4.3 bn pkm. Due to cross financing strategies there is also a loss in pkm at relations not directly affected by the EU ETS (ROW – ROW). The passenger gain of network airlines from ROW on ROW – ROW relations due to the relative price decline in relation to EU+ airlines does not compensate the loss in passengers because of their own cross financing strategy. Overall Network Carriers from ROW lose 2.0 bn pkm. This corresponds to 0.05% of their baseline pkm, and is about one seventh of the relative loss of Network Carriers with homeland EU+ (-0.36%).

The impact of the EU ETS on LCC with homeland EU+ is in relative terms about 3 times higher than the impact on network airlines from EU+. They lose about 1.19% of their pkm. The higher impact has two reasons. First, passengers of LCC airlines have on average a higher price-elasticity than those of network airlines, since the share of business passenger (that show lower price elasticities) is lower. The reaction on price increases is stronger. Second, since the initial ticket price of LCC airlines is lower than that of network airlines the same absolute price increase results in a higher relative price increase. The relative price increase on ROW – ROW relation with respect to LCC from ROW lead for those airlines to a pkm increase of about 50 m pkm. Still the losses on other relations overcompensate this gain. In the end pkm of LCC from ROW are reduced by 0.02%.

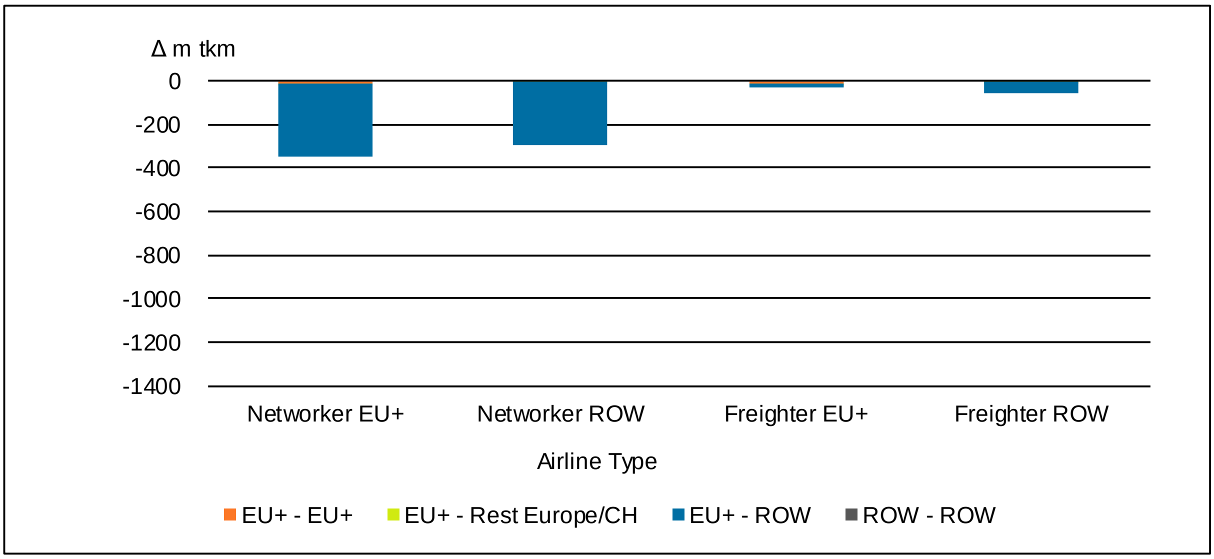
Compared to the STC scenario the loss in pkm of Network Carriers from EU+ is doubled and for LCC from EU+ the demand effect rises by 40%. The stronger rise for the Network Carriers is caused by the higher share of intercontinental flights.

The impact of the EU ETS is about three times higher, when opportunity costs are passed on completely. The exemption is LCC with homeland ROW. When opportunity costs are fully passed on, the effect of cross financing becomes relatively less strong than in the case without passing on of opportunity costs so that the impact increases more than 10 times. We expect in the short term no passing on of opportunity costs. In the long run in a persistent system at least partial passing on of opportunity costs is likely.

Impact on cargo demand

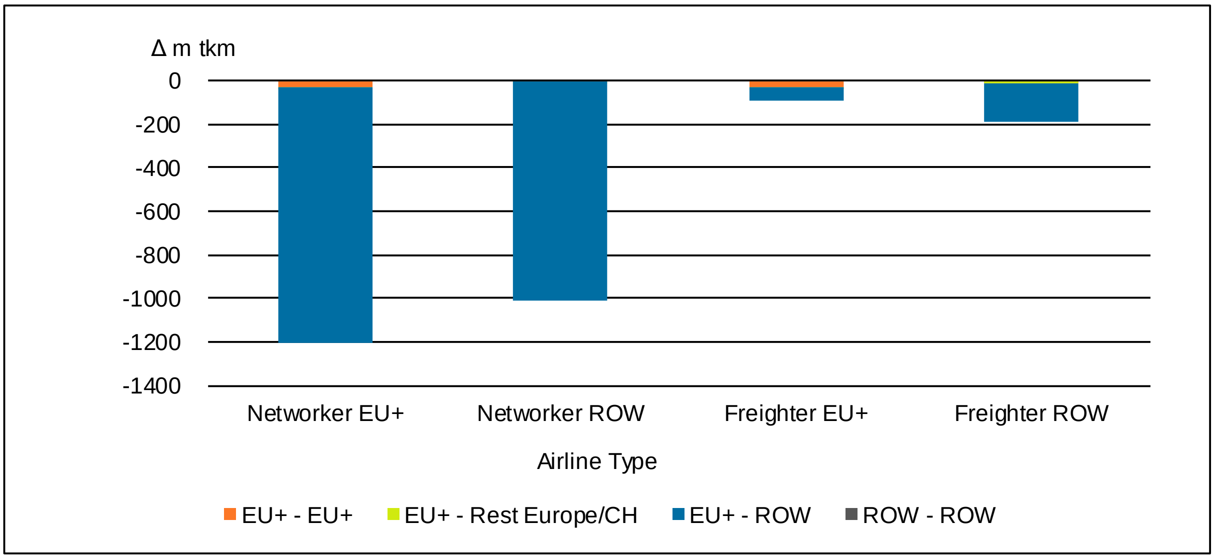
The following figures and table show the impact of the EU ETS on cargo demand in the EAS scenario:

Figure 29: Impact on cargo demand in EAS scenario without passing on opportunity costs (short term)



Source INFRAS

Figure 30: Impact on cargo demand in EAS scenario with full passing on opportunity costs (maximum long term)



Source INFRAS

Table 29: Impact on cargo demand in m tkm

in m tkm	Without passing on opportunity costs*				Full passing on opportunity costs*			
Airlinetype	Network Carriers		Freighter		Network Carriers		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW	EU+	ROW
EU+ - EU+	-10		-10	0	-30		-30	-10
EU+ - Rest Europe/CH	-0	-0	-0	-0	-0	-0	-0	-0
EU+ - ROW	-340	-290	-20	-50	-1.130	-1.000	-60	-180
ROW - ROW	0	0	0	0	0	0	0	0
Total impact	-350	-290	-30	-50	-1.200	-1.000	-90	-190
tkm before EU ETS	29.500	92.200	5.800	51.500	29.500	92.200	5.800	51.500
Total impact in %	-1,2 %	-0,3%	-0,5%	-0,1%	-4,1%	-1,1%	-1,6%	-0,4%

Source INFRAS. * We expect in the short term no passing on of opportunity costs. In the long term at least partial passing on of opportunity costs is possible.

Unlike the STC scenario, in the EAS scenario the impact of the EU ETS on cargo is stronger than on passengers. This follows from the fact that the share of intercontinental transport in total transport in the freight sector is higher than in the passenger sector.

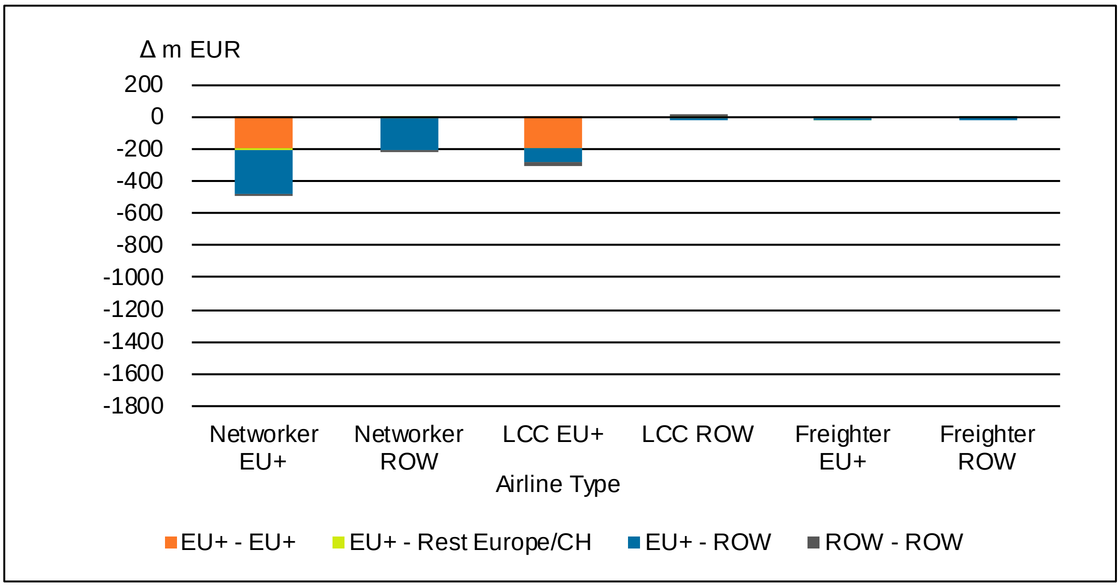
Network airlines are significantly more affected than freighter airlines. Their costs increase significantly more, since they have higher CO_2 emissions per tkm. Airlines from ROW are affected less than European airlines.

Assuming opportunity costs are passed on, the relative impact rises by a factor 3. We expect in the short term no passing on of opportunity costs. In the long run in a persistent system at least partial passing on of opportunity costs is likely.

Impact on revenues

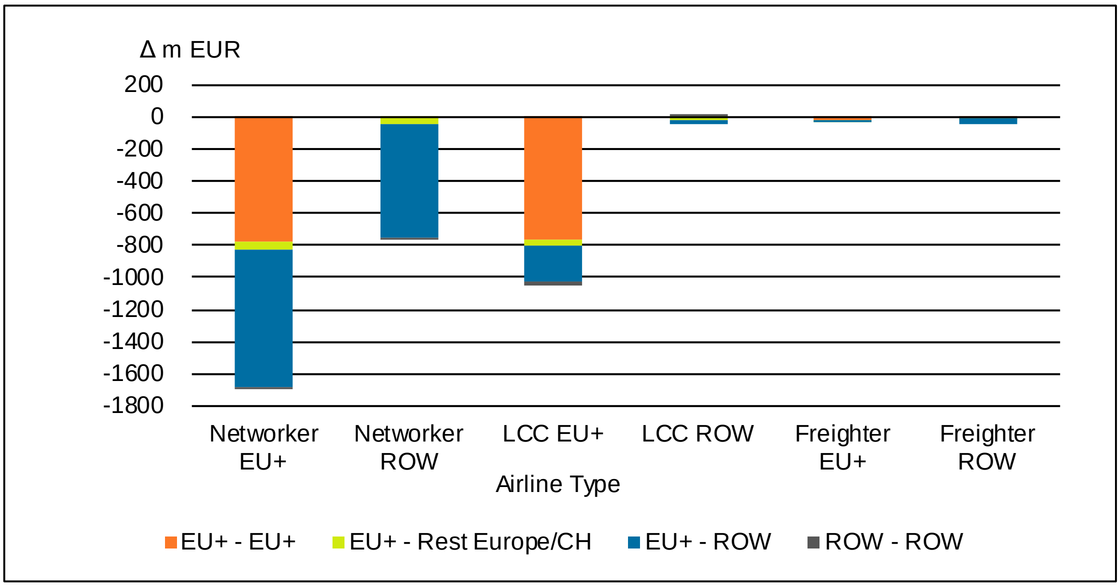
The following figures and tables show the impact of the EU ETS in the EAS scenario on revenue:

Figure 31: Impact on revenues in the EAS scenario without passing on of opportunity costs (short term)



Source INFRAS

Figure 32: Impact on revenues in the EAS scenario with full passing on of opportunity costs (maximum long term)



Source INFRAS

Table 30: Impact on revenue EAS scenario without passing on opportunity costs in m EUR

in m €	Without passing on opportunity costs*					
Airline type	Network Carriers		LCC		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW
EU+ - EU+	-200		-190		-6	-1
EU+ - Rest Europe/CH	-10	-10	-10	-5	-1	-1
EU+ - ROW	-380	-200	-90	-0	-4	-13
ROW - ROW	-0	-0	-10	+0	0	0
Total impact	-490	-210	-300	-5	-11	-15
Revenue before EU ETS	125.000	330.000	26.400	21.700	2.420	22.400
Total impact in %	-0,39%	-0,06%	-1,14%	-0,02%	-0,45%	-0,07%

Source INFRAS. * We expect in the short term no passing on of opportunity costs. In the long term at least partial passing on of opportunity costs is possible.

Table 31: Impact on revenues EAS scenario with full passing on opportunity costs in m EUR

in m €	Full passing on opportunity costs*					
Airline type	Network Carriers		LCC		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW
EU+ - EU+	-780		-760		-20	-5
EU+ - Rest Europe/CH	-40	-50	-50	-20	-3	-2
EU+ - ROW	-860	-700	-230	-20	-15	-43
ROW - ROW	-0	-0	-10	+0	0	0
Total impact	-1.690	-750	-1.050	-40	-38	-50
Revenue before EU ETS	125.000	330.000	26.400	21.700	2.420	22.400
Total impact in %	-1,35%	-0,23%	-3,98%	-0,18%	-1,57%	-0,22%

Source INFRAS. * We expect in the short term no passing on of opportunity costs. In the long term at least partial passing on of opportunity costs is possible.

Assuming opportunity costs are not passed on, the EU ETS reduces revenues of network airlines with homeland EU+ by about 0.4%. The effect on LCC from EU+ is with a loss in revenue of 1.1% about three times higher. For EU+ freighters the effect is about 20% higher as for Network Carriers. This follows from a higher share of fuel costs in total operating costs.

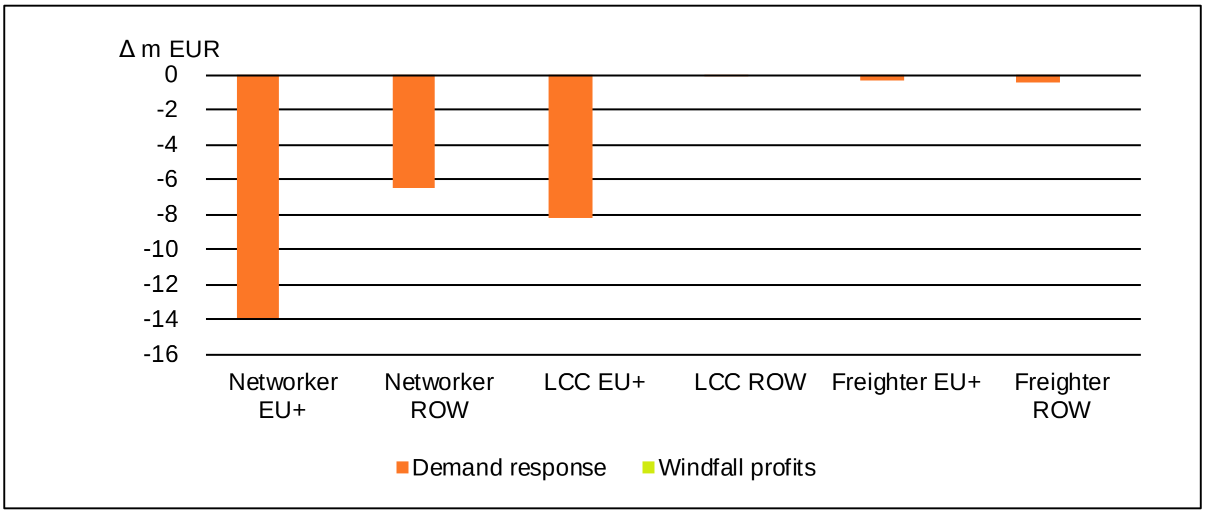
Airline with homeland ROW are less affected. Their revenues decrease by less than 0.1%.

If opportunity costs are fully passed on, the relative effects for European airlines are multiplied on average by a factor of 3,5. We expect in the short term no passing on of opportunity costs. In the long run in a persistent system at least partial passing on of opportunity costs is likely.

Impact on profits

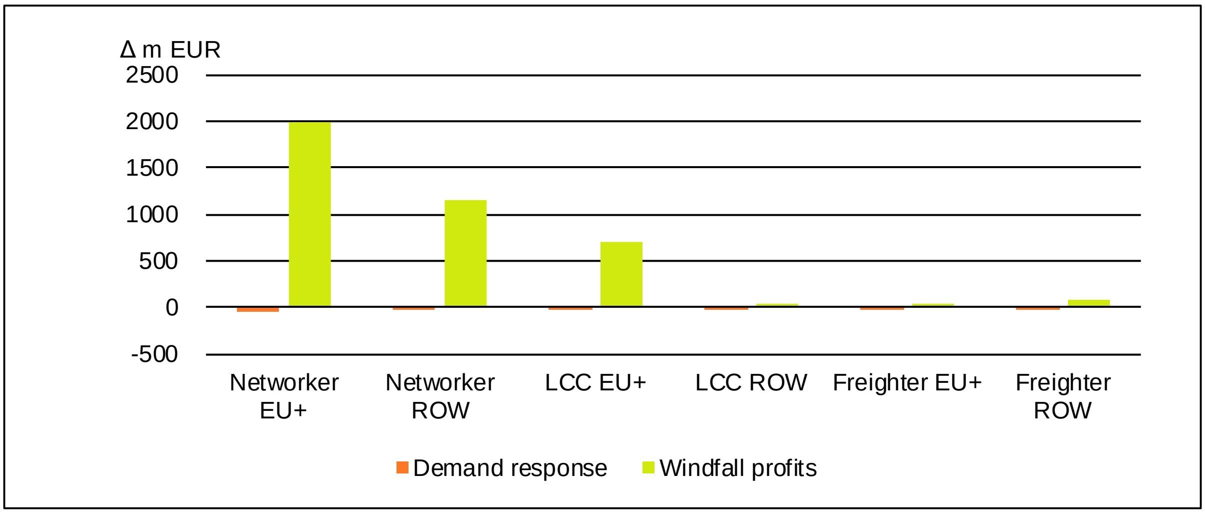
The following figures and tables show the impact on profits of the EU ETS in the EAS scenario:

Figure 33: Impact on profits in the EAS scenario without passing on of opportunity costs (short term)



Source INFRAS

Figure 34: Impact on profits in the EAS scenario with full passing on of opportunity costs (maximum long term)



Source INFRAS

Table 32: Impact on profit EAS scenario without passing on opportunity costs in m EUR

in m €	Without passing on opportunity costs*					
Airline type	Network Carriers		LCC		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW
Demand response	-13,9	-6,5	-8,4	-0,1	-0,3	-0,4
Windfall profits	0	0	0	0	0	0
Total impact	-13,9	-6,5	-8,4	-0,1	-0,3	-0,4
Profit before EU ETS	3.600	10.100	720	660	70	690
Total impact in %	-0,4%	-0,1%	-1,2%	-0,0%	-0,5%	-0,1%

Source INFRAS. * We expect in the short term no passing on of opportunity costs. In the long term at least partial passing on of opportunity costs is possible.

Table 33: Impact on profit EAS scenario with full passing on opportunity costs in m EUR

in m €	Full passing on opportunity costs*					
Airline type	Network Carriers		LCC		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW
Demand response	-50	-20	-30	-0	-0	-0
Windfall profits	-2.000	1.150	700	35	50	90
Total impact	-1.950	1.130	670	35	50	90
Profit before EU ETS	3.600	10.100	720	660	70	690
Total impact in %	54%	11%	93%	5%	71%	13%

Source INFRAS. * We expect in the short term no passing on of opportunity costs. In the long term at least partial passing on of opportunity costs is possible.

Assuming opportunity costs are not passed on, the impact of EU ETS on profits is about the same as the impact on revenues.

If opportunity costs are completely passed on, European airlines can raise their profits significantly (54% to 93%). This is for Network Carriers and freighters about 2.5 times more than in the STC scenario, where fewer emissions are covered and thereby less windfall profits occur. For LCC due to a lower share of intercontinental destinations the profit increases by 30% more than in the STC scenario. Airlines from ROW can raise their profits by 5% to 13% whereas in the STC scenario the impact on profits for these airlines sis marginal.

We expect in the short term no passing on of opportunity costs. In the long run in a persistent system at least partial passing on of opportunity costs is likely.

Impact on CO_2 emissions

Assuming opportunity costs are not passed on in the EAS scenario CO_2 emissions are reduced by 1,6 mt CO_2. This is 2,67 times more than in the STC scenario. On a global level 0,25% of aviation emissions are reduced. In the space covered by EU ETS the reduction is 0,7%.

A further 30,1 mt CO_2 are reduced in other industries by buying CO_2 certificates. This is almost three times more than in the STC scenario. The calculation shows that the main environmental impact of the EAS EU ETS is seen in industries not belonging to aviation.

Assuming opportunity costs are passed on, the CO_2 reduction within the aviation industry increases to 5,7 mt CO_2 and the for 28,1 mt CO_2 emission rights are bought. We expect in the short term no passing on of opportunity costs. In the long run in a persistent system at least partial passing on of opportunity costs is likely.

6.2.3 Impact of the assumption about the CO_2 price

In Annex E the corresponding results are shown, if a CO_2 price of 10 € per t CO_2 instead of 25 € is assumed. It shows that with one exception all numbers are reduced to 40% of the above calculated values. This corresponds to the reduction in CO_2 price (10 € is 40% of 25 EUR). Consequently if we assume a price of 5 € per t CO_2 the numbers are reduced to 20% and if we assume a price of 2,5 € per t CO_2 to 10% of the above reported values.

The only exemption is the amount of emission rights bought from other industries. It relays only slightly on the CO_2 prices. It is mostly depending on the growth of the aviation sector. Since price increases have a negative impact on the growth, more emission rights are bought from other industries if the CO_2 price is lower.

6.2.4 Effect of crossfinancing between continental and intercontinental flights

SECAN-ET does also assess the effect of crossfinancing. In all results presented above, the effect of crossfinancing is included. In this section we show, how the results would change, if no crossfinancing would occur. It is assumed that the CO_2 price is 25 EUR/t CO_2 and that European airlines shift 20% of the effective EU ETS costs for passengers on continental relations to passengers on intercontinental flights.

Table 34: Reduction in revenue loss due to crossfinancing relative to total revenue before EU ETS

	Without passing on opportunity costs*		Full passing on opportunity costs*	
	Network Carriers EU+	LCC EU+	Network Carriers EU+	LCC EU+
STC	0,01%	0,03%	0,01%	0,03%
EAS	0,01%	0,02%	0,01%	0,02%

Source INFRAS. * We expect in the short term no passing on of opportunity costs. In the long term at least partial passing on of opportunity costs is possible.

The table above is to read as follows: If opportunity costs are not passed on, in the STC scenario the revenue loss due to EU ETS for Network Carriers from EU+ is 0,01% higher if no crossfinancing occurs than if crossfinancing occurs.

The table shows that:

- Overall the effect of crossfinancing is limited.

- Network Carriers have a lower relative gain from crossfinancing than LCC. The customers of LCC have a higher price sensitivity and react stronger on price changes. So the loss of an introduction of the EU ETS is stronger than for Network Carriers but also the reallocation of the burden has a higher impact. This effect can be seen, if the share of intercontinental destinations is high enough. It is assumed that 33% of all EU+ LCC pkm are on intercontinental flights.
- Passing on opportunity costs have only a marginal impact on the results.

The overall conclusion is that crossfinancing has only a minor impact on the burden of the EU ETS.

6.3 Interpretation

The modulations with SECAN-ET show the following:

The **environmental impact** of the EU ETS is significantly higher in the EAS scenario than in the STC scenario. Moving from STC to EAS environmental benefits almost triple.

The **impact on airlines** in both scenarios is small. This is even true if a much higher CO_2 price than actually observed is assumed.

In the *short term* the impact on the revenue of network and freight airlines rises by the factor two when moving from STC to EAS (assuming no passing on of opportunity costs). For LCC airlines the burden increases only by 30%. Revenues decline by 1,1% at most (LCC EU+ in EAS scenario). The impact on non-European airlines is also in the EAS scenario - which is the scenario with the higher impact - relatively low. Assuming no passing on of opportunity costs, the decrease in revenue is in both scenarios below 0,1%. The outcome of this is that competition impacts between European and non-European airlines are higher in the EAS scenario than in the STC scenario.

Looking at European airlines, the strongest effect falls on LCC, followed by freighter airlines. Network Carriers face the smallest impact. Differences in the size of the impact are smaller in the EAS scenario than in the STC scenario. This means that competition impacts between European airlines are smaller in the EAS scenario than in the STC scenario.

In the *long term* if airlines expect the system to be persistent it is likely that airlines pass on a part of opportunity costs. The windfall profit of passing on opportunity costs affects the airlines positively. The airlines that are the most affected by the EU ETS have the highest potential to profit from windfall profits.

Since the EU ETS could be replaced by a global scheme after 2020 and because market participants may doubt in the persistence of the actually installed system, it is highly probable that at the moment the short term impacts are relevant. Nevertheless in order to design emission trading schemes properly it is important to think about long term impacts.

7 Modulation with AERO-MS (2026)

7.1 Model description

A general description of the AERO-MS, including the main analysis principles, is provided in Annex A to this document.

The AERO-MS is applied to assess the quantitative impacts of the 2 different EU ETS options relative to a Business as Usual (BaU) scenario. In relation to the preparation and specification of the analysis carried out with the AERO-MS the following steps were taken:

- Specification of BaU scenario;
- Specification of EU ETS options;
- Specification of AERO-MS outputs.

The specification of the EU ETS options, in terms of model runs, is presented in section 5.3 of this report.

7.1.1 Specification of BaU scenario model run

The AERO-MS takes into account long term supply side responses, for which reason analyses with the AERO-MS are always done for a future year. The basic analysis principle of the AERO-MS is that the model first assesses future economic and environmental quantities for the aviation industry based on a Business as Usual (BaU) scenario. In a subsequent model run a policy scenario for the reduction of aviation emissions (in this study EU ETS scenarios) is specified. By comparing the results of the run with and without the policy scenario in place, the impacts of the policy scenarios are assessed.

The BaU scenario used in this study is the CAEP/8 Medium Growth scenario for the year 2026. The scenario is based on specifications of ICAO's Committee on Aviation Environmental Protection (CAEP). The main characteristics of this scenario are:

- CAEP8 medium aviation demand growth scenario for the period up to 2026. Annual passenger demand growth according to this CAEP scenario for the routes included in the EU ETS is: Intra Europe: 3.9%; Europe - North America: 4.5%; Europe - Latin America: 5.5%; Europe - Middle East: 5.9%; Europe - Africa: 5.5%; and Europe - Asia: 5.5%. Annual cargo demand growth is generally 0.5% to 1% higher compared with passenger demand growth.

- CAEP8 moderate technology improvement scenario: annual fuel efficiency improvement of new aircraft of 0.96% up to 2026;

- Increase (in real terms) of the crude oil price to 114.3 US$ per barrel in 2026 based on the 2011 World Energy Outlook (WEO) from the International Energy Agency (IEA).

The BaU scenario is further referred to as the CAEP8-M 2026 scenario.

7.1.2 Description of AERO-MS output format

The computational results for the various model runs are presented in Annex F. First the absolute quantities for the CAEP8-M 2026 scenario, without the implementation of any EU ETS scenarios, are presented (tables F1 and F6). The results of the EU ETS scenarios are presented in terms of a percentage change relative to the CAEP8-M 2026 scenario quantities. Annex F contains the following tables:

F1. Results for Business as Usual scenario CAEP8-M 2026 for flights covered by Stopping the Clock.

F2. Effects of R1: Stopping the Clock; allowance price 25€; opportunity costs for freely obtained allowances not passed on - % effects relative to BaU scenario CAEP8-M 2026.

F3. Effects of R2: Stopping the Clock; allowance price 25€; opportunity costs for freely obtained allowances fully passed on - % effects relative to BaU scenario CAEP8-M 2026.

F4. Effects of R5: Stopping the Clock; allowance price 50€; opportunity costs for freely obtained allowances not passed on - % effects relative to BaU scenario CAEP8-M 2026.

F5. Effects of R6: Stopping the Clock; allowance price 50€; opportunity costs for freely obtained allowances fully passed on - % effects relative to BaU scenario CAEP8-M 2026.

F6. Results for Business as Usual scenario CAEP8-M 2026 for flights covered by European Air Space.

F7. Effects of R3: European Air Space; allowance price 25€; opportunity costs for freely obtained allowances not passed on - % effects relative to BaU scenario CAEP8-M 2026.

F8. Effects of R4: European Air Space; allowance price 25€; opportunity costs for freely obtained allowances fully passed on - % effects relative to BaU scenario CAEP8-M 2026.

F9. Effects of R7: European Air Space; allowance price 50€; opportunity costs for freely obtained allowances not passed on - % effects relative to BaU scenario CAEP8-M 2026.

F10. Effects of R8: European Air Space; allowance price 50€; opportunity costs for freely obtained allowances fully passed on - % effects relative to BaU scenario CAEP8-M 2026.

All tables in Annex F include 16 indicators related to the airline industry. Hereby the following categories are considered:

- Aircraft km;
- Passengers and passenger km;
- Cargo and cargo km;
- Revenue Tonne Km (RTK)[14];
- Airline revenues;
- Fuel consumption and emissions;
- Operating efficiency.

In the case of the Stopping the Clock scenario flights within and between EEA countries (including EEA outermost regions) are affected. Moreover the STC scenario covers flights between EEA countries and EEA overseas countries and territories, and flights between EEA countries and Switzerland. All flights covered in the STC scenario are subject to the

[14] The number of Revenue Tonne Km expresses the total demand for aviation services, whereby passenger and cargo demand are added together in a single indicator. In line with ICAO recommendations, an average weight of 90 kg is assumed for 1 passenger including baggage.

EU ETS for the full flight distance. The effects are presented for a single route group containing all affected flights (this route group is referred to as "Intra EEA+", see tables F1 through F5).

The European Air Space scenario not only covers Intra EEA flights, but also flights between EEA countries and the included third countries. For the latter set of flights only the trajectories through European Airspace are subject to the EU ETS. For the EAS scenario, effects are presented for two route groups (see tables F6 through F10):

- Intra EEA — All flights between and within EEA countries (including EEA outermost regions) for which the full distance is subject to the EU ETS
- Extra EEA — All flights between EEA countries and the third countries included in the EAS scenario for which only the trajectories through European Air Space are subject to the EU ETS.

For the route group "Extra EEA" the absolute quantities in table F6 and the percentage effects in tables F7 through F10 are related to the full distance of the flights (i.e. distance flown both within and outside the European Airspace). This because, also if only part of a flight is subject to emission trading, there will be impacts for the full flight.

Furthermore, in all tables in Annex F, outputs are separately presented for three different flight types:

- Scheduled passenger flights operated by network carriers;
- Non-scheduled (charter) passenger flights and flights operated by Low Cost Carriers (LCC);
- Freighter flights.

As shown by the tables in Annex F, for some of the flight types, some of the outputs are not applicable:

- Charter passenger flights and flights operated by LCC (flight type 2) only contain economy class passengers;
- Cargo is carried in both the belly hold of scheduled passenger flights (flight type 1) and by dedicated freighter flights (flight type 3). Charter passenger flights and flights operated by LCC (flight type 2) do not carry cargo.

7.2 Results

The assumed behaviour of airlines in the case of the EU ETS for aviation is to achieve the same per unit profits as they would have secured in the CAEP8-M BaU scenario situation. While unit operating costs increase due to the EU ETS induced cost increases, the increase in total operating costs is restrained by the reduction of demand growth. The reduction of demand growth follow from the pass on of the EU ETS induced cost increases to the consumers of air transport services into higher fares and the price elasticities of demand. A reduction of demand growth also triggers a reduction of supply and hence a lower number of flights and aircraft km, with resulting lower fuel use and emissions. Moreover, because the cost increases of the EU ETS are related to CO_2 emissions (and hence fuel), there will be a positive effect on the fuel efficiency of the aircraft fleet. The AERO-MS takes into account various mechanisms which have a positive effect on the fuel efficiency of the aircraft fleet. These are described as supply side responses in section 5.1 of this report.

Because the cost increases of the EU ETS are related to CO_2 emissions (and hence fuel), in the long term there will be a positive effect on the fuel efficiency of the aircraft fleet. In the long term there are various mechanisms which can have a positive effect on the fuel efficiency of the aircraft fleet. These are: i) new aircraft technology shift; ii) accelerated fleet renewal; and iii) new aircraft capacity shift. The AERO-MS takes into account these mechanisms and computes the overall effect on fuel efficiency in terms of a reduction of the fuel use per RTK. Because of the relatively small EU ETS induced price incentive for technology improvement (i.e. the allowance prices of 25€ and 50€ being equivalent to an increase of respectively 10€ and 20€ per barrel of oil), the effect on the fuel use per RTK is also small. In the case of R2 (Stopping the Clock scenario with the opportunity costs for freely obtained allowances fully passed on and allowance prices of 25€) for Intra EEA routes the reduction in the fuel use per RTK in 2026 is 0.2% for both network carriers and low cost carriers and 0.5% for freighter flights. With a higher allowance price of 50€, the incentive for technology improvement is larger and hence the reduction of fuel use per RTK is stronger (reduction varies between 0.4% for network carriers and 0.8% for freighter flights)

In the case of R1 (Stopping the Clock scenario with allowance price of 25€ with none of the opportunity costs for freely obtained allowances passed on), the number of aircraft km on Intra EEA routes goes down by 1.8% (see effects 1 in table F2). This follows from the reduction in passenger demand (see effect 4 in table F2) and cargo demand (see effect 6 in table F2) by respectively 1.7% and 0.8%. Effects in the case of R5 (Stopping the Clock scenario with allowance price of 50€ with none of the opportunity costs for freely obtained allowances passed on) are about twice as high compared to the effects of R1.

The results for R2 show that in case the opportunity costs for freely obtained allowances are assumed to be fully passed on into higher passenger fares and freight rates, the demand effects are larger compared to the effects of R1. For R2, passenger and cargo demand go down by respectively 3.3% and 1.7% (see effects 4 and 6 in table F3), which is larger compared to the effect of R1. In the case of R1, in 2026 for about 50% of the emissions, allowances costs are passed on. The other 50% of the emissions in 2026 are covered by benchmarked allowances (82% of the emissions under the cap) for which opportunity costs are assumed not to be passed on in R1. In R2 for all emissions in 2026, allowances costs are assumed to be passed on and hence the effect on demand in R2 is about twice as large compared to the effect of R1 (compare results in tables F3 and F2). Effects in the case of R6 (Stopping the Clock scenario with allowance price of 50€ with opportunity costs for freely obtained allowances passed on) are almost twice as high compared to the effects of R2.

In the case of the European Air Space scenario (runs R3, R4, R7 and R8), both Intra EEA and Extra EEA routes are affected. The effects for Intra EEA routes (presented in tables F7 through F10) are almost identical to the effects for these routes in the equivalent Stopping the Clock scenario model runs. This because the cost increases for Intra EEA routes, resulting from the EU ETS, are identical for R1/R3, R2/R4, R5/R7 and R6/R8 (small differences follow from a somewhat different scope of the Intra EEA routes for the STC versus the EAS scenario).

In the case of the EAS scenario, the effects for extra EEA routes are much smaller compared to the effects for Intra EEA routes. This logically follows from the scope of the EAS scenario where for extra EEA routes only the flight trajectories through European Air Space are subject to emissions trading. About 23% of the emissions between EEA and the included third countries take place within European Airspace and are therefore subject to the emission trading in the EAS scenario. In fact this implies the effects for the routes between EEA and the included third countries are comparable to a situation where there would be emission trading with a much lower allowance prices of 5,75€ (23% of 25€) and 11.50€ (23% of 50€) for the full flight distance.

Tables F7 through F10 clearly show the smaller effects for the extra EEA routes. Where for example passenger demand on intra EEA routes goes down by 1.8% and 3.3% for respectively R3 and R4 (see effect 4 in tables F7 and F8), for extra EEA routes the reduction in passenger demand is only 0.3% and 0.5% for respectively R3 and R4 (see also effect 4 in tables F7 and F8).

In order to have a better notion of the EU ETS induced cost increase, the allowance prices can be converted into an equivalent increase of the oil price per barrel based on the following equation:

$OilPricePerBarrel = CO_2PricePerTon * 0.127 * 3.157$[15]

The factor of 0.127 relates to the weight in tonnes of a barrel of oil (159 litres of 0.8 kg per litre is 0.127 ton). The factor of 3.157 relates to kg of CO_2 emitted per kg of jet fuel use. On the basis of the above equation, the CO_2 prices of 25€ and 50 € are comparable to an equivalent increase in the oil price of respectively 10€ and 20 € per barrel of oil.

The results also show that the effects for network carriers are smaller compared to the effects for low cost carriers. In the case of R2 (Stopping the Clock scenario with the opportunity costs for freely obtained allowances fully passed on) passenger demand on Intra EEA routes for network carriers goes down by 1.6%, whereas the effect for low cost carriers is -4.9% (see effect 4 in table F3). All other runs also show a larger reduction of demand for low cost carriers compared to the demand reduction for network carriers. In the case of the EAS scenario, this is true for the passenger demand on both Intra EEA routes and Extra EEA routes (see tables F7 through F10).

The larger demand reduction for low cost carriers is related to three factors. Firstly, network carriers and low cost carriers have different cost structures, whereby for low cost carriers fuel cost are a larger proportion of total operating costs (see also section 4.1.4). Hence, given a certain allowances price, the percentage increase of total operating costs is larger for low cost carriers. As the assumptions is that the cost increases are passed on into higher fares, the percentage increase of fares is also larger for low cost carriers. Secondly, passenger demand for low cost carriers is more price elastic in comparison to passenger demand for network carriers. This is due to a larger proportion of business purpose passengers for network carriers, where low cost carries have a larger proportion of – more price sensitive – leisure purpose passengers.

---

[15] 0.127 * 3.157 is 0.4. So as a rule of thumb any CO_2 price per ton can be converted into an equivalent increase of oil price per barrel by dividing the CO_2 price by 2.5.

The third factor is only relevant in relation to Extra EEA routes, and hence the EAS scenario. The extra EEA routes for low cost carriers on average are shorter distance flights compared to the extra EEA routes for network carriers. Hence, on average a larger proportion of the Extra EEA flights for low cost carriers goes through the European air space and is therefore subject to emission trading in the case of the EAS scenario. For low cost carriers, in 2026 about 29% of their emissions on Extra EEA are expected to be subject to emission trading in the EAS scenario, whereas for network carriers this is a less than 20% (see also figure 17). The larger proportion of emissions on Extra EEA routes being subject to emission trading, also contributes to a larger demand effect for low cost carriers on Extra EEA routes.

The reduction of fuel use (and CO_2 emissions) within the aviation industry follows from a summation of two effects. The most dominant effect is that of demand reduction, which leads to a reduction of supply and hence fuel use and emissions. Another effect is the EU ETS induced technology improvement of the fleet in use. In the tables in Annex F the latter effect is shown by the reduction of the fuel use per RTK. Because of the relatively small EU ETS induced price incentive for technology improvement (i.e. the allowance prices of 25€ and 50€ being equivalent to an increase of respectively 10€ and 20€ per barrel of oil), the effect on the fuel use per RTK is also small. In the case of R2 (Stopping the Clock scenario with the opportunity costs for freely obtained allowances fully passed on) for Intra EEA routes the reduction in the fuel use per RTK is 0.2% for both network carriers and low cost carriers and 0.5% for freighter flights (see effect 13 in table F3). With a higher allowance price, the incentive for technology improvement is larger.

In all EU ETS scenarios allowances have to be bought for the emissions above the cap of 95% of the average CO_2 emission level across the years 2004-2006. Tables 35 and 36 present how CO_2 emissions in 2026 are covered for the different EU ETS scenarios. In addition the tables include a number of key financial impacts. The tables help to understand the various mechanisms for CO_2 emission reduction in case of the EU ETS scenarios.

The first part of tables 35 and 36 is involved with the assessment of the aviation CO_2 emissions in 2026 which are subject to emission trading in case the various EU ETS scenarios would be in place. This is simply the BaU CO_2 emissions in 2026 under the scope of the two EU ETS scenarios (105 Megaton for STC and 166.6 Megaton for EAS - (A) in table 35) minus the CO_2 emission reduction *within* the aviation sector (B). The CO_2 emission reduction within the aviation industry directly follows from the results of the AERO-MS model runs (effect 12 in the tables).

The second part of tables 35 and 36 show how the CO_2 emissions in 2026 are covered. Hereby it is assumed that the current EU ETS cap for aviation (which is valid until 2020) is also applicable for the year 2026. This assumption has been made because no new aviation cap for the period beyond 2020 (i.e. EU ETS phase 4) has yet been set. Hence the analysis shows the long term effects of the EU ETS for aviation under the current cap.

For the two EU ETS scenarios the tables shows the following:

- Stopping the Clock scenario. The cap for the aviation CO_2 emissions (61.7 megaton) is far below the aviation CO_2 emissions in 2026 with STC in place (103.3 megaton for R1; 101.6 for R2 and R5; and 98.5 for R6). The difference is covered by emission allowances bought by the aviation industry from the other economic sectors which are included in the EU ETS (see E in tables 35 and 36: the number of allowances to be bought is 41.6 million allowances for R1; 40.0 million for R2 and R5; and 36.9 for R6).

- European Air Space scenario. Also for this scenario the emission cap (89.8 megaton) is far below the aviation CO_2 emissions in 2026 with the EAS in place (164.6 megaton for R3; 163.0 megaton for R4; 162.7 megaton for R7; and 159.7 megaton for R8). Again the difference is covered by emission allowances bought by the aviation industry from other economic sectors included in the EU ETS (see E in tables 35 and 36).

Hence for both the Stopping the Clock and the European Air Space scenario the main mechanism to reach the cap will be to buy emission allowances from other economic sectors. The total CO_2 emission reduction in 2026, resulting from the STC scenario will be 43.3 Megaton (CAEP8-M BaU emissions minus the emissions under the cap). The CO_2 emission reduction in 2026 for the EAS scenario will be 76.8 Megaton.

The last part of tables 35 and 36 shows a number of financial impacts. First the tables show the costs for the aviation sector for buying emission allowances from other economic sectors (G). These costs for the aviation sector are computed by multiplying the number of allowances bought by the aviation sector with the assumed allowance price of 25€ or 50€. As shown in tables 35 and 36, in 2026 for the STC scenario these costs are in the order of 1 billion € in case of an allowance price of 25€ (R1 and R2) and in the order of in the order of 2 billion € in case of an allowance price of 50€ (R5 and R6). For the EAS scenario these costs are in the order of 1.85 billion € in case of an allowance price of 25€ (R3 and R4) and in the order of in the order of 3.5 billion € in case of an allowance price of 50€ (R7 and R8).

For both the STC and EAS scenario there are also auction revenues. These are computed by multiplying the number of auctioned allowances (15% of the emissions under the cap) with the allowance price. Assuming an allowances price of 25€, for the STC scenario auction revenues are 231.2 million €, whereas for the EAS scenario this is a 336.6 million €. In the case of an allowances price of 50€, the auction revenues are twice as high.

In some of the cases airlines generate windfall profits. These profits result from passing on opportunity costs of freely obtained allowances into higher passenger fares and freight rates. Windfall profits for the airline industry follow from the amount of freely obtained allowances and the allowance price. In the case of R2, 52.4 million allowances are obtained freely (i.e. 82% of the emission cap). For the Stopping the Clock scenario, assuming an allowances price of 25€, this can result in a windfall profit for airlines of over 1.2 billion €. For the European Air Space scenario the windfall profits, assuming the same allowances price, can be over 1.8 billion € (see R4). In the case of an allowances price of 50€, the windfall profits are twice as high.

Table 35: Covering of CO_2 emissions in 2026 and financial impacts

Effect	Unit	EU ETS scenarios			
		R1: STC, allowance price 25 €, no pass on opportunity costs	R2: STC, allowance price 25 €, full pass on opportunity costs	R3: EAS, allowance price 25 €, no pass on opportunity costs	R4: EAS, allowance price 25 €, full pass on opportunity costs
Aviation CO_2 emissions under the scope of EU ETS scenarios					
A. BaU CO_2 emissions 2026 (CAEP8-M)	Megaton	105.0	105.0	166.6	166.6
B. Reduction CO_2 by aviation sector	Megaton	1.7	3.4	2.0	3.6
C. Aviation CO_2 emissions in 2026 (A-B)	megaton	103.3	101.6	164.6	163.0
Covering of CO_2 emissions in scenario year					
D. Aviation CO_2 emission under cap	megaton	61.7	61.7	89.8	89.8
E. Allowances bought from other sectors	million allowances	41.6	40.0	74.8	73.2
F. Total (D+E)	megaton	103.3	101.6	164.6	163.0
Financial impacts					
G. Costs for aviation to buy allowances from other sectors (fully passed on to consumers)	million €	1,040.3	998.9	1,871.0	1,830.4
H. Auction revenues (fully passed on to consumers)	million €	231.2	231.2	336.6	336.6
I. Windfall profits for airlines	million €	0.0	1,263.9	0.0	1,840.3

Table 36: Covering of CO_2 emissions in 2026 and financial impacts

Effect	Unit	EU ETS scenarios			
		R5: STC, allowance price 50 €, no pass on opportunity costs	R6: STC, allowance price 50 €, full pass on opportunity costs	R7: EAS, allowance price 50 €, no pass on opportunity costs	R8: EAS, allowance price 50 €, full pass on opportunity costs
Aviation CO_2 emissions under the scope of EU ETS scenarios					
A. BaU CO_2 emissions 2026 (CAEP8-M)	Megaton	105.0	105.0	166.6	166.6
B. Reduction CO_2 by aviation sector	Megaton	3.4	6.4	3.9	6.9
C. Aviation CO_2 emissions in 2026 (A-B)	megaton	101.6	98.5	162.7	159.7
Covering of CO_2 emissions in scenario year					
D. Aviation CO_2 emission under cap	megaton	61.7	61.7	89.8	89.8
E. Allowances bought from other sectors	million allowances	40.0	36.9	72.9	69.9
F. Total (D+E)	megaton	101.6	98.5	162.7	159.7
Financial impacts					
G. Costs for aviation to buy allowances from other sectors (fully passed on to consumers)	million €	1,997.7	1,843.6	3,646.6	3,494.6
H. Auction revenues (fully passed on to consumers)	million €	462.4	462.4	673.3	673.3
I. Windfall profits for airlines	million €	0.0	2,527.8	0.0	3,680.6

7.3 Interpretation on the basis of the AERO model

The main interpretations on the basis of the AERO-MS calculations are summarised below.

- For both the STC and EAS scenario a significant larger proportion of the emissions of European charter/LCC operations is subject to emissions trading in comparison with the proportion of emissions - subject to emission trading - of (the competing) network carriers. For scheduled passenger network carrier operations the emission coverage is reduced to 19% and 33% of the regular EU ETS emissions for respectively the STC and EAS scenario (percentages for 2026). For charter and LCC operations the relative emission coverage is significantly larger (56% and 67% of the regular EU ETS emissions covered in respectively the STC and EAS scenario). Because of the relatively unimportance of aviation activities on intra EEA routes in the freighter market, for freighter operations the relative emission coverage for the STC and EAS scenarios is lower compared to the passenger market (respectively 12% and 31% of the regular EU ETS emissions covered).
- In case of the STC scenario (assuming an allowance price of 25€ or 50€; and short term response, i.e. none of the opportunity costs for freely obtained allowances passed on) passenger demand on Intra EEA routes goes down by respectively 1.7% and 3.3%. Effects on cargo demand are -0.8% (allowance price of 25€) and -1.7% (allowance price of 50€). In the long run if opportunity costs for freely obtained allowances are assumed to be (at least partly) passed on into higher passenger fares and freight rates, in 2026 the demand effects are about twice as large. In the case of the EAS scenario, the effects for Intra EEA routes are very similar to the effects of the STC scenario.
- For the EAS scenario, the effects for extra EEA routes are much smaller compared to the effects for Intra EEA routes. This follows from the scope of the EAS scenario where for extra EEA routes only the flight trajectories through European Air Space are subject to emission trading. About 23% of the emissions between EEA and the included third countries take place within European Airspace and are therefore subject to emission trading in the EAS scenario. In fact this implies the effects for the routes between EEA and the included third countries are comparable to a situation where there would be emission trading with a much lower allowance price of 5.75€ (23% of 25€) and 11.50€ (23% of 50€) for the full flight distance.
- In case of both the STC and EAS scenario there is a larger reduction of demand for low cost carriers compared to the demand reduction for network carriers. Firstly this is because network carriers and low cost carriers have different cost structures, whereby for low cost carriers fuel cost are a larger proportion of total operating costs. Another factor is that passenger demand for low cost carriers is more price elastic in comparison to passenger demand for network carriers. A third factor, only of relevance in case of the EAS scenario, is that flights on extra EEA routes for low cost carriers on average are shorter distance flights compared to the extra EEA flights for network carriers. Hence, on average a larger proportion of the Extra EEA flights for low cost carriers goes through the European air space and is therefore subject to emission trading in the case of the EAS scenario. For low cost carriers, in 2026 about 29% of their emissions on Extra EEA are subject to emission trading in the EAS scenario, whereas for network carriers this is a less than 20%.
- For both the Stopping the Clock and the European Air Space scenario the main mechanism to reach the cap will be to buy emission allowances from other economic

sectors. For the STC scenario these costs are in the order of 1 billion € in case of an allowance price of 25€, and in the order of in the order of 2 billion € in case of an allowance price of 50€. For the EAS scenario these costs are in the order of 1.85 billion € in case of an allowance price of 25€ and in the order of in the order of 3.5 billion € in case of an allowance price of 50€

- In case airlines would be able to pass on the opportunity costs of freely obtained allowances, windfall profits will be generated. We assume that airlines are able in the long term to pass on at least partly the opportunity cost. For the Stopping the Clock scenario, assuming an allowances price of 25€ and all of the opportunity costs to be passed on (maximal potential impact), the windfall profit for airlines will be 1.2 billion € in 2026. Under the same assumptions, for the European Air Space scenario the windfall profits will be 1.8 billion € in 2026. In the case of an allowances price of 50€, the windfall profits are twice as high.

8 Conclusion

This chapter presents our conclusions on the environmental impacts and the competitiveness impacts of the inclusion of aviation in the EU ETS, based on the analysis presented in the previous chapters.

The financial impacts of EU ETS are affected by the assumption on passing on opportunity costs or not. But the main conclusion of the analysis is valuable for all periods (short or long term) regardless of whether or not opportunity costs are passed on: The inclusion of aviation into the EU ETS under STC or EAS implicates small absolute and relative cost increases. This is true for the actual price level of 7 € in 2012 and also if we assume higher prices (e.g. 25 EUR/tCO_2). The cost effects are too small to be accompanied by competitive distortions that are relevant in the total market. Other effects or basic parameters on the European aviation markets (like fuel price changes, grandfathering of slots, differences in cost structures between airlines) are more relevant.

Three stages of effects have to be distinguished when analysing the impacts.

In the ***very short run*** (i.e. a few months after the EU ETS introduction), it is possible that only a small share of the effective costs are passed on. This effect is very transitory and no indication for possible relevant competitive impacts on the market. The very short run responses are not analysed in this report.

In the ***short run*** (up to about two years, i.e. the timeframe within the network of airlines and therefore their costs are for some parts basically fixed), it is likely that airlines will be able to pass on expenditures (i.e. effective costs for the acquisition of allowances) but not the opportunity costs of the freely allocated allowances. In this timeframe, the marginal unit of output is a passenger and the marginal carbon costs of a passenger are negligible. Moreover, prices will be set at a level to maximise revenues, since costs are to some extent fixed. This would result in a relatively modest increase in prices and subsequently a modest reduction in demand, while profit margins would remain more or less stable. The scenarios with only passing on of effective costs of EU ETS give the relevant information about the current size of the impact (relatively new system which future is uncertain). The results for the scenario with no passing on of opportunity costs represent the ***main result*** and basis for the main conclusions of this report.

In the ***long run*** (after more than five years or in a timeframe in which the network of airlines is largely flexible), the competitive market will allow airlines to pass on expenditures *and* opportunity costs, if market participants see the EU ETS for aviation as persistent. The reason is that in this timeframe, the marginal unit of output is a flight, and the marginal flight will need to surrender allowances for all its emissions. This would result in higher price increases, which would have a larger impact on demand, but the losses associated with the lower demand would be more than offset by the profits from the pass on of the value of the free allowances. Both SECAN-ET and AERO-MS deliver results for the long run. The results for the scenario with passing on opportunity costs represent ***additional results*** with a (long run) assumption of a flat supply curve of aviation.

In the ***medium term*** (between about 2 and 5 years) there is a transition phase between the short and long term behaviour and expected impact.

Whether and which part of opportunity costs are passed on depends largely on the steepness of the supply curve. Furthermore, the pass on will be smaller if airlines aim to maximise revenues than when they aim to maximise profits (details see chapter 3).

The next Section concludes on the environmental impacts of the inclusion of aviation in the EU ETS. Conclusions on competitiveness are in Section 8.2, and Section 8.3 contains the core conclusions.

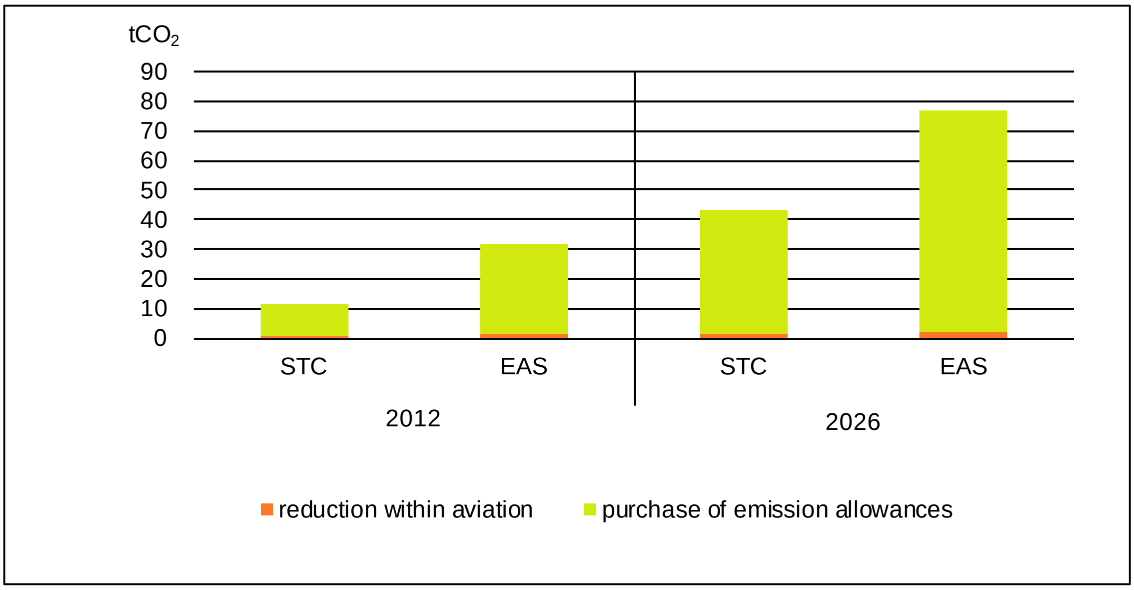
8.1 Environmental impacts

Shifting from the regular EU ETS design to the Stopping the Clock or European Air Space scenario, emissions under the cap are reduced to respectively 29.4% and 42.8%. Because of the expected relatively large growth of emissions on routes between EEA countries and third countries (compared to growth on intra EEA routes), the relative emission coverage of especially the Stopping the Clock scenario will reduce over time (i.e. only 24.8% of regular EU ETS emissions covered in 2026). Since in the EAS scenario the coverage of the system is wider, CO_2 emission reduction is in 2012 almost three times higher than in the STC scenario. As the market for intercontinental flights grows faster than the market for continental flights, in the year 2026 the CO_2 reduction in the EAS scenario is even 4,6 times bigger than in the STC scenario.

In the following figure we see that the reduction of CO_2 emission increases over time. Since the aviation market is a growing market and emission reductions are only possible to a limited extent, the main reduction results from buying CO_2 allowances from other sectors. The effect of the decrease in demand for aviation services has only a minor effect. As the main driver for emission reductions is the purchase of emission allowances from other industries and not the reaction on price increases of customers, the CO_2 price has not a big impact on the level of emission reductions.

Assuming a price of 25 EUR/tCO2, the CO_2 reduction due to the EU ETS within the aviation sector corresponds in the STC scenario in 2012 to 0.9% of the emissions within the EU ETS and 0.1% of global emission. With the actual price of 7 EUR/t CO_2 the environmental benefit is reduced to approximately one quarter. If we count also for reductions in other industries, the reduction corresponds to 1,8% of global aviation emissions or 16% of the aviation emissions within the EU ETS.

Figure 35: Reduction in CO_2 emission (25 EUR/tCO_2, no passing on of opportunity costs)



Source: INFRAS

Provided that the EU ETS continues to exist unmodified, the opportunity costs of freely allocated allowances will be passed on in the long run, resulting in a higher increase in ticket prices and a larger reduction in demand compared to the baseline- and therefore emission reductions in the sector increase to 3.2% for STC scenario in the year 2012. The total emission reduction, including offsets, remains at the same level because it is determined by the cap.

8.2 Impact on competition

With two different models (SECAN-ET, AERO-MS) we analysed the impact of the EU ETS in the STC and the EAS scenario holding all other regulations in the airline markets worldwide constant. SECAN-ET analyses the short term effect in the year 2012 and is focussed on airline types. AERO-MS analyses the long term effects in the year 2026 and is focussed on markets.

In 2012 the CO_2-price was low (about 7 EUR/tCO_2). If we would model the impact of the EU ETS with this price, the impact would be very small and it would be difficult to identify any possible structural influences and effects, which are of importance for the effects in competition. In order to obtain a clearer picture of the possible impacts on competition in the aviation market, the quantitative analysis was made using a higher CO_2 price than effectively observed. In this way the results presented show the potential impacts of the EU ETS. The real impacts in 2012 are significantly smaller, because the CO_2 price was much lower. Presently markets do not expect high price increases for CO_2 allowances in the future. In order to get a clearer idea of the potential effects in the year 2026, in the analysis we have used CO_2 prices which lie above the actual market expectation. In this sense the model runs do not forecast a specific situation but try to identify the structure and level of possible influences on the competition situation in the aviation markets in Europe. These influences get more relevant if allowance prices would rise in the future.

Models always reflect a simplification of the real world. They help to answer specific question, but they cannot picture the complexity of reality. Therefore aspects which are not covered by the two models are discussed qualitatively on the basis of theory and empiric evidence.

In the following we discuss the potential impact on competition of the EU ETS in the enlarged logic of the concept of the effective competition (Schmidt 2005) taking into account dynamic effects as well. This concept differs between the market structure, the market conduct and the market performance, whereby the market structure affects the market conduct, which has an impact on the market performance and the performance affects again the market structure.

8.2.1 Short term: cost impact on market conduct (without passing on of opportunity costs)

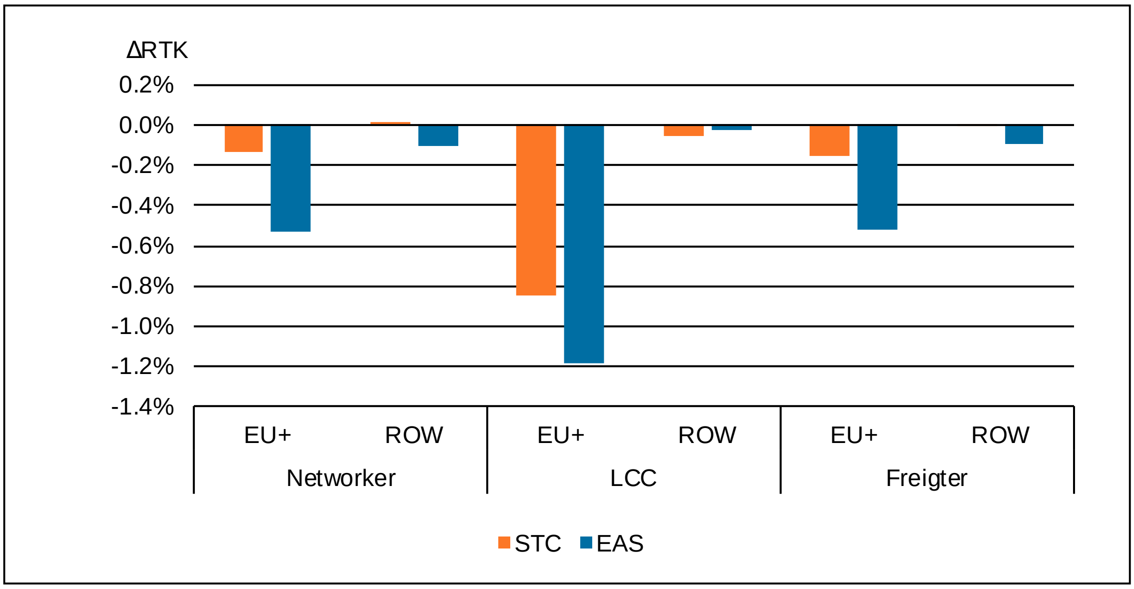
Effect with the actual CO_2 price

In the first step, the EU ETS increases the effective costs for airline services. We assume that with the actual prices of the year 2012 and in the framework of the STC scenario European airlines face in total additional effective costs in the order of 100 m. to 150 m. EUR. This corresponds to 0,07% to 0,10% of their total costs and has the same cost effects as an oil price increase from 100 USD per barrel to 102 USD per barrel. Non-European airlines are hardly affected by the STC design because of their very limited market shares on intra-European routes. On average the costs due to the EU ETS have no significant impact on the behaviour, price setting and competition intensity in the aviation market because the effect is too small. In scientific research it is (ex ante) and will be (ex post) difficult to separate the effect of such a small cost increase from other incidents like short term oil price changes or other cost sensitive changes.

Potential effect with a higher CO_2 price – results from the models

To analyse the potential structural impact of the EU ETS we have analysed the possible impacts under a CO_2 price of 25 € per ton. To cover the additional costs, airlines have to increase their fares, which leads to a reduction in demand for airline services. The following figure shows the impact demand - measured in revenue ton km (RTK) – for different airline types.

Figure 36: **Potential reduction in aviation demand differentiated by airline types (situation 2012, 25 EUR/tCO_2, no passing on of opportunity costs of free allowances)**



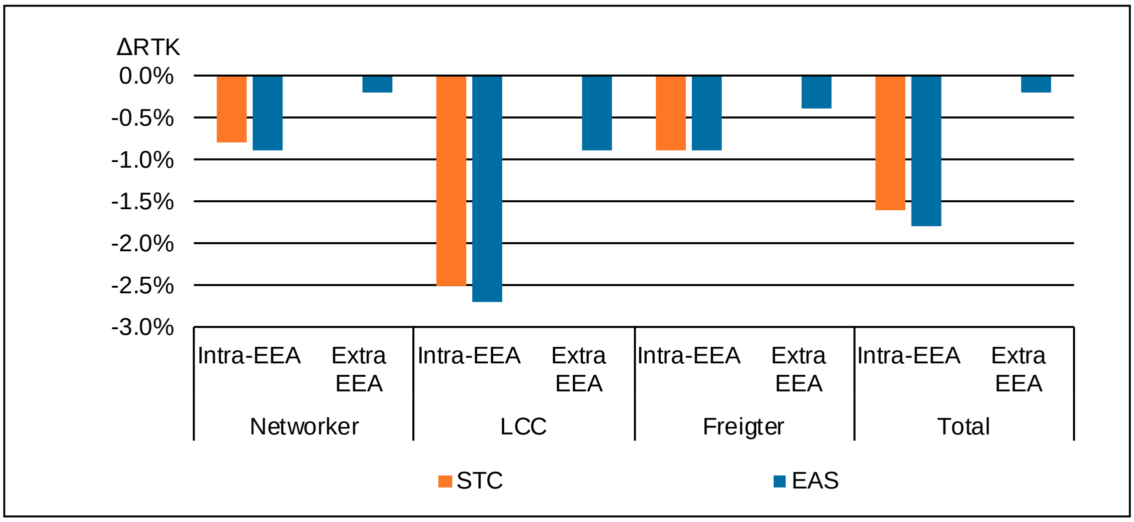
Source: INFRAS

The most affected actors on the aviation market are European LCC airlines. Assuming no passing on of opportunity costs and a price of 25 € per t CO_2, they lose in the STC scenario 0.8% of their RTK and in the EAS scenario 1.2% of their RTK. European freighters and Network Carriers are with a loss in RTK of 0.15% (STC) and 0.5% (EAS) respectively affected in the same magnitude.

Non-European airlines are only marginally affected by the STC design. In the EAS scenario RTK of non-Europe freighters and Network Carriers are reduced by 0.1%. Non-European LCC are almost not affected.

The reduction in demand for 2026, as calculated by the AERO-MS and assuming a CO_2 price of 25 EUR/t CO_2, is shown in figure 37.

Figure 37: **Potential reduction in aviation demand differentiated by markets (situation 2026, 25 EUR/tCO_2, no passing on of opportunity costs of free allowances)**



Source: INFRAS

The demand reduction in 2026 is larger compared with the reduction in 2012, because of the share of emissions for which airlines have to pay (i.e. the emissions not covered by the freely allocated allowances), grow over time.

Also we see that the burden for all scenarios the EU ETS induces a stronger reduction in demand for the intra-European market than for the intercontinental market. Furthermore it gets obvious that in the same market LCC are stronger affected than Network Carriers and freighters.

The higher impacts on LCC compared with the impact on Network Carriers and freighters have several reasons:

- The higher the relative burden of the EU ETS, the higher the share of fuel cost in the total costs of an airline (type). In Chapter 4.1 we saw, that for Network Carriers fuel costs have a significant lower share at total costs than for LCC and freighters.
- The decrease in demand is higher for markets with more price sensitive customers. LCC focus on the most price sensitive customer segment, followed by the customers of Network Carriers and then followed by the costumers of freighters.
- Due to the design of the STC and EAS scenario (intercontinental destinations not or only partly included) airlines are more affected from additional costs if they have a higher share of continental flights (or the lower the share of intercontinental flights). The highest share of continental destinations is seen by LCC, followed by Network Carriers and then followed by freighters.

The first two reasons for the higher effects for LCC are intentional: The EU ETS internalizes a share of external costs of CO_2 emissions. If customers have no willingness to pay this price increase they have a lower valuation for airline services than the real economic cost, and it is economically more efficient if they do not fly anymore. The third reason leads to unintended distortions of competition since both analysed EU ETS designs favour the intercontinental market over the continental market with lower burdens. But this is due to the fact that the realisation of a full EU-ETS with the inclusion of all flights from/to EU has turned out to be politically not feasible.

Table 37: Impact on profits STC scenario without passing on opportunity costs in m EUR

Airline type	Networker		LCC		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW
baseline profits	3.600	10.100	720	660	70	690
profits without pass on of opportunity costs	-0,20%	0,00%	-0,90%	0,10%	-0,20%	0,00%

Table 38: Impact on profits EAS scenario without passing on opportunity costs in m EUR

Airline type	Networker		LCC		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW
baseline profits	3.600	10.100	720	660	70	690
profits without pass on of opportunity costs	-0,40%	-0,10%	-1,20%	0,00%	-0,50%	-0,10%

8.2.2 Long term: cost impact on market conduct (with passing on of opportunity costs)

Potential effect with a higher CO_2 price - results from the models

With a full pass on of opportunity costs, the ticket prices and freight rates will increase more, implying a larger reduction in passenger kilometres and freight kilometres. Our calculations for 2012 show that the impacts will be a little over three times as high in terms of passenger kilometres and freight kilometres. In the STC scenario, the competitive position of non-EU network carriers would increase more, although this is probably a result of the cross-subsidisation assumed in the modelling rather than of the cost pass on.

A major difference between the scenarios is that when markets allow for the pass on of opportunity costs, the net impact on airline profits and on competition would no longer be negative for Europe based airlines, but would become positive. The two tables below show that the EU low cost carriers, which see their profits deteriorate the most if they could not pass on opportunity costs (in relative terms), make the largest gains when they would be able to pass on opportunity costs. A reason for this is that they receive more free allowances relative to their emissions, because their emissions per RTK are lower.

Table 39: Impact on profits STC scenario with and without passing on opportunity costs in m EUR

Airline type	Networker		LCC		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW
baseline profits	3.600	10.100	720	660	70	690
profits with full pass on of opportunity costs	19,00%	0,00%	67,00%	0,00%	28,00%	1,00%

Table 40: Impact on profits EAS scenario with and without passing on opportunity costs in m EUR

Airline type	Networker		LCC		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW
baseline profits	3.600	10.100	720	660	70	690
profits with full pass on of opportunity costs	54,00%	11,00%	93,00%	5,00%	71,00%	13,00%

The tables show that the value of the freely allocated allowances is large relative to the profits of the airlines. This means that a pass on of just a fraction of the opportunity costs, as could for example occur if airlines are not profit-maximising companies but aim to maximise their output, would be sufficient to offset any negative impact of the EU ETS on airline profits.

8.2.3 Effects not covered by the models

Three aspects with relation to the market conduct and often discussed in the context of competition distortions due to the EU ETS cannot be analysed with our two models.

The first aspect is if customers shift their flying routes due to the EU ETS. This question is only relevant for the EAS design, where parts of intercontinental flights are covered by the EU ETS. So one can avoid costs on intercontinental flights if one avoids having a bigger share of the flight as necessary within Europe. E.g. if someone flies from Frankfurt to San Francisco normally three option are available: i) a direct flight ii) a flight with one change in Europe or iii) a flight with one change in the USA. The second option has higher CO_2 costs than the other two options. So customers who do not choose option i) have an incentive to prefer option iii) before option ii). This could lead to a disadvantage for European airlines. As we discussed in Chapter 3 this phenomena is only relevant for some specific long haul destinations. With the current price for CO_2 allowances we do not expect a significant impact. Since under the EAS design only a small part of the intercontinental flying distance is covered by the EU ETS, the price difference between option ii) and iii) and thereby the competition distortion stays small even with significant higher CO_2 prices.

The second aspect is whether Network Carriers shift their hubs to airports which are not covered by the EU ETS. This aspect is mainly relevant in the EAS scenario where intercontinental flights are partly covered by the EU ETS. Under the current political situation we do not expect that airlines shift their hubs due to the EU ETS. At the moment the EU ETS is timely limited until there will be a global solution. This way the timeframe in which airlines might benefit from better conditions with respect to CO_2-costs is expected to be restrained to only a limited number of years. Also the shift of hubs is very time and cost intensive because airline would have to completely redesign their hub-and-spoke network. Moreover, an airline would have to receive the necessary operation rights from the non-European country where the new hub is located, and also the starting/landing slots at the European airport would have to be adjusted. Since in Europe flying slots are grandfathered, there are not always open slots available at the preferred flying times. Furthermore the larger part of aviation demand is in the centre of Europe and it is an advantage for airlines to have the hub nearby their customers. All in all one can be quite sure that the transfer costs of shifting a hub to a non-European country are higher than the expected gains due to the reduced CO_2 costs.

Nevertheless we observe in the last years on the one hand a more intensive competition from airlines from the Gulf region with European airlines. On the other hand we see that European airlines try to outsource labour intensive activities in countries with lower labour costs. These two tendencies exist, but they have no direct link to the EU ETS. The EU ETS will in the maximum increase these tendencies slightly.

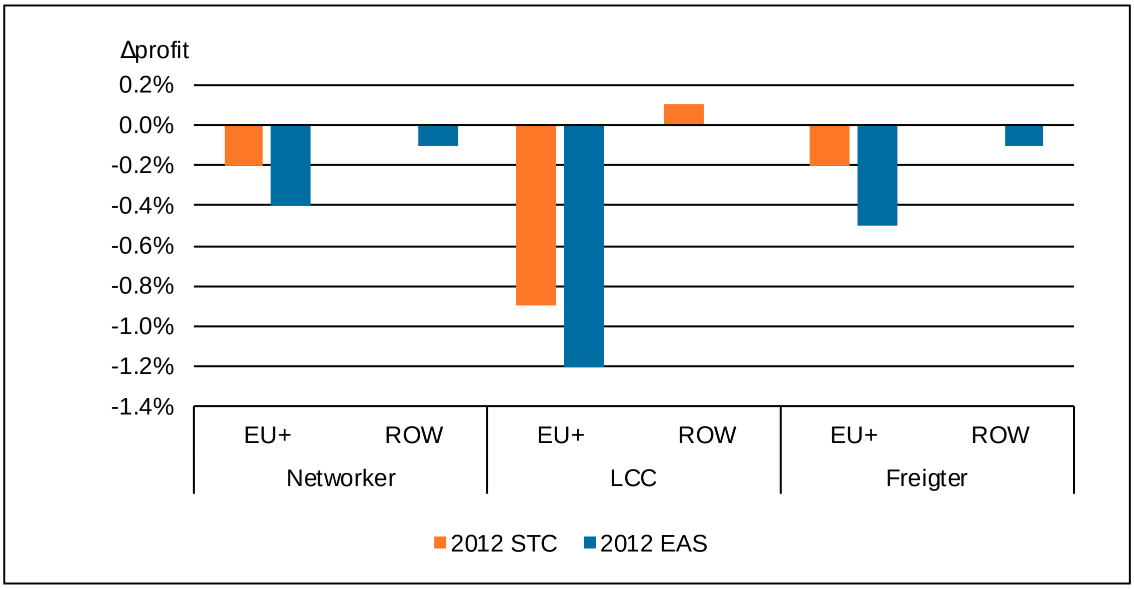
The third question is, whether LCC airlines might have a competitive advantage due to the allocation of free allowances. For 2012 the free allocation of allowances is based on the reported revenue ton km (RTK) in the year 2010. Per 1.000 RTK flown in 2010 emission rights for 0.6422 t CO_2 are allocated for free. Since LCC often have more fuel efficient airplanes (see chapter 4.1), the free allowances covers a larger part of their emissions. But this is exactly the purpose of the EU ETS. Fuel efficiency should be rewarded. Hence we see no unintended distortion of competition in this respect. On the other hand in 2012 this advantage is at least partly compensated by the higher average growth of LCC compared to the growth of the total market. Since the allocation is based on historical transport volumes, airlines with higher growth rates have to pay for a larger share of their emissions than airlines with lower growth rates. In other words, the emission rights for historic traffic volumes are allocated for free whereas emission rights for traffic growth have to be bought. This is an unintended distortion. It favours airlines with low growth rates (or even shrinking transport volumes). In the end it can help airlines, which are at the edge of running out of business, staying marginally longer in the market.

8.2.4 Short term: Impact on market performance (without passing on of opportunity costs)

As already mentioned the allocative efficiency of the aviation market will increase somewhat, since a part of external costs is internalized. The fact that intercontinental flights are not or only partly included biases the market in favour of intercontinental flights.

In the dynamic view the development of profits and investments is of crucial importance. In the models we assume in a first step that all effective costs are passed on to customers, no opportunity costs are passed on and the average load factor stays the same. Therefore the profit per pkm and tkm stays per definition the same. Still, since demand decreases, the absolute profit of European airlines decreases relative to a situation without EU ETS. This decrease in demand has to be seen in the context of a growing market. A decrease in absolute profits relative to the situation without EU ETS means that the absolute profit is growing somewhat slower. The following figure shows how the absolute profits change due to the EU ETS assuming a price of 25 EUR/tCO_2 and the market structure of the year 2012:

Figure 38: Potential reduction in profits (situation 2012, 25 EUR/tCO_2, no pass on of opportunity costs of free allowances)



Source: INFRAS

With respect to demand, the largest decrease in absolute profits is seen by European LCC. Depending on the scenario their profits decrease in the fictive situation by 0,9% (STC) and 1,2% (EAS) respectively. Because of crossfinancing strategies a small part of passengers switch from European LCC to non-European LCC. This leads in the STC scenario to a small increase of the profit of LCC from ROW (+0.1%). In the EAS scenario these gains are compensated by losses due to cost increases by the EU ETS on intercontinental destinations. The losses for European Network Carriers and freighters are again in the same magnitude (-0,2% in the STC scenario and -0,4% respectively -0,5% in the EAS scenario).

The figure shows the effect with a CO_2 price of 25 € per ton. With the actual CO_2 price in the year 2012 (about 7 EUR) the effect of the EU ETS is only about one quarter of the calculated impact (e.g. -0.2% profits for European LCC in the STC scenario). Assuming the STC scenario with a CO_2 price of 7 € we estimate that the total loss in profit for all airlines in 2012 was 3,5 m. EUR.

The loss in profits is higher if not all effective costs can be passed on and if load factors decrease. For the following reasons we believe that at least in the longer run these assumptions are true. In the short term it is possible that due to further efficiency increases (e.g. by cost-cutting programs like “Score” of Lufthansa or “Shape & Size” of Air Berlin) the observed price increase is lower than the effective additional CO_2 costs of the EU ETS. But efficiency increases are not endless and in order to stay in the market in the long run the effective costs have to be passed on to customers finally. Therefore additional effective costs of EU ETS have to be passed on. With respect to load factors it seems plausible that if on a specific destination a given demand level is exceeded a further flight will be supplied. Since the aviation market is growing due to the EU ETS it will take somewhat longer until the level is reached, where an additional flight will be supplied. But in the long run this will not change the average load factor. An exception is the market for national flights, which shows almost no growth. Airlines which operate only on this market can see significant profit decreases since - because of fixed costs - they cannot reduce their costs in lockstep with the shrinking demand.

Profits are important for innovations and investments. If profits decrease there are less means for innovations and investments. But also in this respect we have to appreciate the slightly lower profits against the background of a growing market. We assume that the impact on innovation and investments of the EU ETS will be minor. This has the positive aspect that the repression of investments is low but implies also that the additional incentive for the development of more fuel efficient planes is small. Because the cost increases of the EU ETS are related to CO_2 emissions (and hence fuel), in the long term there will be a positive effect on the fuel efficiency of the aircraft fleet. On the long term there are various mechanisms which can have a positive effect on the fuel efficiency of the aircraft fleet. These are: i) new aircraft technology shift; ii) accelerated fleet renewal; and iii) new aircraft capacity shift. Because of the relatively small EU ETS induced price incentive for technology improvement, the effect on the fuel use per RTK is computed to be rather small. According to the AERO-MS calculation the fuel efficiency increases in maximum (all costs passed on) only by 0.2 % for passenger flights and 0.5% for freighters due to the EU ETS.

Facing the competitive pressure from airlines from especially the Middle East and Far East Asia (that sometimes have advantages in competition with European airlines because they profit from subsidies infrastructure fees at their home base or fuel prices below market prices), for European airlines the free allowances give a certain buffer against this advantages in competition of non-European airlines. Non-European airlines entering or growing clearly in the European market need to buy emission allowances for all of the emissions of their flights. But the buffer through the free allowances is relatively small in comparison to the advantages of the growing competition from East. Therefore no pass on of opportunity costs is expected in the shorter run.

8.2.5 Long term: impact on market performance (with passing on of opportunity costs)

As shown above, when markets allow the pass on of opportunity costs, the profits of European airlines do not decrease slightly, but increase considerably. When airlines act as maximisers of revenues, rather than profit maximisers, and would just pass on a small share of the value of free allowances, they could offset any negative impact on their profitability.

In case of a pass on of opportunity costs, the impact on profits would allow EU airlines to alter their market performance, e.g. by investing in fuel-efficient aircraft.

8.2.6 Impact on market structure

In the long run the market performance influences the market structure. With the actual CO_2 price the impact of the EU ETS on the market structure is hardly observable. The effect is too small to be distinguished from other effects as e.g. short term oil price changes.

Assuming higher CO_2 prices, full passing on of effective CO_2 costs and a constant load factor, the EU ETS in the STC and EAS design have in the growing aviation market on average no significant impact on the market structure overall. In 2012 the shift of market shares between airline types is even with high price assumptions nearly zero. Moreover the impact on profits is low. Therefore on average there is no significant increase in pressure for a market consolidation.

For small European airlines the administrative costs of the EU ETS can have a noticeable impact. Entec (2008) calculates that the administrative costs per airline are about 20.000 € per year. The airlines estimate their administrative expense per airline and year between 40.000 € and 1 m. EUR. Most airlines estimates lies between 100.000 and 200.000 € (INFRAS 2009). For small airlines the administrative costs of the EU ETS can increase the pressure to merge with other airlines in order to reduce the administrative burden.

The EU ETS will introduce no new market barriers, but existing barriers can increase transaction costs. E.g. is it possible, that a non-profitable flight will not be removed from the time schedule because the airline does not want to lose a specific slot. In the short term this can have an impact on profitability. Still, in growing markets these obstacles should not be of major importance but more a phenomena observed in specific market situation (e.g. shrinking airline with a focus on national destinations).

The impacts with no pass through of opportunity cost will lead to slightly lower market shares of LCC and (less negatively affected than LCC) European networker, and slightly higher market shares for non-European airlines flying from and to Europe.

The impacts with pass on would be exactly opposite: Slightly smaller market shares for non-European airlines and slightly higher market shares for European airlines (LCC more than networker).

Overall the impacts of the STC and EAS scenario on the intensity of competition, market share, profitability, environmental impact are small with or without passing through of opportunity costs. This is the case for the assumed price of 25 Euro/tCO2 and even more for the actual price level.

There is the possibility, that the additional cost of the EU ETS can be the last trigger for an airline being at the edge of profitability to run out of business. This has to be seen against the background of the European aviation market, which is also without the EU ETS in a phase of market consolidation. Nevertheless the EU ETS can only marginally increase the pressure for a market consolidation.

8.3 Core Conclusions

In the core conclusions we focus only on the result of the analysis focussing on the impact in the short and medium run. Under the actual surrounding conditions with uncertainty how long the STC scenario will hold, what ICAO's concrete suggestions towards a global solution are and the development of EU ETS in other world regions, the actual regulation in Europe shows no clear signs of long lasting persistence. According to this market participants on the aviation market build their expectations and take their decisions.

Summing up, we come to the following conclusions for the scenarios when effective additional costs are passed on but with no passing on of opportunity costs.

- The impacts of STC and EAS scenario on competitiveness in European aviation market and European airlines are very limited. In comparison to the relevant market factors (cost structure, fuel price, different national regulations, market organisation, grandfathering) the additional factor EU ETS is rather marginal.
- With the actual price level in 2012 of about 7 € the additional costs of EU ETS have only marginal effects on airlines. In the STC framework European airlines face in total additional effective costs in the order of 100 m. to 150 m. EUR. This corresponds to 0,07% to 0,10% of their total costs and has the same cost effect as an oil price increase from 100 USD per barrel to 102 USD per barrel.
- The impacts assuming a price of 25 EUR/tCO_2 are still limited. Thereby we see the following small effects:
  - Overall the impacts of STC and EAS on intensity of competition, market share, profitability, environmental impact are small with or without passing trough of opportunity costs.
  - LCC are confronted with a higher reduction of demand than Network Carriers and freighters. As long as this is due to a higher share of fuel costs at total cost and/or demand with higher price sensitivities, this is the consequence of the partly internalisation of external emission costs and therefore an intended result.
  - LCC face also a higher reduction in demand than Network Carriers and freighters because intercontinental flights are not or only partly included in the EU ETS. In contrast to Network Carriers and freighters, LCC are mainly focussed on continental destination. The EAS and even more the STC design put a higher burden on continental than on intercontinental flights. This is an distortion of competition in favour of intercontinental destinations because not all flights worldwide or all flights from and to Europe are included.
  - The free allocation of emission rights is based on historic RTK (2010). Because of this allocation method slower growing airlines receive relatively to their transport volumes more CO_2 certificates than faster growing airlines (as long the threshold for the new entrance reserve is not reached). As LCC are growing faster than Network Carriers and freighters the allocation method leads to a further disadvantage of LCC.
  - The aviation market has some market barriers as landing rights or the allocation of airport slots by grandfathering. These barriers increase transaction costs for adjustments by airlines. Therefore in the short term EU ETS can lead to a reduction of profit margins e.g. because a non-profitable

flight is not cancelled in order not to lose a specific slot. On average these effects are reduced by the growing market. Nevertheless for specific airlines transaction costs can be a relevant factor and can increase the pressure on airlines at the edge of profitability to merge with other airlines and thereby increase the already existing pressure for a market consolidation.

  - In the short term (up to about two years, no passing on of opportunity costs) the absolute profit level decreases somewhat due to the decrease in demand relative to a situation without an EU ETS. This decrease of the absolute level of profit has to be seen with the growing aviation market in mind. Due to market growth airlines' profit will still increase in the future. In the short term the EU ETS will slightly increase the already existing pressure for a market consolidation if no opportunity costs are passed on.
  - In the medium term (between about 2 and 5 years) there is a transition phase between the short and long term behaviour. Two argumentation lines are possible in this situation. Whether and which part of opportunity costs are passed on depends largely on the steepness of the supply curve and the strategy of airlines (details see chapter 3). If market actors expect a stable and persisting EU ETS as installed the probability of passing on parts of the opportunity costs rises. If the expectations dominate, that inclusion of Aviation in the EU ETS will change or fail or be included in a worldwide system, the probability of passing on opportunity costs diminishes.
  - In the long run (more than five years) and if airlines expect that the system is persistent, it is likely that the market situation will result in a pass on of a larger parts of the opportunity costs. The windfall profits from passing on opportunity costs have the same impact as subsidies for airlines acting in Europe and gives them a competitive advantage against entering or sharply growing airlines in the European market, which need to buy emission allowances for all of the emissions of their flights (after possible allocation of the reserve).

- Looking at environmental effects due to the EU ETS CO_2 emissions are reduced slightly. The reduction of emissions within aviation is small. With a price of 7 EUR/tCO_2 (price level 2012) and the stop the clock design, aviation emissions within the EU ETS in 2012 are reduced by 0,24% and global aviation emissions are reduced by 0,03%. The main effect is seen in other industries because airlines buy emission certificates out of the stationary ETS. If we count for reductions within aviation and in other industries the EU ETS reduces emissions in the STC scenario within the EU ETS by 16% and globally by 1,8%.16% and 1,8% respectively.
- Due to the larger coverage area the environmental benefits are about three times higher in the EAS scenario than in the STC scenario. Since intercontinental destinations are growing faster than continental destination the divergence between the two scenarios will increase over time.

Annexes

Annex A. Description of AERO-MS

A1. Introduction

At the end of the last century, emissions from the civil aviation sector and their possible effects on climate change have become a growing concern. In 1993, the Dutch government's Civil Aviation Department initiated to develop a modelling system to compute and project aircraft engine emissions on a global level and to assess the economic and environmental impacts of policy options to reduce these emissions. This was the start of the development of the AERO (Aviation Emissions and Evaluation of Reduction Options) modelling system or the AERO-MS.

The AERO-MS provides a quantitative description of the present and future air transport system aimed at the assessment of aircraft engine emissions. The main capability of the AERO-MS is to assess the effects of a range of possible policy options to reduce aircraft engine emissions taking into account the responses of and effects on all relevant actors (airlines, consumers, governments and manufacturers). The effects of policies are computed relative to a future scenario, whereby a scenario reflects an expectation of autonomous developments with respect to air transport and flight activities. The economic and technical modelling of air transport within the AERO-MS consists of five interacting models.

The value of the AERO-MS has been demonstrated by its successful application in over 30 international and national studies in the period 1998 - 2014. Because the AERO-MS is a CAEP-approved model for already over 15 years, quite a number of AERO-MS studies have been made for the ICAO secretariat and CAEP/FESG. Furthermore, over the years the AERO-MS was applied in various impact assessment studies for the European Commission.

In 2009 EASA initiated the project SAVE (Study on Aviation Economic modelling). SAVE's objectives have been to provide an update of all relevant input data for the AERO-MS and to enhance its modelling capabilities. Parallel to the execution of the SAVE study the IPR for the AERO-MS were transferred from the Dutch government to EASA.

The purpose of this document is to explain the key principles of the AERO-MS. Section A2 of this document provides a system overview of the AERO-MS including a description of the models. Section A3 includes an overview of the general modelling principles and the main schematisation aspects. Section A4 describes the modelling principles and assumptions by computational step.

A2 Description of AERO-MS and models

Figure A1 provides an overview of the 5 core models in the AERO-MS and the interactions between the models. Apart from the models, the AERO-MS contains a User Interface which is involved with the interaction between the five AERO models and the interaction between the user and the system. A user of the AERO-MS is thus interfacing with the integrated system rather than with the individual models. The five models are briefly described below.

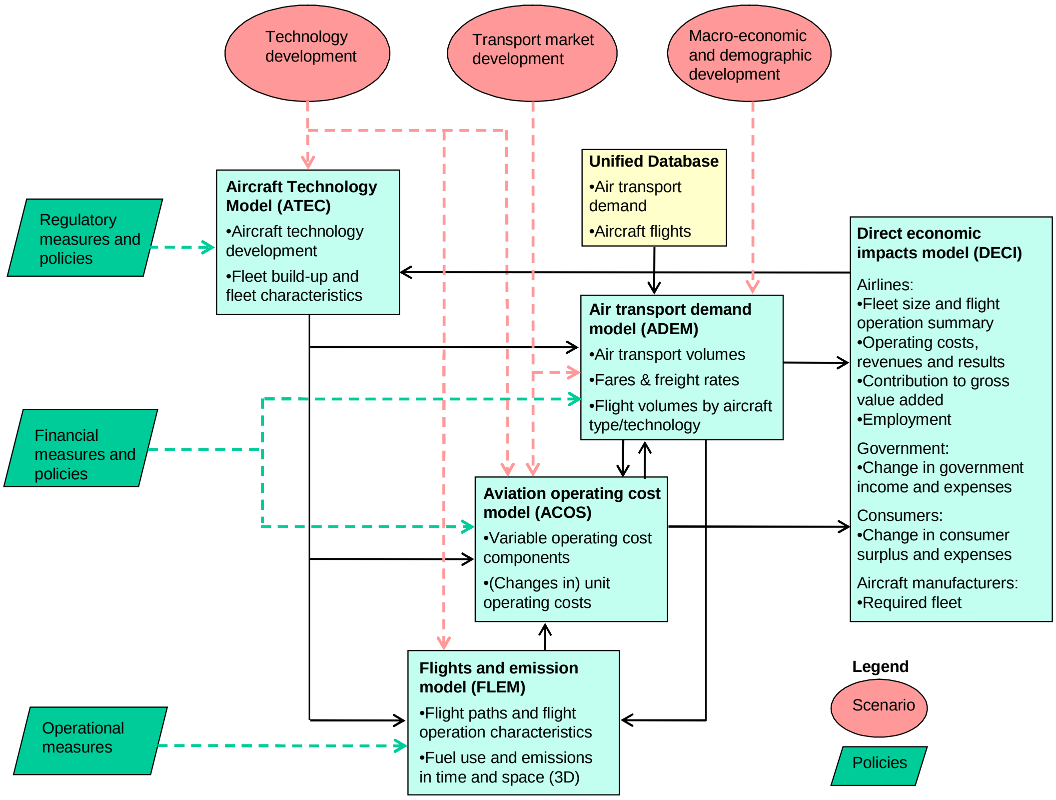


Figure A1. Overview of core models in the AERO-MS

Aircraft technology model (ATEC)

The model ATEC is involved with the computation of technical characteristics by aircraft type and technology level based on a modelling of fleet development over time. Aircraft technology particularly applies to the fuel use and emission characteristics of different aircraft types. The technology characteristics are expressed as a function of aircraft 'technology age' which is defined by the year in which the aircraft (type) is certified. The technology age distribution is determined by the fleet build-up which depends on the development in time of aircraft sales (following air transport demand) and aircraft retirement.

Air transport demand model (ADEM)

The model ADEM matches the demand and supply side of air transport, i.e. air transport demand in terms of passengers and freight and the frequency and capacity of air transport services offered. Volumes of passengers and cargo transported, passenger fares and freight rates are determined in the process of balancing supply and demand. Aircraft flights are determined by origin-destination (flight stages) and expressed in terms of aircraft types and technology levels, in accordance with available fleets.

The starting point for the modelling of air transport demand and aircraft flights is provided by the Unified Database of the AERO-MS, which is a computerised description of the volume and pattern of global air transport activity in the base year (the Base year of the original AERO-MS was 1992; in 2010 the base year was updated to 2006). The Unified Database is based on the WISDOM database from EUROCONTROL.

Aviation cost model (ACOS)

The model ACOS computes all relevant variable aircraft operating cost components and total operating costs. Variable operating costs are associated with flights by aircraft type and technology level and include: fuel costs; route and landing (airport) charges; flight and cabin crew costs; maintenance costs; capital costs (depreciation) and finance costs. In addition, total operating costs include a number of other, volume-related, costs such as the costs of ground-handling, sales, ground facilities (buildings) and overhead. Based on the total operating costs, ACOS determines the unit costs (per passenger and kg of cargo transported) of air transport by aircraft type, technology level and IATA region-pair. In particular, the model ACOS converts the costs of possible measures in the air transport sector to changes in unit operating costs.

Flights and emissions model (FLEM)

The model FLEM provides a detailed description of the actual flight profiles of individual aircraft flights. Fuel-burn and emissions for each flight are computed in three-dimensional space, taking into account the geographical flight specification and the technical characteristics by aircraft type and technology level. The emissions considered include CO2, NOx, SO2, CxHy, CO and H2O. In addition to the computation of fuel-burn and emissions there are a number of other important functions of FLEM. The detailed description of flight paths in FLEM allows for the simulation of a number of specific policy options related to flight operation. Also there is a direct connection between ATEC and FLEM allowing FLEM to take into account developments in aircraft technical and environmental performance as forecasted from scenarios and policies. And finally FLEM provides the information on fuel-burn as a basis for the cost computations in the AERO-MS.

Direct economic impacts model (DECI)

The model DECI is essentially a post-processing model. One of its main functions is to provide a comprehensive overview of the results of the other models in the AERO-MS, in particular the information related to air transport volumes; operating costs, revenues and results; fleet size and flight operation. Another main function of DECI is to compute a number of direct impacts to the relevant actors involved in air transport such as: the contribution of airlines to gross value added; changes in government income and expenses; changes in consumer surplus and expenses; and changes in the required fleet.

Model interactions

Based on the core models described above, the AERO-MS represents an integrated system of interacting models. The model ATEC provides inputs on aircraft technology characteristics by aircraft type and technology level to each of the models ADEM, ACOS and FLEM. The models ADEM and ACOS closely interact, whereby ADEM provides information on flight volumes by aircraft type and technology level to ACOS as a basis for computing operating costs, while ACOS provides information on changes in unit costs (following from measures) to assess the impacts of measures on flight volumes in ADEM. The resulting information on flight volumes by aircraft type and technology level from ADEM is used by the model FLEM for the computations of fuel-burn and emissions. In turn, information on fuel-burn resulting from FLEM computations is used in ACOS to allow for the computation of fuel cost. Finally, the information on fleet size and flight operation as compiled in DECI can be fed back into ATEC to ensure consistency with the fleet build-up used in ATEC to determine fleet technology characteristics. In order to facilitate the above interactions between and among different models, the design of the AERO-MS includes a number of iteration procedures and specific provisions.

A3 General modelling principles and schematisation aspects

A3.1 General modelling principles and modelling dynamics

Future developments with and without measures

The objective of the AERO-MS is specifically to quantify the economic and environmental impacts of possible measures related to the air transport system, under different future developments. For this purpose the modelling approach very clearly distinguishes between the following three situations (see Figure A2).

1. A base situation, providing the best possible description of today's world (the existing situation).
2. A user-defined specification of a future situation, without specific measures taken in the air transport sector – a Business as Usual (BaU) scenario.
3. The user-defined future situation, with specific measures taken in the air transport sector.

The second situation may involve a specification of different future situations (different sets of assumptions on economic and technological development), providing alternative contexts within which the air transport system operates. The effects of different BaU scenarios follow from a comparison of BaU scenarios with the base situation (situations 2 with 1). Within a specified BaU scenario, the effects of an air transport measure or set of measures can be tested by comparing situations 3 and 2. This can be repeated for different measures or sets of measures, allowing for a comparison across different measures within the same BaU scenario context. Figure A2 illustrates these principles.

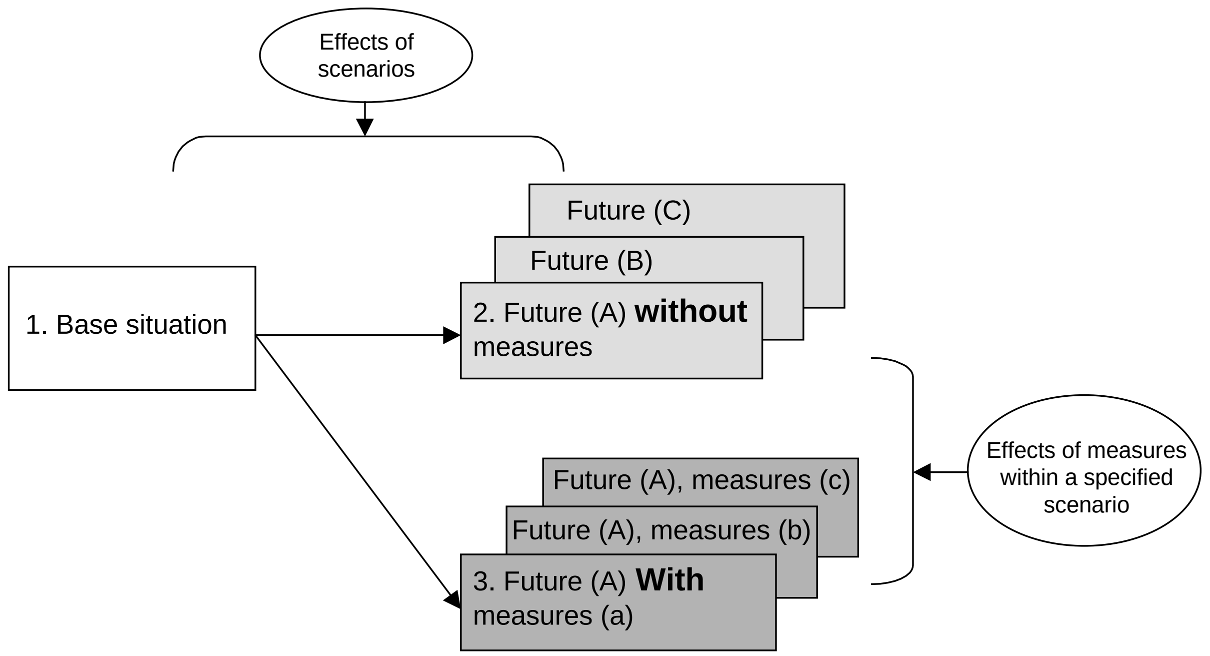


Figure A2 Effects of scenarios and measures

The computational steps in the AERO-MS (see Figure A1) apply to all three situations shown in Figure A2, although the meaning and purpose of some of these computations may change.

- The computations in the base situation provide a coherent description of the existing air transport system in terms of passengers and freight transported; aircraft flights; airline operating costs, revenues and results; fuel use, emissions and related environmental effects.
- The future situation without measures is driven by the effects of autonomous macro-economic, demographic and technological developments. The effects of such developments become manifest in changes in fuel use and emission characteristics and purchase prices of aircraft; air transport demand (passenger and freight), fares and freight rates; and aircraft flights by flight stage, aircraft type and technology level. Consequently, the computation of all economic and environmental effects needs to be updated. These forecasts are applied incrementally to the Base situation thereby reflecting the historic developments in aviation.
- In the future situation with measures a variety of measures can be introduced (including economic, regulatory, operational and other measures). These measures generally lead to an increase in the cost of air transport, which in turn may lead to changes in fares, and therefore to changes in the growth of air transport demand. The AERO-MS takes account of these measure-induced changes (relative to the situation without measures) in costs, fares and demands, and updates the computation of all economic and environmental effects.

Modelling dynamics

The AERO-MS is first and foremost a tool for testing and comparing alternative policy options and therefore, its objective is to quantify the effects of policy options relative to the situation without policy measures (the BaU scenario). To achieve this it focuses directly on estimating the differences in (especially) aircraft operating costs between the ‘with policy’ and a BaU scenario, from which it infers the corresponding differences in airline and consumer behaviour, and ultimately in aircraft emissions.

Thus, the fundamental question addressed by the AERO-MS is: “Given a BaU scenario, and the policy option to be tested, in what ways and to what extent would the results in the policy case differ from the BaU scenario?” The model can answer this question for any BaU scenario in any (forecasting) year specified by the model-user. For a given BaU scenario in the user’s selected year, therefore, the effects of alternative policy options can be quantified in relation to a common benchmark. This produces a “snapshot” of each policy option against the same BaU scenario in the same year, which allows the model-user to carry out a comparative evaluation of the policy options on a completely consistent basis.

In order to inform decisions on the long-term comparative merits and costs of different policy options, it is preferable to consider the effects of measures when they have ‘matured’: that is, when the adaptations of carriers, consumers and other affected parties to the measures can be regarded as reasonably complete. With a time-series model, it is necessary to estimate the process of adaptation to each measure through time, and the years for which the criterion of reasonably-complete adaptation is satisfied may be far into the future, by which time the BaU scenario itself has become highly speculative.

The snapshot approach permits the model-user to compress this timescale. In effect, for the purpose of comparative evaluation of policy options, the user can assume that the measures were introduced sufficiently long before the selected forecast year so that, by that year, reasonable adaptation will have been achieved. Thereby it is straightforward to tale a further snapshot for a different forecasting year for which a BaU scenario has been specified.

As noted above, the AERO-MS focuses on estimating the differences between the policy case and the BaU scenario. This requires in turn estimates of responsiveness of (for example) the choice between older and newer technology aircraft to policy-induced differences in operating costs. The best evidence for this is the observable current mix of aircraft types, and how that is related to differences in operating costs. The current mix is of course the cumulative outcome of many acquisition and operating decisions over a long period of time. Thus, if systematic relationships between fleet mix and costs can be identified from the current situation (which they can be), these will provide appropriate estimates of the ultimate, mature responsiveness to differences in costs that are needed for the snapshot approach.

The snapshot approach is not devoid of a temporal dimension, however. For this it depends on the BaU scenario. In AERO, the model-user is provided with considerable freedom to specify his preferred BaU scenario(s), in terms of future global and regional economic growth, technology development, trends in costs and fares, the competitive environment, etc. These business-as-usual factors are predominantly exogenous to the industry, and thus are “givens” for analysing policy options. The snapshot approach ensures that the estimated effects of policy options are entirely consistent with these “givens”. Consequently, the relative benefits and costs of measures can be explored rapidly and flexibly for different BaU scenarios, such as the extent to which the competitive environment will permit increased operating costs to be reflected in higher (than BaU) fares.

It has already been emphasised that the AERO-MS approach estimates the mature outcome of policy options, to permit consistent comparison of the long-term merits and costs of alternative measures. Thus, though cases with measures are modelled as differences from a BaU scenario, it is important to appreciate that they represent the outcome (by the forecast year) of a different course of events through time compared to the BaU scenario. This reflects that in reality either the case without measures (BaU scenario) or a case with measures could occur, but not both, and certainly not a sudden shift from one to the other when a measure is introduced.

Rather, if policy options are applied in reality, there will be a period of transition from the historical BaU course of history to the mature with measures course of the future. The AERO-MS provides for this. For some policy options (such as certification measures) the model-user is required to specify an "announcement year" in addition to the forecast year; the snapshot taken in the forecast year then takes into account that not necessarily all of the fleet will by that time have become subject to the measure.

For other measures, the model-user can decide whether the time horizon between now and his selected forecast year is too short for the mature position with measures to have been reached. The AERO-MS then applies a transition mechanism to acknowledge that adaptation to the mature position will in reality not be complete by the forecast year. Thus the AERO-MS can estimate more accurately the true – though transitory - position concerning the effects of a measure in a specified future year, as well as allowing the user to compare alternative measures in terms of their long-term mature benefits and costs.

Time Aspects

The current base year considered is 2006. Based on projections from the year 2006, any future year can be simulated from the base year. For each future year a specific computation has to be made. Different assumptions about specific growth rates (for example passenger demand) can be made for different time intervals, allowing for the creation of a consistent scenario projection across a number of subsequent scenario years.

A3.2 Schematisation aspects

This section provides an overview of the key dimensions used in the AERO-MS and their representation or schematisation. The schematisation used in the AERO-MS defines the structure of the model and is primarily a fixed feature of the modelling system and cannot easily be changed or adapted for specific requirements.

Air transport activity

In the AERO-MS, aircraft flights are specified by nine generic aircraft types (following from relevant combinations of range and seat capacity), two technology levels, and two aircraft purposes (passenger/combi and freighter aircraft). Furthermore flights are split into scheduled flights of network carriers and Low Cost Carrier (LCC) and non-scheduled flights. Passengers on scheduled network carrier flights are further divided into three classes: first/business, economy and discount.

Spatial/geographical aspects

In the data underlying the AERO-MS, flights have been considered for more than 123,000 airport pairs. Results for individual flight stages can be aggregated to various aggregation levels to be specified by the AERO-MS user. By default results are aggregated to 196 region pairs, based on 14 geographical regions derived from ICAO definitions (see table A1).

Emissions and concentrations are computed by the AERO-MS in 3-dimensional space, based on a global geographical grid of 1° by 1° (longitude/latitude) and 15 equidistant altitude bands of 1 km.

Table A41 Overview of regions used in AERO

Code	Name
0	North America
1	Central America and Caribbean
2	South America
3	ECAC (non-EU)
4	EU
5	Russia and Belarus
6	North Africa
7	Sub-Saharan Africa
8	Middle East
9	Indian Subcontinent and Central Asia
10	China and Mongolia
11	Japan and Korea
12	South East Asia
13	Australia and Oceania

A4 Main principles and assumptions by computational step

A4.1 Computational steps

The AERO-MS includes a sequence of logical steps from the description and generation of air transport demand to the assessment of the environmental and economic impacts of aircraft engine emissions. These steps cover the following computations:

1. Aircraft technology and fleet build-up (model ATEC).
2. Air transport demand (passengers and freight), supply (capacity offered) and aircraft flights (model ADEM).
3. Costs of air transport (model ACOS).
4. Revenues of air transport (model DECI).
5. Direct economic effects of air transport (model DECI).
6. Aircraft flight paths, fuel use and emissions (model FLEM).

The result from the computations of one step feeds into another and this logical sequence defines the relationships between them. For each computational step the main principles and assumptions are described in the sections below.

A4.2 Aircraft technology and fleet build-up

Background to the AERO-MS approach to modelling technology

The AERO-MS has adopted the concept of generic aircraft types. Named aircraft types are allocated to generic types on the basis of their capacity and range capability. In dispensing with detail concerning individual named types, this process effectively summarises the aircraft fleet while preserving - even emphasising - essential differences in aircraft functionality.

The generic concept takes on increasing value, the longer the forecasting horizon. This is because it can be presumed that generic types are a permanent feature of the aircraft fleet through time, whereas existing named aircraft types will (sooner or later) be phased out. The generic concept avoids the modeller having to speculate on the detail of still-to-be-designed successor types.

The AERO-MS approach to technology development in the aircraft fleet builds on the generic concept. There are two key features of the AERO-MS approach:

- Two technology levels
- The course of technological improvement through time.

Concerning the two technology levels, it was recognised in the design of the AERO-MS that the policy measures which the model was required to test would impact differentially on the operating costs and emission characteristics of different aircraft types. Compared to a BaU scenario, this would cause some aircraft types to become more attractive to carriers, and others less so. An important response to policy measures that the model had to allow for, therefore, was that carriers would purchase technologically different aircraft in the policy case compared to those they would have acquired in the BaU case.

In many instances, however, the basic functionality (capacity and range) required of the aircraft would not be different. This implied that either:

- The average technology characteristics (fuel-burn, emissions index, etc) of the generic types would need to be altered from their BaU scenario values for each policy case; or
- The generic types could be further split by technology level, with fixed technology parameters, and the model constructed formally to estimate the proportional take-up of the technology levels, dependent upon the Policy case being tested.

The latter course was adopted. While several technology levels could have been defined, it was decided that two satisfied the basic modelling requirement. These are often referred to as ‘current’ and ‘older’ within the AERO-MS. For the base-year 2006 ‘current’ are defined as any aircraft type with technology certificated between 1990 and 2006, while ‘older’ covered those with technology certificated earlier than 1990.

Taking the breakpoint as 16 years old (in certification terms) is also helpful in that approximately half of the total fleet would thus be classified as ‘current’ and half as ‘older’. This facilitated choice-modelling between the two technology levels.

For each generic capacity/range/technology aircraft type, the average technology characteristics were estimated from details of the operational fleet in 2006. With the historical trends in technology improvement, however, these averages were clearly going to change through time. While it would have been possible simply to assume that increasing proportions of the total fleet were of post-1990 certification age, this would have implied that, as the forecasting horizon extended into the future, the ‘older’ level would have become steadily defunct. This would have defeated the purpose of having the technology levels in the model, since the opportunity to adapt the choice of technology according to different policy measures would have been lost.

The concept of 'rolling' technology was therefore introduced. Essentially, this recognises that there are trend developments in technology characteristics (specified for the future BaU scenario case in the AERO-MS by the mode-user). Thus the available choices of technology in the future will have moved on from their 2006 levels. There will, however, still be relatively newer and poorer technology in any given year, which can continue to be represented by the 'current' and 'older' levels. The differentiation of 16 years in certification age is maintained, so that they still fulfil the modelling ideal of having similar proportions of the fleet in the two levels.

This means, of course, that all aircraft that were 'current' in 2006 have migrated to the 'older' level by 2022. They retain their original technology parameter values, but now these are 'older' compared to the 'current' values of aircraft certificated since 2006. By 2038 (2022+16 years), these in turn will have become 'older', and there will be a new generation of 'current' aircraft with newer technology.

Thus the 'rolling' technology approach builds on the advantages of the generic concept as described at the start of this section, especially as the forecasting horizon extends. It ensures that the AERO-MS is equally able to assess policy measures against the technology norms expected to prevail in any forecasting year. In reporting the results from the AERO-MS the technology 'levels' of 'older' and 'current' are referred to as 'Technology age > 16 years' and 'Technology age <= 16 years' respectively to avoid the confusion that the general terms for the technology classes have provoked.

Main principles of the technology aspects of the AERO-MS

- The main principles of the technology aspects of the AERO-MS can be summarised as follows:
- Aircraft technology applies to the fuel use and emission characteristics of different generic aircraft types. Fuel use and emission characteristics are expressed as a function of the certification age of aircraft.
- Technology levels ('older' or 'current'), as described above, are defined by certification age: the older fleet consists of the aircraft with certification age 16 or more years prior to the year considered (base or forecast year); the current fleet is the remaining part with more recent certification age.
- Fleet build-up is modelled over time (number of aircraft by aircraft type and purchase year) based on 'natural' aircraft replacement and additional capacity requirements following from demand growth. Natural aircraft replacement takes place as a function of time around an assumed average scrap age.
- Assumed annual technology improvement (fuel use reduction) of newly bought aircraft before 2006 based on observed trends and from 2006 onwards based on user assumptions (typically in the order of 1% improvement per year).
- Fleet build-up and related certification age distribution determine the number of older/current aircraft in the fleet and the weighted average fuel use and emission characteristics by aircraft type and technology level, as a function of time.
- The technical measures which may be considered are:

- o technology improvement (stringency) measures to improve fuel use and emission characteristics of new aircraft entering the fleet beyond the assumed scenario development, at the expense of increasing the new aircraft purchase price (to be specified by year and aircraft type);
- o scrapping a part of the older fleet above a certain age (to be specified by aircraft type).
- o a subsidy measure as a means to increase the proportion of aircraft of latest technology in the fleet (to be specified by aircraft type).

The resulting cost increases and improvement of fuel/emission characteristics are then taken into account in the further computational steps.

An increase in fuel efficiency over time will be due to:

- the annual increase in fuel efficiency assumed;
- the change in the aircraft size mix towards, on average, larger aircraft; and
- a forecast increase in the proportion of the fleet with 'current' technology.

A4.3 Air transport demand, supply and aircraft flights

Demand, supply and aircraft flights (for the base situation) follow from an extensive inventory and combination of existing data sources, leading to the creation of the so-called Unified Database (UD). For the number of flights, and the distribution across aircraft types, the UD is based on the WISDOM database from EUROCONTROL. For demand information use is made of a variety of other sources like ICAO Traffic by Flight Stage (TFS), US Department of Transport (DOT) and IATA Route Tracker passenger class split data.

In the BaU scenario projections used in most policy analysis, demand growth is merely based on autonomous projections supplied by external sources such as CAEP traffic and fleet forecasts.

Changes in fares and freight rates can be specified as part of the scenario (as detailed at the flight stage level). These would lead to an impact on demand growth through the use of a set of variables expressing the price elasticity of demand, thereby affecting airline profitability.

The basic assumption is that capacity on each flight stage will be adjusted in proportion to the changes in forecast demand. Service frequency and the aircraft capacity mix on each route are adjusted to reflect the changes in demand level in accordance with systematic relationships, ensuring that demand is satisfied with realistic load factors. These relationships were derived from, and calibrated against, empirical data. Aircraft technology allocation follows from the historic growth patterns underlying the fleet build-up.

In the 'future situation with measures' a variety of measures (such as taxation, emission trading or technology measures) could be applied. These measures generally lead to cost changes, which may have two important impacts. First, to the extent that cost changes differently affect aircraft types and technology levels (for example a scrapping measure or a fuel related taxation), there will be a shift in the use of aircraft types and technology levels. The extent of this shift is determined based on a comparison of total per unit aircraft operating costs (per passenger or kg of freight) across aircraft types and technology levels, taking into account the relative "substitutability". Basically such shifts reflect the airline responses to minimise cost increases following from imposed measures. These responses are implicit in the model.

A second effect of changes in aircraft operating costs is that airlines may be forced to increase their prices in order to maintain their profitability. Such price increases would reduce the growth of demand (through variables expressing the price elasticity of demand). The crucial question is how airlines would respond to the increase in costs. The AERO-MS allows for an explicit specification of a so-called "profit adjustment factor" by the user. At one extreme, when this factor is set to 0, the carriers will absorb the additional costs. Fares, demand and capacity would be unchanged (from the situation without measures) and the profitability of airlines would deteriorate. At the other extreme (profitability adjustment factor set to 1), the carriers are assumed to be able to pass on cost increases in higher fares and freight rates to achieve the same profitability per **unit** of capacity as would occur in the situation without measures. Demand and capacity growth would then be reduced, which would have an appreciable impact on fuel use/emissions. Using the 'profit adjustment factor', any situation at or between these extremes can be simulated.

With respect to the time aspects of airline responses, it is important to understand such responses (especially the aircraft “substitutability”) in the context of alternative long-term developments over time. In the model, the basic assumption is that airlines are able to adapt their fleets through time, in response to changes in costs of aircraft types. In effect it is assumed that they would purchase different aircraft and retire others at different rates from those that they would have acquired in the situation without measures. For these responses to develop, a considerable amount of time (presumably of the order of 10 years or more) would be required. Depending on the time frame of the analysis, the available time may or may not allow for this. If available time is too short, the AERO-MS provides a possibility to reduce the extent of predicted fleet adjustment in order to ensure the feasibility of the response.

A4.4 Modelling the response of demand to cost changes

The input passenger fare elasticity values in the AERO-MS are based on extensive research of InterVISTAS Consulting. This research was undertaken in 2008 in an assignment for IATA, and are published in an economic briefing of IATA. The input passenger fare elasticity differ by geographical market (route group) and by passenger purpose (business versus leisure).

In the AERO-MS the effective passenger fare elasticity may in principle vary on all flight stages, since these are derived from components of:

- The input fare elasticity by geographical market and passenger travel purpose (business/leisure);
- The business/leisure passenger mix by fare class;
- The mix of fare classes by flight stage.

The combination of these effects gives rise to ‘effective’ scheduled passenger fare elasticities by region pair and class, averaged over all flight stages. It is important to note that the fare elasticities used in the AERO-MS are industry-specific rather than carrier-specific values. Thus, these elasticities are used to illustrate the impacts of increased air fares on the whole market, on the basis that all carriers are equally affected and will react in the same way.

The model user may change the input assumptions that drive the computation of these elasticities. The passenger fare elasticities by passenger class and region pair (or geographical market) are constructed from elasticities defined by travel purpose and a mapping between journey purpose and class of travel chosen. Price elasticities for cargo demand do not vary by route group.

A4.5 Costs of air transport

Variable aircraft operating costs (direct operating costs) are considered on the level of flight stage by aircraft type and technology level. The model is primarily concerned with the marginal operating cost changes which affect whether an airline would choose (in the long term) to adapt the aircraft types used to meet demand as a result of policy measures. Thus the variable operating costs, included in the model, are therefore those that vary significantly by aircraft type and technology level. Given this requirement the costs of air transport are modelled as follows:

- The variable (flight related) cost components considered are: fuel costs, maintenance costs, flight and cabin crew costs, landing (airport) costs, navigation (route) costs, capital (depreciation) and finance costs. The various direct operating cost components are based on an assessment of costs by cycle, by distance (km), block hour, or some combination of these, as appropriate.
- Fuel consumption and cost are computed on the basis of an LTO-related fuel use and a specific fuel use per km, by aircraft type, technology level and distance band, taking into account the fuel use characteristics by aircraft type and technology level and the aircraft weight (based on empty weight, average payload and fuel required for the flight). A very detailed computation is made by the FLEM model, in order to determine emissions in three-dimensional space. A simplified computation of fuel use for the cost assessment is calibrated against this more sophisticated approach and results are, for the various aircraft types and distance bands, within a few %.
- Annual capital costs (depreciation costs and finance costs) follow from the difference in residual value of aircraft by aircraft type and technology level between two subsequent years. Residual value depends on the depreciation scheme applied, the aircraft purchase price and aircraft age.
- In addition, the other (non-flight related) costs, such as the costs of ground handling, sales, ground facilities (buildings) and overhead, are considered as a single, volume related, cost by type of flight activity (scheduled/non-scheduled and pax/freight) and route (region pair). In the future projection these costs are updated with the volume of flight activity (in terms of revenue tonne-km). In addition, as part of the scenario specification, the user can define a scaling factor (by region pair) to reflect more specific developments in the volume related costs (for example an efficiency effect).
- As part of the future projection, various assumptions underlying the computation of the cost components can be varied. In making these projections, there is no implicit link in the model to the specification of fares. Fare developments as part of the scenario, are to be specified by the model user independently. Consequently, the profitability in the scenario projection follows from user-defined inputs.
- In the situation with measures, the various cost components are re-computed to reflect the possible cost changes brought about by the measures. For both the situation with and without measures, the total unit operating costs (per passenger and per kg of freight) are computed by aircraft type, technology level and flight stage.

This is the basis for the cost comparison between the 'with' and 'without' measures situation, which determines the shifts in the use of aircraft types and technology levels.

A4.6 Revenues of air transport

Revenues of air transport directly follow from the numbers of passengers and freight transported and passenger fares and freight rates applied. Scheduled and non-scheduled/LCC passengers and fares are considered for each individual flight stage; for scheduled these are further differentiated by class (first/business, economy and discount). Freight and freight rates are also considered by flight stage. Scheduled and non-scheduled freight are separately considered, but there is presently no distinction between scheduled and non-scheduled freight rates.

In the scenario projection, numbers of passengers and amount of freight transported by flight stage follows from specified air transport growth rates. Scenario developments of fares and freight rates can be explicitly specified by the user and these must be set with explicit knowledge of the parallel assumptions made on the changes in air transport costs. As noted earlier, within the model, scenario changes in fares and freight rates will have an impact on projected air transport demand (through the price elasticity of demand).

In the future situation with measures, depending on the scenario assumptions made with respect to the possibilities to maintain profitability, fares and freight rates will be adjusted if aircraft operating costs increase due to the cost of measures. This will lead to an increase in fares and freight rates, and at the same time reduce demand growth.

A4.7 Direct economic effects of air transport

The direct economic effects of air transport include a report of airlines' total operating costs, revenues and results. In addition, a number of other economic effects are computed. These include:

- airline related employment;
- airlines' contribution to gross value added;
- changes in government income;
- changes in consumer expenses and consumer surplus.

The latter two effects apply to the 'with measures' situation only. Possible effects on manufacturers could be inferred from changes in required fleet capacity and related aircraft sales.

Airlines are considered as 'airline clusters' which coincide with the groups of carriers based in each of the (14) ICAO based regions. Aircraft operating costs and revenues by route (flight stage and ICAO based region pairs) are converted to airline 'clusters', taking into account the relative shares of these airline clusters on the flight activity per route. Operating result is the difference between operating revenues and costs.

Airline related employment includes flight crew, cabin crew and maintenance staff, as well as a volume related employment part. Flight and cabin crew employment follow from block hours flown and crew needed by aircraft type. Maintenance employment is based on maintenance hours, following from the number of block hours operated. Volume related employment is an input to the model. Projected volume related employment is scaled with projected volume related costs.

Gross value added is defined as the summation of total labour expenses, airline operating results, capital cost and finance charges by airline cluster.

Changes in 'government' income reflect the revenues from taxation measures in the air transport sector. Regional governments are distinguished by region.

The changes in consumer expenses reflect the changes in the costs spent on air transport by 'clients' between the future situations with and without measures. Consumer surplus is defined as the difference between the price a consumer of air transport is willing to pay and the price he actually pays. On theoretical grounds, this can be derived from the air transport demand curve. In the AERO-MS only the change in consumer surplus is computed between the with and without measures situation, based on the changes in air transport demand and the changes in fares.

A4.8 Aircraft flight paths, fuel use and emissions

A detailed fuel use and emission computation takes place for each individual flight in three dimensional space based on a specification of the flight profile, taking into account the geographical flight specification and the technical characteristics by aircraft type and technology level.

The flight profile calculation starts with a computation of the aircraft's take-off and landing weight (based on empty weight, payload and fuel weight). As part of the standard ICAO LTO-cycle, the flight profile includes the phases: taxi-out (from gate to runway), takeoff, climb out (to 3000 ft), final approach, landing and taxi-in (from runway to gate). The remaining flight phases include continued climb (from 3000 ft to cruise level), cruise phase and initial descent (down to 3000 ft). For the latter phases, a detailed flight profile is computed by aircraft type and technology level, in terms of altitude, speed, thrust and fuel flow, as a function of actual flight distance.

Emissions in three dimensional space are computed by aircraft type and technology level, based on a mapping of flight profiles to a world wide grid, using emission indices of the relevant engine exhaust gases (CO2, NOx, SO2, CxHy, CO and H2O). Some of these emission indices (CO2, H2O and SO2) are directly related to fuel use. Fuel use and emissions per grid cell can be aggregated to obtain values per airport and/or region; per aircraft type and technology level; and per altitude band.

Annex B Airport per country with highest number of flights

Table B1. Airport per EEA country with highest number of flights to/from destinations in third countries in 2012.

EEA country		Airport Code	Airport City
1	Austria	LOWW	VIENNA
2	Belgium	EBBR	BRUSSELS
3	Bulgaria	LBSF	SOFIA
4	Croatia	LDZA	ZAGREB
5	Cyprus	LCLK	LARNACA
6	Czech Republic	LKPR	PRAGUE
7	Denmark	EKCH	COPENHAGEN
8	Estonia	EETN	TALLINN
9	Finland	EFHK	HELSINKI
10	France	LFPG	PARIS
11	Germany	EDDF	FRANKFURT
12	Greece	LGAV	ATHENS
13	Hungary	LHBP	BUDAPEST
14	Iceland	BIKF	REYKJAVIK
15	Ireland	EIDW	DUBLIN
16	Italy	LIMC	MILAN
17	Latvia	EVRA	RIGA
18	Lithuania	EYVI	VILNIUS
19	Luxembourg	ELLX	LUXEMBOURG
20	Malta	LMML	MALTA
21	Netherlands	EHAM	AMSTERDAM
22	Norway	ENGM	OSLO
23	Poland	EPWA	WARSAW
24	Portugal	LPPT	LISBON
25	Romania	LROP	BUCHAREST
26	Slovakia	LZIB	BRATISLAVA
27	Slovenia	LJLJ	LJUBLJANA
28	Spain	LEMD	MADRID
29	Sweden	ESSA	STOCKHOLM
30	United Kingdom	EGLL	LONDON

Table B2. Airport per third country with highest number of flights to/from destinations in EEA countries in 2012.

Third country*		Airport Code	Airport City	Third country*		Airport Code	Airport City
1	Albania	LATI	TIRANA	48	Macedonia, Former Yugoslav Republic	LWSK	SKOPJE
2	Algeria	DAAG	ALGIERS	49	Malaysia	WMKK	KUALA LUMPUR
3	Antigua and Barbuda	TAPA	ANTIGUA	50	Mauritius	FIMP	MAURITIUS
4	Argentina	SAEZ	BUENOS AIRES	51	Mexico -6	MMMX	MEXICO CITY
5	Azerbaijan	UBBB	BAKU	52	Mexico -7	MMHO	HERMOSILLO
6	Bahamas	MYNN	NASSAU	53	Mexico -8	MMTJ	TIJUANA
7	Bahrain	OBBI	BAHRAIN	54	Moldova, Republic of	LUKK	KISHINEV
8	Barbados	TBPB	BRIDGETOWN	55	Montenegro	LYPG	PODGORICA
9	Belarus	UMMS	MINSK	56	Morocco	GMMN	CASABLANCA
10	Belize	MZBZ	BELIZE CITY	57	Namibia	FYWH	WINDHOEK
11	Bosnia and Herzegovina	LQSA	SARAJEVO	58	Oman	OOMS	MUSCAT
12	Botswana	FBSK	GABORONE	59	Papua New Guinea	AYPY	PORT MORESBY
13	Brazil -3	SBGR	SAO PAULO	60	Puerto Rico	TJSJ	SAN JUAN, PR
14	Brazil -4	SBEG	MANAUS	61	Qatar	OTBD	DOHA
15	Brunei Darussalam	WBSB	BANDAR SERI BEGAWAN	62	Russian Federation 2	UMKK	KALININGRAD
16	Cameroon	FKKD	DOUALA	63	Russian Federation 3	UUEE	MOSCOW
17	Canada -3.5	CYQX	GANDER	64	Russian Federation 5	USSS	YEKATERINBURG
18	Canada -4	CYHZ	HALIFAX	65	Russian Federation 6	UNNT	NOVOSIBIRSK
19	Canada -5	CYYZ	TORONTO	66	Russian Federation 7	UNKL	KRASNOYARSK
20	Canada -6	CYWG	WINNIPEG	67	Russian Federation 8	UIBB	BRATSK
21	Canada -7	CYYC	CALGARY	68	Russian Federation 9	UEEE	YAKUTSK
22	Canada -8	CYVR	VANCOUVER	69	Russian Federation 10	UHHH	KHABAROVSK
23	Chile	SCEL	SANTIAGO	70	Russian Federation 11	UHPP	PETROPAVLOVSK-KAMCHATS
24	China	VHHH	HONG KONG	71	Saint Kitts and Nevis	TKPK	ST KITTS
25	Cote D'ivoire	DIAP	ABIDJAN	72	Saint Lucia	TLPL	ST LUCIA
26	Cuba	MUHA	HAVANA	73	Saint Vincent and The Grenadines	TVSV	ST VINCENT
27	Dominica	TDPD	DOMINICA	74	Saudi Arabia	OEJN	JEDDAH
28	Dominican Republic	MDPC	PUNTA CANA	75	Serbia	LYBE	BELGRADE
29	Egypt	HECA	CAIRO	76	Seychelles	FSIA	MAHE ISLAND
30	Gabon	FOOL	LIBREVILLE	77	Singapore	WSSS	SINGAPORE
31	Ghana	DGAA	ACCRA	78	South Africa	FAJS	JOHANNESBURG
32	Grenada	TGPY	GRENADA	79	Suriname	SMJP	PARAMARIBO
33	Guyana	SYCJ	GEORGETOWN	80	Swaziland	FDMS	MANZINI
34	India	VIDP	DELHI	81	Switzerland	LSZH	ZURICH
35	Iran, Islamic Republic of	OIII	TEHRAN	82	Thailand	VTBD	BANGKOK
36	Israel	LLBG	TEL AVIV	83	Trinidad and Tobago	TTCP	TOBAGO
37	Jamaica	MKJS	MONTEGO BAY	84	Tunisia	DTMB	MONASTIR
38	Japan	RJAA	TOKYO	85	Turkey	LTBA	ISTANBUL
39	Jordan	OJAI	AMMAN	86	United Arab Emirates	OMDB	DUBAI
40	Kazakhstan 6	UAAA	ALMATY	87	United States -5	KJFK	NEW YORK, NY
41	Kazakhstan 5	UATG	ATYRAU	88	United States -6	KORD	CHICAGO, IL
42	Kenya	HKJK	NAIROBI	89	United States -7	KDEN	DENVER, CO
43	Korea, Democratic People's Republic of	ZKPY	PYONGYANG	90	United States -8	KLAX	LOS ANGELES, CA
44	Korea, Republic of	RKSI	SEOUL	91	United States -9	PANC	ANCHORAGE, AK
45	Kuwait	OKBK	KUWAIT	92	Uruguay	SUMU	MONTEVIDEO
46	Lebanon	OLBA	BEIRUT	93	Venezuela	SVMI	CARACAS
47	Libyan Arab Jamahiriya	HLLT	TRIPOLI	94	Zimbabwe	FVHA	HARARE

* Where a third country is in multiple time zones, for each time zone an airport with the highest number of flights is presented. The time zone number (following the country name) is the number relative to Greenwich Mean Time

Annex C: Emission percentages applicable to EU ETS in EAS scenario for flights between EEA and third countries

Table C1. Percentages of emissions applicable to EU ETS in EAS scenario for flights between EEA countries and third countries.

Third country* / EEA country	Austria	Belgium	Bulgaria	Croatia	Cyprus	Czech Republic	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Iceland	Ireland	Italy	Latvia	Lithuania	Luxem-bourg	Malta	Nether-lands	Norway	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	Sweden	United Kingdom
Albania	44,9%	90,7%	24,9%	12,2%	24,2%	57,8%	73,9%	75,7%	76,6%	72,5%	60,8%	72,4%	23,2%	35,7%	93,1%	75,2%	71,9%	42,9%	90,6%	80,5%	69,2%	80,7%	56,3%	47,4%	48,3%	45,8%	23,5%	85,2%	74,7%	89,9%
Algeria	56,8%	82,0%	20,4%	59,9%	31,6%	44,4%	60,6%	69,0%	70,6%	81,3%	69,8%	56,0%	66,7%	48,3%	75,1%	26,3%	60,3%	62,7%	76,6%	3,5%	83,7%	87,3%	57,8%	68,9%	60,0%	58,2%	49,5%	54,4%	65,4%	81,1%
Antigua and Barbuda	19,3%	3,2%	26,9%	18,2%	28,2%	17,4%	20,1%	23,4%	22,6%	8,5%	12,5%	34,2%	19,9%	0,4%	4,4%	12,0%	26,6%	22,9%	12,2%	0,8%	9,8%	15,1%	22,6%	0,9%	23,9%	19,1%	14,0%	8,0%	19,5%	4,5%
Argentina	6,4%	13,8%	5,5%	6,5%	0,8%	17,4%	18,0%	23,3%	18,0%	12,4%	17,9%	2,2%	8,9%	0,3%	2,8%	13,0%	25,0%	23,2%	15,5%	0,3%	13,3%	10,6%	21,2%	0,6%	7,2%	14,0%	10,8%	5,5%	13,3%	1,9%
Azerbaijan	31,9%	35,9%	17,3%	33,3%	4,0%	21,3%	24,4%	7,3%	7,6%	46,0%	31,7%	9,1%	27,0%	34,3%	47,3%	44,6%	8,6%	1,2%	36,0%	35,0%	36,2%	30,4%	7,4%	55,8%	11,6%	30,5%	36,9%	50,5%	23,2%	41,3%
Bahamas	19,1%	14,5%	16,0%	17,0%	20,2%	21,7%	16,4%	13,6%	12,6%	4,7%	17,6%	24,2%	21,1%	0,3%	4,2%	12,0%	18,1%	14,7%	11,0%	8,9%	13,6%	5,0%	23,3%	0,8%	26,7%	19,8%	15,6%	6,6%	9,6%	10,2%
Bahrain	27,7%	42,0%	9,9%	14,8%	1,7%	32,0%	21,0%	5,8%	5,5%	35,9%	38,0%	14,6%	24,1%	19,4%	50,4%	23,0%	6,3%	0,9%	36,4%	0,8%	42,4%	22,3%	7,4%	40,0%	8,4%	27,5%	18,0%	54,0%	15,9%	46,2%
Barbados	17,4%	3,5%	27,4%	26,4%	21,1%	18,0%	20,6%	22,3%	22,4%	7,8%	13,9%	14,7%	16,9%	0,4%	5,3%	20,3%	26,3%	21,4%	11,4%	0,4%	10,0%	15,1%	16,6%	0,9%	28,1%	18,0%	24,8%	8,7%	18,5%	5,5%
Belarus	64,8%	82,1%	46,5%	67,5%	3,5%	71,9%	32,7%	65,3%	70,1%	84,3%	79,4%	63,1%	55,9%	58,1%	81,5%	76,9%	59,3%	14,3%	81,7%	49,8%	84,3%	85,6%	43,1%	91,2%	39,5%	62,1%	71,0%	80,3%	80,3%	88,4%
Belize	20,7%	12,3%	13,4%	13,5%	16,0%	18,2%	13,9%	11,2%	12,3%	7,8%	15,2%	21,0%	22,4%	0,3%	3,5%	10,3%	12,4%	13,6%	9,0%	7,6%	11,9%	4,2%	19,3%	0,9%	26,9%	21,1%	12,4%	5,5%	8,3%	8,6%
Bosnia and Herzegovina	71,7%	84,1%	14,0%	28,5%	18,0%	79,7%	89,8%	86,4%	87,2%	71,2%	79,2%	49,3%	64,0%	40,5%	88,7%	77,3%	84,6%	68,1%	78,2%	88,4%	84,7%	92,2%	83,5%	95,0%	45,5%	70,1%	48,8%	93,5%	92,7%	84,6%
Botswana	8,9%	14,1%	12,0%	6,5%	0,5%	15,4%	20,7%	22,2%	24,2%	8,6%	16,2%	5,4%	5,0%	18,5%	18,7%	2,6%	20,1%	18,5%	8,7%	0,5%	11,9%	22,3%	16,2%	3,2%	21,7%	4,8%	11,5%	5,2%	20,3%	11,3%
Brazil -3	16,1%	17,4%	7,8%	7,8%	1,0%	19,8%	22,5%	29,6%	27,8%	16,3%	20,8%	2,5%	10,4%	0,4%	3,0%	15,1%	29,9%	26,4%	20,2%	0,3%	16,5%	13,0%	23,4%	1,0%	8,3%	15,3%	11,7%	5,9%	24,4%	5,5%
Brazil -4	23,1%	10,6%	17,1%	26,9%	1,3%	16,0%	14,1%	15,0%	22,4%	7,2%	12,2%	10,2%	28,2%	0,3%	4,5%	21,4%	19,5%	19,7%	10,2%	3,6%	5,8%	14,8%	20,2%	4,1%	20,3%	23,4%	25,9%	10,9%	19,6%	3,6%
Brunei Darussalam	4,1%	12,2%	3,9%	8,7%	0,7%	6,7%	9,3%	1,9%	1,7%	13,6%	10,0%	1,2%	5,8%	3,7%	18,7%	13,3%	2,4%	0,3%	11,4%	10,7%	11,3%	9,6%	1,6%	23,3%	3,0%	3,6%	9,8%	18,6%	3,8%	13,9%
Cameroon	24,9%	17,2%	12,1%	20,6%	0,6%	32,1%	26,2%	34,2%	35,7%	12,8%	21,1%	6,0%	16,7%	12,2%	27,8%	15,9%	30,0%	14,1%	12,9%	0,8%	19,9%	33,1%	25,6%	5,9%	20,3%	26,8%	21,6%	10,2%	40,7%	26,0%
Canada -3.5	39,4%	25,6%	39,9%	39,9%	33,3%	33,8%	28,3%	22,7%	21,1%	24,2%	30,7%	26,8%	41,9%	0,8%	8,3%	17,0%	30,3%	35,0%	27,6%	28,5%	25,0%	8,9%	37,5%	1,4%	48,0%	40,0%	38,5%	13,9%	16,4%	17,3%
Canada -4	33,8%	21,2%	34,8%	34,9%	27,9%	30,5%	23,6%	19,3%	17,7%	12,4%	25,9%	27,8%	36,3%	0,6%	6,7%	15,3%	26,0%	21,8%	23,2%	27,6%	20,9%	7,4%	32,3%	1,1%	42,2%	34,4%	33,4%	10,9%	14,1%	14,4%
Canada -5	24,5%	17,5%	30,0%	29,6%	30,1%	22,9%	16,6%	22,1%	19,7%	16,3%	20,5%	29,9%	28,0%	0,4%	5,5%	21,7%	22,5%	20,2%	20,0%	21,5%	15,5%	7,9%	24,6%	0,9%	34,2%	26,2%	28,4%	9,3%	16,9%	12,6%
Canada -6	11,6%	14,2%	17,2%	27,7%	30,6%	8,7%	16,5%	14,3%	13,7%	15,3%	19,9%	29,7%	18,0%	0,4%	3,7%	20,3%	16,0%	19,4%	16,4%	32,1%	15,4%	6,4%	20,9%	0,9%	31,8%	12,0%	26,1%	7,8%	10,6%	10,9%
Canada -7	13,6%	15,6%	26,4%	16,7%	17,1%	10,3%	10,9%	14,6%	14,8%	12,9%	22,1%	19,8%	20,6%	0,4%	3,6%	20,3%	16,2%	18,7%	19,2%	29,6%	17,7%	5,9%	18,9%	0,8%	25,7%	14,1%	17,9%	6,4%	9,9%	8,5%
Canada -8	17,7%	18,5%	26,4%	13,4%	15,1%	10,3%	11,0%	15,3%	14,5%	14,1%	9,2%	24,0%	21,5%	0,3%	3,4%	23,5%	16,0%	18,9%	20,7%	23,7%	17,1%	5,5%	17,7%	1,0%	18,7%	19,0%	11,5%	5,5%	9,6%	8,6%
Chile	18,6%	6,0%	2,5%	15,2%	0,8%	18,3%	8,7%	16,8%	15,6%	10,0%	13,9%	2,0%	10,2%	0,2%	3,0%	13,9%	16,3%	21,8%	12,4%	0,3%	7,1%	12,8%	22,2%	1,3%	4,1%	19,3%	9,1%	5,8%	5,7%	1,6%
China	5,4%	15,0%	5,4%	9,9%	0,8%	7,9%	11,0%	1,9%	2,1%	17,8%	12,1%	2,6%	3,1%	3,5%	23,1%	12,1%	3,0%	0,4%	13,7%	12,1%	16,8%	12,8%	2,4%	24,0%	3,8%	5,0%	7,3%	21,7%	7,0%	19,9%
Cote D'ivoire	15,4%	27,3%	5,1%	11,7%	1,8%	23,5%	22,6%	39,8%	40,1%	19,7%	13,8%	5,0%	13,8%	0,6%	16,9%	5,2%	34,7%	28,2%	24,1%	0,8%	29,2%	38,5%	23,8%	5,7%	12,5%	16,2%	10,7%	10,7%	27,6%	32,5%
Cuba	22,7%	13,7%	14,7%	14,9%	17,5%	19,8%	15,4%	12,6%	11,4%	8,7%	16,7%	22,9%	24,5%	0,3%	4,0%	11,4%	17,4%	20,4%	9,9%	8,4%	13,1%	4,6%	20,6%	1,1%	29,1%	23,1%	13,5%	6,1%	9,1%	9,6%
Dominica	18,3%	3,4%	27,2%	17,5%	25,0%	18,6%	20,5%	23,0%	23,5%	8,3%	14,2%	33,7%	17,7%	1,4%	4,8%	18,4%	26,5%	20,4%	11,9%	0,6%	9,9%	15,8%	23,3%	0,9%	30,5%	18,9%	14,3%	8,2%	19,3%	5,0%
Dominican Republic	19,9%	10,1%	17,6%	14,5%	33,2%	11,9%	19,1%	13,6%	17,5%	8,1%	7,4%	31,5%	21,8%	0,3%	3,8%	10,5%	11,8%	19,9%	8,1%	8,2%	9,9%	4,9%	25,9%	1,2%	19,9%	20,4%	12,7%	7,3%	15,1%	4,5%
Egypt	44,6%	55,8%	33,4%	40,1%	6,8%	54,3%	60,3%	17,7%	19,1%	45,2%	55,3%	15,9%	46,0%	39,9%	68,3%	73,0%	26,6%	16,9%	60,2%	1,6%	59,7%	63,9%	39,7%	20,9%	17,5%	51,5%	41,7%	21,0%	48,9%	63,3%
Gabon	23,0%	16,0%	11,2%	19,2%	1,2%	26,0%	24,3%	31,6%	33,5%	12,4%	19,9%	5,5%	15,2%	11,8%	28,6%	16,0%	27,5%	12,3%	12,3%	0,8%	18,4%	30,2%	23,3%	5,4%	18,7%	24,6%	19,9%	9,6%	38,1%	24,7%
Ghana	16,6%	26,4%	7,4%	11,6%	1,9%	25,9%	21,1%	31,4%	34,6%	19,8%	12,6%	5,4%	21,8%	6,7%	21,0%	4,9%	30,2%	32,9%	22,7%	0,9%	28,6%	31,0%	24,2%	5,7%	15,0%	18,0%	11,5%	11,4%	36,2%	29,6%

* Where a third country is in multiple time zones, for each time zone an airport with the highest number of flights is presented. The time zone number (following the country name) is the number relative to Greenwich Mean Time.

Table C1. Percentages of emissions applicable to EU ETS in EAS scenario for flights between EEA countries and third countries (continued).

Third country* / EEA country	Austria	Belgium	Bulgaria	Croatia	Cyprus	Czech Republic	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Iceland
Grenada	17,7%	3,6%	26,5%	25,4%	18,3%	17,7%	20,1%	21,9%	22,1%	7,6%	13,4%	15,1%	16,5%	0,8%
Guyana	22,2%	10,1%	19,4%	25,4%	9,9%	15,6%	15,6%	15,5%	24,7%	6,8%	12,3%	11,4%	24,5%	0,4%
India	14,3%	21,4%	7,6%	15,5%	1,4%	10,9%	5,0%	3,2%	1,4%	22,3%	16,8%	2,3%	12,6%	19,1%
Iran, Islamic Republic of	31,2%	43,4%	15,9%	26,5%	3,8%	25,9%	21,5%	6,9%	6,5%	49,4%	40,1%	3,9%	27,8%	30,7%
Israel	37,2%	43,8%	23,4%	20,6%	7,8%	54,4%	62,6%	15,9%	18,6%	47,5%	41,9%	37,0%	45,6%	44,8%
Jamaica	18,6%	8,3%	15,9%	14,7%	29,9%	15,4%	14,4%	12,7%	12,2%	4,2%	11,9%	29,4%	21,2%	0,3%
Japan	7,3%	22,4%	5,5%	8,8%	1,5%	11,9%	15,2%	2,7%	5,3%	24,4%	19,5%	1,0%	4,1%	2,8%
Jordan	38,4%	48,7%	24,9%	20,2%	5,9%	53,3%	55,1%	13,2%	15,6%	38,2%	45,5%	34,1%	42,3%	45,2%
Kazakhstan 6	10,2%	25,0%	10,8%	18,7%	1,6%	14,5%	20,8%	4,6%	1,6%	28,0%	20,7%	4,7%	6,3%	18,0%
Kazakhstan 5	16,5%	38,9%	20,7%	33,0%	7,3%	25,4%	10,5%	7,6%	9,1%	43,1%	34,9%	11,1%	16,0%	30,8%
Kenya	19,1%	23,3%	14,1%	8,4%	0,7%	20,8%	28,5%	7,6%	7,5%	13,5%	20,1%	8,1%	16,2%	31,6%
Korea, Democratic People's Republic of	7,8%	22,5%	6,2%	7,8%	0,5%	12,8%	15,0%	1,0%	4,2%	23,7%	18,4%	3,4%	4,0%	7,9%
Korea, Republic of	7,7%	21,5%	6,1%	7,5%	0,8%	12,2%	14,4%	1,0%	4,0%	20,6%	17,9%	3,4%	3,9%	7,7%
Kuwait	31,2%	45,8%	11,2%	18,2%	2,3%	35,6%	23,4%	7,2%	6,5%	39,8%	41,8%	15,3%	27,2%	21,6%
Lebanon	44,8%	54,3%	26,8%	25,4%	13,2%	54,4%	55,4%	14,3%	16,8%	38,6%	49,7%	38,7%	43,9%	58,6%
Libyan Arab Jamahiriya	71,9%	45,7%	10,8%	64,0%	7,2%	74,9%	81,4%	78,1%	78,4%	61,7%	39,0%	22,0%	67,5%	55,1%
Macedonia, Former Yugoslav Rep. of	48,4%	66,6%	57,5%	13,9%	28,2%	62,2%	70,6%	78,3%	80,7%	55,0%	62,7%	79,5%	23,8%	39,6%
Malaysia	8,8%	13,4%	4,1%	9,9%	0,7%	6,5%	8,8%	1,9%	0,9%	14,1%	10,3%	3,1%	7,4%	9,9%
Mauritius	10,8%	14,9%	3,9%	10,3%	0,4%	14,2%	20,6%	4,3%	3,4%	15,8%	17,8%	5,4%	10,4%	16,1%
Mexico -6	18,7%	11,5%	21,2%	19,8%	19,1%	16,4%	11,0%	12,8%	9,0%	7,1%	14,3%	17,7%	20,3%	0,2%
Mexico -7	18,7%	10,4%	20,9%	20,3%	17,9%	16,2%	10,6%	10,4%	10,2%	11,5%	13,0%	21,5%	10,2%	0,3%
Mexico -8	11,0%	10,3%	18,1%	19,9%	20,4%	8,5%	8,2%	11,1%	10,3%	11,0%	14,6%	22,7%	24,0%	0,3%
Moldova, Republic of	91,4%	81,6%	88,5%	93,7%	3,9%	69,8%	63,5%	34,3%	35,2%	95,4%	80,6%	86,6%	90,9%	50,0%
Montenegro	51,9%	74,8%	23,5%	15,6%	37,1%	64,6%	79,8%	77,2%	75,7%	72,0%	64,5%	64,9%	43,1%	38,7%
Morocco	81,0%	85,2%	27,3%	32,2%	26,3%	72,7%	88,9%	91,5%	91,6%	83,2%	85,8%	33,9%	43,7%	8,5%
Namibia	12,5%	10,7%	9,8%	10,7%	0,5%	18,9%	25,7%	20,4%	21,7%	8,3%	8,9%	4,9%	2,4%	8,6%
Oman	23,1%	35,8%	6,9%	16,9%	1,3%	26,8%	16,1%	4,7%	4,5%	33,5%	32,3%	9,2%	19,3%	24,4%
Papua New Guinea	3,9%	6,8%	3,4%	4,6%	0,5%	5,4%	7,0%	0,9%	1,8%	13,2%	9,3%	1,6%	1,8%	1,8%
Puerto Rico	20,2%	10,8%	24,7%	15,2%	39,6%	12,2%	19,6%	19,6%	17,6%	8,4%	10,4%	32,7%	21,8%	0,4%
Qatar	26,7%	40,8%	9,5%	14,1%	1,5%	30,9%	20,2%	5,7%	5,2%	34,3%	36,9%	15,4%	23,1%	18,6%
Russian Federation 2	92,8%	91,0%	93,8%	94,5%	36,4%	91,2%	25,3%	93,9%	95,1%	92,3%	94,1%	97,0%	93,1%	42,3%
Russian Federation 3	38,0%	58,6%	34,9%	43,0%	3,3%	44,7%	62,8%	19,7%	23,5%	67,7%	62,8%	40,2%	22,0%	41,8%

Third country* / EEA country	Ireland	Italy	Latvia	Lithuania	Luxem-bourg	Malta	Nether-lands	Norway	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	Sweden	United Kingdom
Grenada	5,0%	20,3%	25,4%	20,3%	11,4%	1,2%	9,7%	14,3%	16,4%	0,8%	27,4%	18,0%	23,6%	8,3%	18,3%	5,1%
Guyana	5,0%	19,5%	20,9%	22,3%	10,3%	0,7%	9,3%	13,6%	21,7%	0,8%	27,6%	22,7%	23,9%	8,5%	21,4%	6,7%
India	27,7%	23,4%	5,2%	0,6%	18,9%	19,7%	20,2%	16,0%	3,5%	34,9%	4,9%	13,0%	18,4%	31,0%	10,2%	24,6%
Iran, Islamic Republic of	42,3%	31,1%	7,1%	1,0%	43,0%	34,9%	34,0%	27,0%	6,9%	27,9%	9,8%	29,2%	30,5%	41,4%	19,9%	43,5%
Israel	58,0%	48,4%	13,1%	4,8%	43,8%	1,4%	50,7%	56,0%	37,0%	35,4%	21,5%	46,6%	26,7%	76,1%	26,2%	51,8%
Jamaica	3,8%	10,3%	18,4%	22,4%	11,1%	9,1%	13,3%	8,7%	23,3%	0,8%	23,1%	18,9%	14,3%	6,2%	12,7%	4,3%
Japan	11,2%	16,9%	3,4%	1,4%	22,4%	6,3%	21,5%	14,5%	4,3%	28,9%	2,3%	6,9%	9,9%	31,6%	10,1%	25,4%
Jordan	56,1%	48,1%	11,1%	3,8%	38,8%	1,3%	51,0%	50,6%	34,2%	34,3%	19,6%	46,7%	19,6%	73,4%	22,4%	46,6%
Kazakhstan 6	36,8%	20,5%	5,7%	0,8%	23,4%	20,5%	23,2%	19,3%	3,8%	39,0%	7,5%	9,3%	14,5%	34,7%	13,3%	27,9%
Kazakhstan 5	47,4%	34,8%	12,3%	1,5%	38,4%	37,2%	38,2%	33,1%	8,1%	61,6%	15,0%	14,8%	34,3%	58,3%	22,8%	43,8%
Kenya	33,1%	17,9%	9,0%	3,7%	21,1%	0,6%	26,7%	38,9%	20,7%	7,7%	5,6%	18,2%	8,1%	6,2%	19,8%	29,7%
Korea, Democratic People's Republic of	28,3%	16,1%	3,6%	0,5%	20,9%	16,8%	23,2%	14,9%	3,1%	35,9%	2,5%	7,2%	10,5%	30,4%	11,2%	26,3%
Korea, Republic of	27,7%	15,3%	3,5%	0,5%	20,0%	16,4%	22,4%	14,4%	3,0%	34,5%	2,5%	7,1%	10,3%	29,6%	10,9%	25,6%
Kuwait	54,5%	25,9%	7,2%	1,0%	41,2%	4,6%	46,3%	24,2%	8,3%	57,9%	9,8%	30,9%	21,5%	58,6%	17,6%	50,1%
Lebanon	63,5%	54,3%	10,5%	2,3%	48,8%	14,5%	55,8%	53,1%	34,3%	94,5%	19,0%	48,0%	25,9%	94,2%	24,5%	56,5%
Libyan Arab Jamahiriya	72,2%	13,1%	78,5%	68,4%	34,6%	8,4%	42,8%	83,3%	76,5%	33,0%	32,1%	69,4%	68,0%	20,9%	83,9%	67,5%
Macedonia, Former Yugoslav Rep. of	77,4%	64,8%	76,9%	35,6%	62,8%	4,7%	71,9%	77,5%	70,4%	83,3%	79,8%	36,5%	26,5%	78,7%	81,4%	70,7%
Malaysia	14,5%	15,0%	2,9%	0,4%	11,7%	1,1%	12,2%	9,8%	2,0%	21,8%	2,6%	8,3%	11,5%	17,8%	5,9%	15,6%
Mauritius	22,1%	11,7%	2,8%	0,6%	9,3%	0,4%	20,6%	13,9%	9,4%	5,2%	4,2%	9,7%	10,8%	4,2%	7,8%	16,6%
Mexico -6	3,4%	9,2%	15,7%	13,9%	12,4%	11,3%	10,3%	5,8%	16,8%	0,6%	24,6%	19,0%	18,9%	5,3%	12,5%	7,6%
Mexico -7	3,2%	15,3%	11,7%	14,2%	12,7%	15,9%	10,6%	4,5%	18,7%	0,6%	25,9%	18,6%	18,1%	6,2%	7,6%	7,6%
Mexico -8	2,6%	15,0%	12,3%	14,3%	11,9%	24,8%	11,0%	4,5%	15,1%	0,6%	20,7%	13,4%	19,8%	6,0%	7,4%	7,7%
Moldova, Republic of	84,8%	96,0%	27,0%	5,1%	90,0%	39,0%	78,7%	41,9%	34,9%	97,8%	75,1%	90,9%	94,4%	97,0%	45,9%	83,8%
Montenegro	85,5%	85,4%	74,2%	53,0%	73,8%	76,3%	73,0%	84,7%	61,7%	84,0%	51,7%	52,7%	27,0%	79,3%	81,4%	82,4%
Morocco	39,8%	76,0%	90,8%	80,4%	85,0%	2,5%	85,8%	60,1%	80,8%	35,6%	36,6%	81,2%	36,2%	63,0%	90,7%	82,4%
Namibia	18,3%	8,7%	18,9%	15,7%	13,4%	0,5%	17,7%	28,4%	9,2%	3,4%	14,4%	11,0%	14,3%	6,0%	21,8%	16,3%
Oman	42,9%	19,5%	4,7%	0,7%	34,7%	1,0%	35,1%	19,4%	5,4%	46,7%	6,6%	22,2%	18,9%	46,6%	13,6%	39,7%
Papua New Guinea	17,0%	8,8%	1,7%	0,3%	10,4%	7,6%	10,7%	8,3%	1,6%	19,9%	2,3%	3,3%	4,6%	14,0%	6,1%	15,7%
Puerto Rico	3,8%	11,1%	13,4%	21,0%	8,3%	5,7%	9,9%	10,8%	21,7%	0,8%	20,0%	20,6%	12,3%	7,4%	18,5%	4,6%
Qatar	49,1%	19,9%	5,9%	0,8%	35,4%	0,7%	41,2%	21,5%	7,1%	20,6%	8,0%	26,5%	17,1%	51,7%	15,5%	44,9%
Russian Federation 2	82,4%	89,4%	90,7%	51,4%	94,5%	90,9%	90,4%	61,1%	80,4%	97,8%	73,3%	92,7%	94,4%	97,7%	43,3%	92,7%
Russian Federation 3	78,8%	55,0%	29,1%	4,1%	65,9%	38,4%	71,4%	59,5%	19,2%	78,2%	20,8%	36,1%	45,7%	66,9%	46,5%	76,3%

*** Where a third country is in multiple time zones, for each time zone an airport with the highest number of flights is presented. The time zone number (following the country name) is the number relative to Greenwich Mean Time.**

Table C1. Percentages of emissions applicable to EU ETS in EAS scenario for flights between EEA countries and third countries (continued).

Third country* / EEA country	Austria	Belgium	Bulgaria	Croatia	Cyprus	Czech Republic	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Iceland	Ireland	Italy	Latvia	Lithuania	Luxem-bourg	Malta	Nether-lands	Norway	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	Sweden	United Kingdom
Russian Federation 5	20,2%	45,5%	16,7%	18,1%	4,0%	24,0%	32,5%	8,8%	8,0%	44,8%	37,6%	2,4%	10,0%	26,4%	20,7%	34,3%	10,3%	1,5%	38,1%	15,3%	43,8%	34,6%	8,6%	59,2%	7,6%	19,0%	25,7%	47,7%	22,4%	49,5%
Russian Federation 6	14,0%	33,8%	11,2%	12,6%	3,4%	16,8%	23,2%	3,4%	5,3%	36,4%	27,5%	2,0%	6,6%	12,6%	44,5%	24,8%	6,2%	0,9%	29,7%	23,6%	32,6%	27,4%	5,7%	47,3%	4,9%	13,1%	18,3%	43,1%	17,2%	37,0%
Russian Federation 7	12,7%	31,5%	10,0%	12,4%	3,0%	20,6%	20,3%	2,9%	5,9%	34,9%	28,0%	1,5%	6,9%	5,8%	41,1%	23,9%	6,2%	0,8%	30,8%	10,8%	18,9%	24,4%	5,1%	47,7%	4,5%	11,8%	16,8%	41,2%	18,2%	38,6%
Russian Federation 8	12,2%	31,7%	9,3%	13,9%	2,7%	21,1%	22,2%	1,6%	6,5%	33,2%	26,9%	0,7%	6,3%	5,4%	39,1%	25,5%	5,6%	1,2%	30,0%	10,2%	32,7%	22,1%	4,9%	47,2%	4,1%	11,0%	15,5%	41,5%	17,5%	37,0%
Russian Federation 9	19,9%	35,5%	9,2%	21,2%	1,8%	27,2%	25,4%	10,5%	9,2%	37,9%	32,0%	7,8%	9,0%	4,2%	8,2%	32,9%	7,2%	5,0%	34,5%	12,9%	34,0%	24,3%	12,3%	51,0%	4,6%	19,4%	23,5%	46,4%	17,5%	39,9%
Russian Federation 10	10,5%	27,2%	7,2%	10,7%	1,9%	14,9%	18,9%	5,1%	7,1%	29,6%	25,2%	1,0%	6,8%	3,3%	11,9%	20,7%	4,3%	2,6%	26,8%	13,4%	26,4%	17,8%	8,9%	41,2%	3,0%	9,3%	13,3%	37,3%	12,6%	29,9%
Russian Federation 11	22,1%	29,4%	7,6%	19,4%	1,4%	24,4%	25,1%	8,0%	7,8%	30,3%	31,3%	10,1%	14,3%	0,6%	12,0%	29,8%	9,0%	4,3%	32,0%	15,2%	27,0%	19,4%	12,1%	16,2%	3,8%	18,9%	24,4%	15,9%	15,5%	3,1%
Saint Kitts and Nevis	19,5%	3,3%	26,6%	17,3%	26,6%	15,4%	19,9%	23,0%	22,4%	8,4%	11,6%	34,1%	20,5%	0,4%	4,3%	11,5%	25,5%	21,7%	12,1%	1,3%	8,7%	14,8%	22,0%	0,9%	22,6%	19,4%	13,5%	7,9%	19,2%	4,7%
Saint Lucia	18,5%	3,5%	26,9%	26,1%	19,7%	18,3%	20,6%	22,5%	22,6%	8,0%	13,7%	18,3%	17,0%	0,9%	5,0%	20,2%	26,0%	19,7%	11,7%	0,7%	10,0%	14,7%	19,1%	0,9%	28,3%	19,0%	22,2%	8,6%	18,7%	5,2%
Saint Vincent and The Gre	18,7%	3,3%	26,8%	26,3%	19,0%	18,1%	20,4%	22,3%	22,4%	7,8%	13,6%	17,4%	16,8%	1,0%	3,8%	20,5%	25,8%	19,5%	11,6%	1,5%	9,9%	14,5%	17,5%	0,8%	27,8%	19,5%	22,8%	8,5%	18,6%	5,2%
Saudi Arabia	18,8%	42,5%	11,7%	25,6%	1,7%	26,1%	43,4%	9,9%	11,4%	32,7%	38,7%	17,7%	26,7%	34,7%	53,4%	49,3%	6,9%	1,5%	44,9%	1,0%	44,2%	41,7%	25,2%	15,5%	12,2%	22,0%	19,7%	7,1%	17,4%	44,4%
Serbia	65,6%	90,7%	17,3%	70,7%	31,8%	77,9%	87,9%	92,6%	92,7%	93,1%	88,0%	46,1%	49,5%	40,9%	94,0%	76,4%	91,2%	66,2%	90,5%	57,2%	89,9%	91,5%	84,4%	86,8%	81,7%	65,4%	78,5%	83,4%	91,0%	93,0%
Seychelles	10,5%	24,6%	5,3%	12,8%	0,5%	16,3%	21,5%	4,4%	3,7%	28,6%	21,3%	4,1%	14,3%	31,2%	30,2%	24,5%	3,4%	0,7%	23,6%	0,5%	24,2%	9,4%	9,4%	7,7%	4,6%	12,4%	13,7%	4,8%	9,5%	27,0%
Singapore	8,5%	12,8%	4,2%	9,6%	0,7%	6,3%	8,6%	1,9%	0,9%	13,6%	10,1%	3,0%	7,2%	9,2%	15,0%	14,6%	2,8%	0,3%	11,4%	9,3%	12,0%	7,4%	2,0%	12,4%	2,5%	7,8%	10,7%	17,3%	5,8%	15,0%
South Africa	5,0%	12,7%	11,8%	6,4%	0,5%	12,4%	17,7%	17,6%	18,2%	8,6%	17,3%	5,1%	4,4%	18,0%	16,1%	4,8%	19,6%	12,6%	6,0%	0,4%	9,1%	21,9%	17,7%	3,1%	8,1%	4,1%	11,0%	5,0%	22,7%	11,2%
Suriname	23,0%	9,9%	23,7%	27,3%	9,4%	15,7%	15,3%	16,9%	25,2%	6,7%	11,5%	10,9%	27,9%	0,4%	5,2%	20,4%	21,7%	15,8%	9,7%	5,0%	6,6%	17,9%	21,3%	0,8%	28,6%	23,4%	25,2%	8,6%	22,1%	5,5%
Swaziland	4,7%	10,2%	11,7%	6,8%	0,4%	12,2%	13,7%	13,7%	14,6%	14,1%	17,5%	4,7%	7,4%	14,6%	15,3%	11,7%	15,0%	8,5%	14,1%	0,4%	17,5%	18,0%	21,6%	3,0%	8,0%	4,9%	10,5%	4,9%	24,1%	11,5%
Switzerland	86,7%	97,1%	51,1%	87,4%	32,8%	92,1%	96,5%	98,2%	98,4%	93,0%	######	67,1%	88,9%	61,6%	98,3%	27,5%	97,7%	97,4%	95,6%	89,7%	97,8%	98,3%	95,3%	87,9%	86,6%	88,2%	83,5%	82,5%	97,8%	97,4%
Thailand	5,1%	14,3%	4,8%	9,6%	0,8%	7,9%	10,2%	2,2%	1,7%	16,4%	12,2%	1,3%	7,6%	9,7%	22,3%	16,6%	3,1%	0,4%	13,9%	13,4%	13,9%	9,8%	2,1%	25,4%	3,1%	4,5%	12,3%	21,6%	7,0%	17,2%
Trinidad and Tobago	16,7%	3,4%	27,1%	25,5%	10,9%	17,5%	20,0%	21,8%	20,8%	8,4%	13,3%	13,2%	16,5%	0,4%	5,1%	19,6%	25,4%	20,8%	11,5%	2,1%	10,4%	14,6%	16,1%	0,8%	27,3%	17,3%	23,9%	8,3%	17,9%	5,6%
Tunisia	56,3%	75,6%	51,1%	45,6%	37,1%	58,3%	68,2%	72,7%	71,9%	77,1%	34,1%	70,5%	52,6%	58,2%	84,3%	36,0%	73,8%	67,3%	64,4%	15,1%	71,9%	74,0%	67,3%	42,6%	54,5%	60,7%	46,3%	36,3%	75,1%	81,3%
Turkey	85,5%	79,9%	53,9%	50,2%	11,4%	90,3%	94,2%	45,9%	45,8%	77,5%	77,8%	50,1%	85,9%	57,0%	86,2%	54,4%	48,5%	35,2%	73,5%	79,0%	91,8%	83,6%	68,1%	76,5%	75,4%	87,6%	56,2%	72,5%	61,8%	79,6%
United Arab Emirates	25,2%	38,5%	8,0%	18,4%	1,4%	28,8%	17,4%	5,5%	4,8%	34,9%	34,8%	11,0%	21,1%	25,5%	46,2%	20,8%	5,2%	0,7%	37,0%	1,3%	38,7%	20,9%	6,3%	61,6%	7,3%	24,2%	21,1%	49,8%	14,4%	42,5%
United States -5	29,2%	18,0%	30,6%	29,7%	26,1%	25,2%	19,6%	17,6%	20,2%	11,3%	22,1%	24,0%	31,2%	0,4%	5,5%	11,9%	17,8%	25,1%	19,5%	8,1%	16,1%	6,4%	27,8%	0,9%	35,8%	29,5%	28,5%	8,7%	12,1%	12,0%
United States -6	24,6%	15,0%	25,9%	26,3%	27,8%	22,4%	4,7%	13,2%	12,5%	14,5%	18,4%	28,9%	27,1%	0,4%	4,8%	19,7%	23,0%	25,1%	17,9%	20,1%	12,6%	13,0%	12,9%	0,8%	23,6%	25,5%	25,1%	8,4%	17,4%	11,6%
United States -7	11,7%	11,1%	14,4%	23,8%	29,3%	7,7%	13,4%	12,1%	11,7%	13,6%	16,4%	25,3%	12,7%	0,3%	3,4%	17,9%	13,5%	16,5%	13,2%	22,4%	12,5%	5,3%	21,6%	0,7%	31,2%	10,7%	22,3%	7,0%	8,9%	9,0%
United States -8	13,4%	11,6%	27,4%	19,9%	20,0%	10,5%	7,5%	11,4%	10,8%	11,2%	14,7%	16,9%	24,2%	0,3%	2,7%	15,1%	12,2%	14,8%	13,3%	24,7%	11,6%	4,6%	15,3%	0,6%	21,3%	14,6%	19,1%	5,7%	7,5%	7,8%
United States -9	24,7%	2,0%	37,3%	26,9%	0,3%	21,0%	13,8%	22,6%	34,6%	16,1%	6,7%	41,4%	30,0%	2,7%	7,1%	9,4%	26,0%	28,5%	5,9%	33,6%	0,9%	6,8%	17,6%	1,2%	31,2%	26,8%	25,2%	12,6%	16,3%	11,6%
Uruguay	12,9%	14,0%	5,5%	7,0%	0,8%	17,1%	18,7%	24,3%	23,8%	13,8%	17,9%	2,2%	9,2%	0,3%	2,7%	12,8%	26,7%	23,2%	16,6%	0,3%	14,0%	11,5%	20,4%	0,5%	7,4%	13,1%	4,1%	5,0%	15,8%	4,5%
Venezuela	17,1%	3,0%	24,8%	16,3%	22,3%	16,7%	17,7%	20,8%	19,9%	7,9%	12,3%	15,9%	16,9%	0,3%	3,8%	10,5%	23,8%	20,6%	10,8%	0,7%	8,6%	13,2%	20,3%	0,6%	27,9%	17,6%	14,1%	7,7%	17,3%	3,9%
Zimbabwe	5,1%	8,5%	13,1%	7,6%	0,4%	13,4%	15,1%	15,7%	15,8%	15,3%	19,9%	5,6%	9,0%	15,7%	15,6%	13,6%	16,1%	9,6%	17,2%	0,5%	22,2%	22,5%	25,0%	3,2%	9,1%	7,9%	10,5%	5,7%	28,3%	19,3%

* Where a third country is in multiple time zones, for each time zone an airport with the highest number of flights is presented. The time zone number (following the country name) is the number relative to Greenwich Mean Time.

Annex D. Baseline Secan-ET

Baseline STC scenario

From/To	To/From	Airlinetype	Home land	Passengers							Passenger - km	Tonnes of cargo	Tonne-km of cargo	Revenues (2012 EUR)	Fuel use (kg)
				Business purpose in business class	Leisure purpose in business class	Total business class	Business purpose in economy class	Leisure purpose in economy class	Total economy class	Total					
EU+/CH	EU+/CH	Networker	EU+	43'971'210	4'348'801	48'320'011	134'889'023	220'082'089	354'971'112	403'291'123	351'745'515'556	696'090	983'085'650	52'612'176'727	12'648'497'002
EU+/CH	EU+/CH	LCC	EU+						314'466'075	314'466'075	366'429'866'667			17'376'650'585	9'550'487'632
EU+/CH	EU+/CH	Freighter	EU+									1'734'338	1'240'314'428	874'558'221	365'488'071
EU+/CH	EU+/CH	Freighter	ROW									415'655	297'256'550	209'598'593	87'593'695
EU+	OT	Networker	EU+	267'674	26'473	294'148	897'108	1'463'703	2'360'811	2'654'959	8'424'530'667	34'414	249'860'160	676'865'878	286'134'646
EU+	OT	Networker	ROW	66'919	6'618	73'537	224'277	365'926	590'203	663'740	2'106'132'667	8'603	62'465'040	169'216'469	71'533'661
EU+	OT	LCC	EU+						2'709'869	2'709'869	1'844'475'200			86'601'041	71'769'991
EU+	OT	LCC	ROW						677'467	677'467	461'118'800			21'650'260	17'942'498
EU+	OT	Freighter	EU+									10'125	14'482'369	3'927'343	4'989'203
EU+	OT	Freighter	ROW									2'531	3'620'592	981'836	1'247'301
ROW	ROW	Networker	EU+	19'433'417	1'235'765	20'669'181	79'547'039	71'612'627	151'159'666	171'828'847	843'620'690'776	4'341'179	28'417'056'354	73'113'250'469	25'629'370'997
ROW	ROW	Networker	ROW	98'519'532	3'737'717	102'257'248	1'148'415'356	663'692'744	1'812'108'100	1'914'365'348	3'663'690'434'700	24'029'833	92'075'501'628	327'137'026'051	123'008'209'677
ROW	ROW	LCC	EU+						93'396'729	93'396'729	252'408'141'722			9'086'899'142	6'710'035'682
ROW	ROW	LCC	ROW						360'604'340	360'604'340	449'698'826'635			21'534'333'997	13'194'332'124
ROW	ROW	Freighter	EU+									1'143'139	4'540'877'170	1'540'646'960	899'294'321
ROW	ROW	Freighter	ROW									21'698'487	51'211'409'503	22'170'280'008	11'861'182'359
Quelle: AERO-MS Szenario 2012			Total	162'258'752	9'355'374	171'614'125	1'363'972'803	957'217'089	3'093'044'372	3'264'658'497	5'940'429'733'390	54'114'394	179'095'929'444	526'614'663'580	204'408'108'860

Baseline EAS scenario

From /To	To/From	Airlinetype	Home-land	Passengers							Passenger - km	Passenger-km under EU ETS	Tonnes of cargo	Tonne-km of cargo	Tonne-km under EU ETS	Revenues (2012 EUR)	Fuel use (kg)
				Business purpose in business class	Leisure purpose in business class	Total business class	Business purpose in economy class	Leisure purpose in economy class	Total economy class	Total							
EU+	EU+	Networker	EU+	41'846'523	4'138'667	45'985'190	128'382'658	209'466'442	337'849'100	383'834'290	336'574'533'333	336'574'514'315	641'740	937'897'540	937'897'482	50'150'672'707	12'058'167'108
EU+	EU+	LCC	EU+	0	0	0	0	305'457'660	305'457'660	305'457'660	358'841'022'222	358'841'036'987	0	0	0	16'951'343'274	9'321'547'587
EU+	EU+	Freighter	EU+	0	0	0	0	0	0	0	0	0	1'709'886	1'230'442'563	1'230'442'237	867'595'841	361'001'800
EU+	EU+	Freighter	ROW	0	0	0	0	0	0	0	0	0	409'795	294'890'637	294'890'558	207'929'974	86'518'505
EU+	Rest Europe	Networker	EU+	2'885'533	207'239	3'092'772	10'695'846	11'984'478	22'680'324	25'773'096	39'043'025'260	24'991'707'505	88'650	161'689'627	97'796'520	4'792'348'226	1'151'591'849
EU+	Rest Europe	Networker	ROW	3'201'798	229'953	3'431'751	11'868'148	13'298'020	25'166'168	28'597'919	43'322'279'184	27'730'887'210	98'367	179'411'383	108'515'365	5'317'606'574	1'277'810'397
EU+	Rest Europe	LCC	EU+	0	0	0	0	17'338'456	17'338'456	17'338'456	30'658'236'789	24'364'949'857	0	0	0	1'243'527'180	723'606'799
EU+	Rest Europe	LCC	ROW	0	0	0	0	8'982'003	8'982'003	8'982'003	15'882'174'322	12'622'003'791	0	0	0	644'196'063	374'856'826
EU+	Rest Europe	Freighter	EU+	0	0	0	0	0	0	0	0	0	222'041	578'860'162	285'350'705	408'845'935	101'203'650
EU+	Rest Europe	Freighter	ROW	0	0	0	0	0	0	0	0	0	145'618	379'625'216	187'137'292	268'127'325	66'370'879
EU+	ROW	Networker	EU+	15'860'146	1'072'916	16'933'062	49'481'181	52'154'345	101'635'525	118'568'587	750'697'960'903	134'072'998'292	3'855'697	26'867'195'442	4'800'752'526	63'999'170'385	22'658'029'008
EU+	ROW	Networker	ROW	13'587'872	919'200	14'507'072	42'392'042	44'682'223	87'074'265	101'581'337	643'145'916'875	114'864'440'701	3'303'294	23'017'948'558	4'112'951'607	54'830'047'849	19'411'826'860
EU+	ROW	LCC	EU+	0	0	0	0	33'685'052	33'685'052	33'685'052	169'472'691'788	36'758'802'855	0	0	0	5'314'615'142	4'434'812'476
EU+	ROW	LCC	ROW	0	0	0	0	4'123'394	4'123'394	4'123'394	20'745'187'101	4'499'652'627	0	0	0	650'563'134	542'866'308
EU+	ROW	Freighter	EU+	0	0	0	0	0	0	0	0	0	561'163	3'179'219'331	662'192'255	763'364'588	611'160'174
EU+	ROW	Freighter	ROW	0	0	0	0	0	0	0	0	0	1'617'648	9'164'635'369	1'908'880'744	2'200'527'041	1'761'772'173
ROW	ROW	Networker	EU+	1'701'595	55'881	1'757'477	22'476'659	12'542'542	35'019'201	36'776'677	61'282'211'516	0	423'457	1'415'852'911	0	5'505'502'774	2'106'750'385
ROW	ROW	Networker	ROW	83'175'284	2'731'517	85'906'801	1'098'676'270	613'089'039	1'711'765'309	1'797'672'110	2'995'521'377'293	0	20'698'915	69'207'973'371	0	269'113'187'080	102'979'570'377
ROW	ROW	LCC	EU+	0	0	0	0	48'717'696	48'717'696	48'717'696	57'555'547'112	0	0	0	0	2'822'035'699	1'713'294'250
ROW	ROW	LCC	ROW	0	0	0	0	353'550'218	353'550'218	353'550'218	417'687'569'689	0	0	0	0	20'479'854'535	12'433'583'680
ROW	ROW	Freighter	EU+	0	0	0	0	0	0	0	0	0	378'477	790'525'348	0	373'740'331	190'405'298
ROW	ROW	Freighter	ROW	0	0	0	0	0	0	0	0	0	19'959'648	41'689'761'986	0	19'709'861'927	10'041'362'471
Quelle: AERO-MS Szenario für 2012				162'258'751	9'355'374	171'614'125	1'363'972'803	1'729'071'569	3'093'044'372	3'264'658'497	5'940'429'733'388	1'075'320'994'140	54'114'396	179'095'929'444	14'626'807'291	526'614'663'582	204'408'108'860

Annex E: Additional Results SECAN ET with a carbon price of 10 EUR/t CO_2

STC scenario

Table 42: Impact on passenger demand in m. pkm

in m. pkm	Without passing on opportunity costs				With passing on opportunity costs			
Airline type	Networker		LCC		Networker		LCC	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW	EU+	ROW
EU+/CH-EU+/CH	-570		-1640		-2.290		-6.580	
EU+ - OT	-20	-5	-10	-5	-60	-15	-40	-10
ROW-ROW	-200	+45	-460	+105	-200	+46	-450	+105
Total impact	-790	+40	-2.110	+100	-2.550	+30	-7.070	+95
pkm before EU ETS	1.200.000	3.700.000	620.000	450.000	1.200.000	3.700.000	620.000	450.000
Total impact in %	-0,07%	+0,00%	-0,34%	0,02%	-0,21%	0,00%	-1,14%	0,02%

Source: INFRAS

Table 43: Impact on cargo demand in m tkm

in m tkm	Without passing on opportunity costs				With passing on opportunity costs			
Airline type	Networker		Freighter		Networker		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW	EU+	ROW
EU+/CH-EU+/CH	-3,5		-3,4	-0,8	-11,9		-11,5	-2,7
EU+ - OT	-1,7	-0,4	-0,1	-0,0	-5,8	-1,4	-0,4	-0,1
ROW-ROW	0	0	0	0	0	0	0	0
Total impact	-5,2	-0,4	-3,5	-0,8	-17,7	-1,4	-11,9	-2,8
m tkm before EU ETS	29.500	92.200	5.800	51.500	29.500	92.200	5.800	51.500
Total impact in %	-0,02%	0,00%	-0,06%	0,00%	-0,06%	0,00%	-0,20%	-0,01%

Source: INFRAS

Table 44: Impact on revenues STC scenario without passing on opportunity costs in m EUR

in m EUR	Without passing on opportunity costs					
Airline type	Networker		LCC		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW
EU+/CH-EU+/CH	-80		-80		-2	-1
EU+ - OT	-0	-0	-0	-0	-0	-0
ROW-ROW	-20	+0	-25	+5	0	0
Total impact	-100	+0	-95	+5	-2	1
Revenue before EU ETS	125.000	330.000	26.400	21.700	2.420	22.400
Total impact in %	-0,08%	0,00%	-0,36%	0,02%	-0,10%	-0,00%

Source INFRAS

Table 45: Impact on revenues STC scenario with passing on opportunity costs in m EUR

in m EUR	With passing on opportunity costs					
Airline type	Networker		LCC		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW
EU+/CH-EU+/CH	-330		-310		-8	-2
EU+ - OT	-10	-0	-0	-0	-0	-0
ROW-ROW	-10	+0	-20	+5	0	0
Total impact	-350	+0	-330	+5	-8	-1
Revenue before EU ETS	125.000	330.000	26.400	21.700	2.420	22.400
Total impact in %	-0,28%	0,00%	-1,24%	0,02%	-0,34%	-0,01%

Source INFRAS

Table 46: Impact on profits STC scenario without passing on opportunity costs in m EUR

in m EUR	Without passing on opportunity costs					
Airline type	Networker		LCC		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW
Demand response	-2,6	0,1	-2,5	0,2	-0,1	-0,0
Windfall profits	0,0	0,0	0,0	0,0	0,0	0,0
Total impact	-2,6	0,1	-2,5	0,2	-0,1	-0,0
Profit before EU ETS	3.600	10.100	720	660	70	690
Total impact in %	0,1%	0,0%	-0,3%	0,0%	-0,1%	-0,0%

Source INFRAS

Table 47: Impact on profits STC scenario with passing on opportunity costs in m EUR

in m EUR	With passing on opportunity costs					
Airline type	Networker		LCC		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW
Demand response	-9	-0	-9	0,1	-0,2	-0,1
Windfall profits	287	2	211	0,4	8,2	2,0
Total impact	278	2	202	0,5	8,0	1,9
Profit before EU ETS	3.600	10.100	720	660	70	690
Total impact in %	7,7%	0%	28%	<0,5%	12%	<0,5%

Source: INFRAS

Impact on CO_2 emissions

in m t CO_2	Reduced emissions	
	Without passing on opportunity costs	With passing on opportunity costs
within aviation sector	0,25	0,88
purchase of emission rights	11,4	10,8

Source INFRAS

EAS scenario

Table 48: Impact on passenger demand EAS in m. pkm without passing on opportunity costs

in m. pkm	Without passing on opportunity costs			
Airline type	Networker		LCC	
Homeland	EU+	ROW	EU+	ROW
EU+ - EU+	-540		-1.600	
EU+ - Rest Europe/CH	-40	-40	-110	-60
EU+ - ROW	-1.100	-730	-1.110	-0
ROW - ROW	-20	-10	-120	20
Total impact	-1.700	-780	-2.940	-40
pkm before EU ETS	1.200.000	3.700.000	620.000	450.000
Total impact in %	-0,14%	-0,02%	-0,48%	-0,01%

Source INFRAS

Table 49: Impact on passenger demand EAS in m. pkm with passing on opportunity costs

in m. pkm	With passing on opportunity costs			
Airline type	Networker		LCC	
Homeland	EU+	ROW	EU+	ROW
EU+ - EU+	-2.190		-6.450	
EU+ - Rest Europe/CH	-150	-160	-450	-230
EU+ - ROW	-3.290	-2.610	-2.860	-220
ROW - ROW	-10	-10	-120	20
Total impact	-5.640	-2.780	-9.880	-430
pkm before EU ETS	1.200.000	3.700.000	620.000	450.000
Total impact in %	-0,47%	-0,19%	-1,60%	-0,10%

Source INFRAS

Table 50: Impact on cargo demand in m tkm

in m tkm	Without passing on opportunity costs				With passing on opportunity costs			
Airlinetype	Networker		Freighter		Networker		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW	EU+	ROW
EU+ - EU+	-5		-0	-0	-10		-10	-5
EU+ - Rest Europe/CH	-0	-0	-0	-0	-0	-0	-0	-0
EU+ - ROW	-135	-120	-10	-20	-170	-400	-30	-70
ROW - ROW		0	0	0	0	0	0	0
Total impact	-140	-120	-10	-20	-480	-400	-40	-75
tkm before EU ETS	29.500	92.200	5.800	51.500	29.500	92.200	5.800	51.500
Total impact in %	-0,5 %	-0,1%	-0,2%	-0,0%	-1,6%	-0,4%	-0,7%	-0,1%

Source INFRAS

Table 51: Impact on revenue EAS scenario without passing on opportunity costs in m EUR

in m EUR	Without passing on opportunity costs					
Airline type	Networker		LCC		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW
EU+ - EU+	-80		-75		-2	-1
EU+ - Rest Europe/CH	-10	-10	-5	-2	-0	-0
EU+ - ROW	-110	-80	-35	-0	-2	-5
ROW - ROW	-0	-0	-5	1	0	0
Total impact	-200	-90	-120	-1	-4	-6
Revenue before EU ETS	125.000	330.000	26.400	21.700	2.420	22.400
Total impact in %	-0,16%	-0,03%	-0,46%	-0,01%	-0,18%	-0,03%

Source INFRAS

Table 52: Impact on revenues EAS scenario with passing on opportunity costs in m EUR

in m EUR	With passing on opportunity costs					
Airline type	Networker		LCC		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW
EU+ - EU+	-310		-300		-8	-2
EU+ - Rest Europe/CH	-20	-20	-20	-10	-1	-1
EU+ - ROW	-350	-280	-90	-5	-6	-17
ROW - ROW	-0	-0	-10	+0	0	0
Total impact	-680	-300	-420	-15	-15	-20
Revenue before EU ETS	125.000	330.000	26.400	21.700	2.420	22.400
Total impact in %	-0,54%	-0,09%	-1,59%	-0,07%	-0,63%	-0,09%

Source INFRAS

Table 53: Impact on profit EAS scenario without passing on opportunity costs in m EUR

in m EUR	Without passing on opportunity costs					
Airline type	Networker		LCC		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW
Demand response	-5,6	-2,6	-3,3	-0,0	-0,1	-0,2
Windfall profits	0	0	0	0	0	0
Total impact	-5,6	-2,6	-3,3	-0,0	-0,1	-0,2
Profit before EU ETS	3.600	10.100	720	660	70	690
Total impact in %	-0,2%	0,0%	-0,5%	0,0%	-0,2%	0,0%

Source INFRAS

Table 54: Impact on profit EAS scenario with passing on opportunity costs in m EUR

in m EUR	With passing on opportunity costs					
Airline type	Networker		LCC		Freighter	
Homeland	EU+	ROW	EU+	ROW	EU+	ROW
Demand response	-20	-10	-10	-0	-0	-0
Windfall profits	810	470	290	15	20	35
Total impact	790	460	280	15	20	35
Profit before EU ETS	3.600	10.100	720	660	70	690
Total impact in %	22%	5%	38%	2%	29%	5%

Source INFRAS

Impact on CO_2 emissions

in m t CO_2	Reduced emissions	
	Without passing on opportunity costs	**With passing on opportunity costs**
within aviation sector	0,7	2,3
purchase of emission rights	30,6	29,7

Source INFRAS

Annex F: AERO-MS computational results

Table F1. Results for Business as Usual scenario CAEP8-M 2026 for flights covered by Stopping the Clock.

Indicator	Unit	Route group and flight type			
		Intra EEA+*	Intra EEA+*	Intra EEA+*	Intra EEA+*
		Scheduled pax - network carriers	Non-scheduled pax / LCC carriers	Freighter flights	Total
Aircraft km					
1. Aircraft km	Billion Ac-km	7.1	4.9	0.3	12.3
Demand					
2. Pax - first/business	Million Pax	83.0	---	---	83.0
3. Pax - economy	Million Pax	610.5	540.5	---	1,151.0
4. Pax-km	Billion Pax-km	626.9	629.5	---	1,256.4
5. Cargo	Million Tonne	1.9	---	6.4	8.2
6. Cargo-km	Billion Tonne-km	3.5	---	4.6	8.1
7. Revenue Tonne Km	Billion Tonne-km	59.9	56.7	4.6	121.2
Airline revenues					
8. Revenues pax - first/business	Billion €	24.8	---	---	24.8
9. Revenues pax - economy	Billion €	55.1	26.3	---	81.3
10. Revenues cargo	Billion €	1.4	---	2.8	4.2
Fuel use and emissions					
11. Fuel use	Billion Kg	18.7	13.4	1.1	33.2
12. CO_2 emissions.	Billion Kg	59.0	42.5	3.5	105.0
Operating efficiency					
13. Fuel/RTK	Kg/tonne-km	0.31	0.24	0.24	0.27
14. RTK/aircraft km	Tonne-km/ac-km	8.41	11.63	13.42	9.82
15. Revenues/RTK	€ / tonne km	1.36	0.46	0.62	0.91
16 Fuel/aircraft km	Kg/ac-km	2.62	2.76	3.23	2.69

* The route group "Intra EEA+" relates to all flights between and within EEA countries (including EEA outermost regions). Also flights between EEA states and EEA overseas countries and territories and flights between EEA states and Switzerland are included.

Table F2. Effects R1: Stopping the Clock; 25€/tCO2; opportunity costs for freely obtained allowances not passed on - % effects relative to BaU scenario CAEP8-M 2026.

Indicator	Unit	Route group and flight type			
		Intra EEA+*	Intra EEA+*	Intra EEA+*	Intra EEA+*
		Scheduled pax - network carriers	Non-scheduled pax / LCC carriers	Freighter flights	Total
Aircraft km					
1. Aircraft km	Billion Ac-km	-1.1%	-2.9%	-1.4%	-1.8%
Demand					
2. Pax - first/business	Million Pax	-0.6%	---	---	-0.6%
3. Pax - economy	Million Pax	-0.8%	-2.3%	---	-1.5%
4. Pax-km	Billion Pax-km	-0.8%	-2.5%	---	-1.7%
5. Cargo	Million Tonne	-0.6%	---	-1.0%	-0.9%
6. Cargo-km	Billion Tonne-km	-0.8%	---	-0.9%	-0.8%
7. Revenue Tonne Km	Billion Tonne-km	-0.8%	-2.5%	-0.9%	-1.6%
Airline revenues					
8. Revenues pax - first/business	Billion €	0.2%	---	---	0.2%
9. Revenues pax - economy	Billion €	0.0%	-0.5%	---	-0.2%
10. Revenues cargo	Billion €	0.2%	---	0.4%	0.3%
Fuel use and emissions					
11. Fuel use	Billion Kg	-0.9%	-2.6%	-1.2%	-1.6%
12. CO_2 emissions.	Billion Kg	-0.9%	-2.6%	-1.2%	-1.6%
Operating efficiency					
13. Fuel/RTK	Kg/tonne-km	-0.1%	-0.1%	-0.3%	0.0%
14. RTK/aircraft km	Tonne-km/ac-km	0.2%	0.4%	0.5%	0.2%
15. Revenues/RTK	€ / tonne km	0.9%	2.0%	1.3%	1.6%
16 Fuel/aircraft km	Kg/ac-km	0.1%	0.3%	0.2%	0.2%

* The route group "Intra EEA+" relates to all flights between and within EEA countries (including EEA outermost regions). Also flights between EEA states and EEA overseas countries and territories and flights between EEA states and Switzerland are included.

Table F3. Effects of R2: Stopping the Clock; allowance price 25€; opportunity costs for freely obtained allowances fully passed on - % effects relative to BaU scenario CAEP8-M 2026.

Indicator	Unit	Route group and flight type			
		Intra EEA+*	Intra EEA+*	Intra EEA+*	Intra EEA+*
		Scheduled pax - network carriers	Non-scheduled pax / LCC carriers	Freighter flights	Total
Aircraft km					
1. Aircraft km	Billion Ac-km	-2.1%	-5.6%	-2.7%	-3.5%
Demand					
2. Pax - first/business	Million Pax	-1.2%	---	---	-1.2%
3. Pax - economy	Million Pax	-1.7%	-4.5%	---	-3.0%
4. Pax-km	Billion Pax-km	-1.6%	-4.9%	---	-3.3%
5. Cargo	Million Tonne	-1.3%	---	-1.9%	-1.7%
6. Cargo-km	Billion Tonne-km	-1.6%	---	-1.8%	-1.7%
7. Revenue Tonne Km	Billion Tonne-km	-1.6%	-4.9%	-1.8%	-3.2%
Airline revenues					
8. Revenues pax - first/business	Billion €	0.5%	---	---	0.5%
9. Revenues pax - economy	Billion €	0.0%	-1.1%	---	-0.4%
10. Revenues cargo	Billion €	0.5%	---	0.8%	0.7%
Fuel use and emissions					
11. Fuel use	Billion Kg	-1.8%	-5.2%	-2.2%	-3.2%
12. CO_2 emissions.	Billion Kg	-1.8%	-5.2%	-2.2%	-3.2%
Operating efficiency					
13. Fuel/RTK	Kg/tonne-km	-0.2%	-0.2%	-0.5%	0.0%
14. RTK/aircraft km	Tonne-km/ac-km	0.5%	0.7%	1.0%	0.3%
15. Revenues/RTK	€ / tonne km	1.8%	4.1%	2.6%	3.1%
16 Fuel/aircraft km	Kg/ac-km	0.2%	0.4%	0.5%	0.3%

* The route group "Intra EEA+" relates to all flights between and within EEA countries (including EEA outermost regions). Also flights between EEA states and EEA overseas countries and territories and flights between EEA states and Switzerland are included.

Table F4. Effects R5: Stopping the Clock; 50€/tCO2; opportunity costs for freely obtained allowances not passed on - % effects relative to BaU scenario CAEP8-M 2026.

Indicator	Unit	Route group and flight type			
		Intra EEA+*	Intra EEA+*	Intra EEA+*	Intra EEA+*
		Scheduled pax - network carriers	Non-scheduled pax / LCC carriers	Freighter flights	Total
Aircraft km					
1. Aircraft km	Billion Ac-km	-2.1%	-5.6%	-2.7%	-3.5%
Demand					
2. Pax - first/business	Million Pax	-1.2%	---	---	-1.2%
3. Pax - economy	Million Pax	-1.7%	-4.5%	---	-3.0%
4. Pax-km	Billion Pax-km	-1.6%	-4.9%	---	-3.3%
5. Cargo	Million Tonne	-1.3%	---	-1.9%	-1.8%
6. Cargo-km	Billion Tonne-km	-1.6%	---	-1.8%	-1.7%
7. Revenue Tonne Km	Billion Tonne-km	-1.6%	-4.9%	-1.8%	-3.2%
Airline revenues					
8. Revenues pax - first/business	Billion €	0.5%	---	---	0.5%
9. Revenues pax - economy	Billion €	0.0%	-1.1%	---	-0.4%
10. Revenues cargo	Billion €	0.5%	---	0.8%	0.7%
Fuel use and emissions					
11. Fuel use	Billion Kg	-1.8%	-5.2%	-2.2%	-3.2%
12. CO_2 emissions.	Billion Kg	-1.8%	-5.2%	-2.2%	-3.2%
Operating efficiency					
13. Fuel/RTK	Kg/tonne-km	-0.2%	-0.2%	-0.5%	0.0%
14. RTK/aircraft km	Tonne-km/ac-km	0.5%	0.7%	1.0%	0.3%
15. Revenues/RTK	€ / tonne km	1.8%	4.1%	2.6%	3.1%
16 Fuel/aircraft km	Kg/ac-km	0.2%	0.4%	0.5%	0.3%

* The route group “Intra EEA+” relates to all flights between and within EEA countries (including EEA outermost regions). Also flights between EEA states and EEA overseas countries and territories and flights between EEA states and Switzerland are included.

Table F5. Effects R6: Stopping the Clock; 50€/tCO2; opportunity costs for freely obtained allowances fully passed on - % effects relative to BaU scenario CAEP8-M 2026.

Indicator	Unit	Route group and flight type			
		Intra EEA+*	Intra EEA+*	Intra EEA+*	Intra EEA+*
		Scheduled pax - network carriers	Non-scheduled pax / LCC carriers	Freighter flights	Total
Aircraft km					
1. Aircraft km	Billion Ac-km	-4.0%	-10.3%	-5.0%	-6.5%
Demand					
2. Pax - first/business	Million Pax	-2.3%	---	---	-2.3%
3. Pax - economy	Million Pax	-3.3%	-8.6%	---	-5.8%
4. Pax-km	Billion Pax-km	-3.2%	-9.4%	---	-6.3%
5. Cargo	Million Tonne	-2.5%	---	-3.7%	-3.4%
6. Cargo-km	Billion Tonne-km	-3.1%	---	-3.4%	-3.3%
7. Revenue Tonne Km	Billion Tonne-km	-3.2%	-9.4%	-3.4%	-6.1%
Airline revenues					
8. Revenues pax - first/business	Billion €	0.9%	---	---	0.9%
9. Revenues pax - economy	Billion €	-0.1%	-2.1%	---	-0.7%
10. Revenues cargo	Billion €	1.0%	---	1.6%	1.4%
Fuel use and emissions					
11. Fuel use	Billion Kg	-3.6%	-9.8%	-4.2%	-6.1%
12. CO_2 emissions.	Billion Kg	-3.6%	-9.8%	-4.2%	-6.1%
Operating efficiency					
13. Fuel/RTK	Kg/tonne-km	-0.4%	-0.5%	-0.8%	-0.1%
14. RTK/aircraft km	Tonne-km/ac-km	0.8%	1.1%	1.7%	0.4%
15. Revenues/RTK	€ / tonne km	3.5%	8.1%	5.1%	6.2%
16 Fuel/aircraft km	Kg/ac-km	0.4%	0.6%	0.9%	0.4%

* The route group “Intra EEA+” relates to all flights between and within EEA countries (including EEA outermost regions). Also flights between EEA states and EEA overseas countries and territories and flights between EEA states and Switzerland are included.

Table F6. Results for Business as Usual scenario CAEP8-M 2026 for flights covered by European Air Space.

Indicator	Unit	Route group and flight type							
		Intra EEA*	Extra EEA**	Intra EEA*	Extra EEA**	Intra EEA*	Extra EEA**	Intra EEA*	Extra EEA**
		Scheduled pax - network carriers		Non-scheduled pax / LCC carriers		Freighter flights		Total	
Aircraft km									
1. Aircraft km	Billion Ac-km	6.6	13.6	4.7	2.4	0.3	1.8	11.7	17.7
Demand									
2. Pax - first/business	Million Pax	78.4	73.3	---	---	---	---	78.4	73.3
3. Pax - economy	Million Pax	575.9	447.3	519.3	122.0	---	---	1,095.3	569.3
4. Pax-km	Billion Pax-km	580.1	2,917.7	612.2	454.8	---	---	1,192.4	3,372.4
5. Cargo	Million Tonne	1.6	18.6	---	---	6.2	7.5	7.8	26.2
6. Cargo-km	Billion Tonne-km	2.5	131.9	---	---	4.5	41.6	7.0	173.5
7. Revenue Tonne Km	Billion Tonne-km	54.7	394.5	55.1	40.9	4.5	41.6	114.3	477.0
Airline revenues									
8. Revenues pax - first/business	Billion €	23.2	83.2	---	---	---	---	23.2	83.2
9. Revenues pax - economy	Billion €	51.7	118.6	25.5	13.4	---	---	77.1	132.0
10. Revenues cargo	Billion €	1.2	28.0	---	---	2.8	10.0	4.0	38.0
Fuel use and emissions									
11. Fuel use	Billion Kg	17.3	76.7	13.0	10.0	1.1	7.7	31.3	94.4
12. CO_2 emissions.	Billion Kg	54.5	242.1	41.1	31.6	3.4	24.4	99.0	298.1
Operating efficiency									
13. Fuel/RTK	Kg/tonne-km	0.32	0.19	0.24	0.24	0.24	0.19	0.27	0.20
14. RTK/aircraft km	Tonne-km/ac-km	8.23	29.07	11.74	17.38	13.92	23.58	9.80	26.97
15. Revenues/RTK	€ / tonne km	1.39	0.58	0.46	0.33	0.62	0.24	0.91	0.53
16 Fuel/aircraft km	Kg/ac-km	2.60	5.65	2.77	4.25	3.32	4.39	2.69	5.34

* The route group “Intra EEA” relates to all flights between and within EEA countries (including EEA outermost regions).

** The route group “Extra EEA” relates to all flights between EEA countries and third countries included in EAS scenario.

Table F7. Effects R3: European Air Space; 25€/tCO_2; opportunity costs for freely obtained allowances not passed on - % effects relative to BaU scenario CAEP8-M 2026.

Indicator	Unit	Route group and flight type							
		Intra EEA*	Extra EEA**	Intra EEA*	Extra EEA**	Intra EEA*	Extra EEA**	Intra EEA*	Extra EEA**
		Scheduled pax - network carriers		Non-scheduled pax / LCC carriers		Freighter flights		Total	
Aircraft km									
1. Aircraft km	Billion Ac-km	-1.1%	-0.2%	-3.1%	-1.5%	-1.4%	-0.4%	-1.9%	-0.4%
Demand									
2. Pax - first/business	Million Pax	-0.6%	-0.2%	---	---	---	---	-0.6%	-0.2%
3. Pax - economy	Million Pax	-0.9%	-0.3%	-2.5%	-1.3%	---	---	-1.7%	-0.5%
4. Pax-km	Billion Pax-km	-0.9%	-0.2%	-2.7%	-0.9%	---	---	-1.8%	-0.3%
5. Cargo	Million Tonne	-0.7%	-0.2%	---	---	-1.0%	-0.4%	-1.0%	-0.2%
6. Cargo-km	Billion Tonne-km	-0.8%	-0.2%	---	---	-0.9%	-0.4%	-0.9%	-0.2%
7. Revenue Tonne Km	Billion Tonne-km	-0.9%	-0.2%	-2.7%	-0.9%	-0.9%	-0.4%	-1.8%	-0.2%
Airline revenues									
8. Revenues pax - first/business	Billion €	0.2%	0.2%	---	---	---	---	0.2%	0.2%
9. Revenues pax - economy	Billion €	0.0%	0.1%	-0.6%	-0.1%	---	---	-0.2%	0.1%
10. Revenues cargo	Billion €	0.2%	0.1%	---	---	0.4%	0.1%	0.4%	0.1%
Fuel use and emissions									
11. Fuel use	Billion Kg	-1.0%	-0.2%	-2.8%	-1.1%	-1.2%	-0.4%	-1.8%	-0.3%
12. CO_2 emissions.	Billion Kg	-1.0%	-0.2%	-2.8%	-1.1%	-1.2%	-0.4%	-1.8%	-0.3%
Operating efficiency									
13. Fuel/RTK	Kg/tonne-km	-0.1%	-0.1%	-0.1%	-0.2%	-0.3%	-0.1%	0.0%	-0.1%
14. RTK/aircraft km	Tonne-km/ac-km	0.3%	0.1%	0.4%	0.6%	0.5%	0.0%	0.2%	0.2%
15. Revenues/RTK	€ / tonne km	0.9%	0.3%	2.2%	0.9%	1.4%	0.5%	1.7%	0.4%
16 Fuel/aircraft km	Kg/ac-km	0.1%	0.0%	0.3%	0.3%	0.2%	0.0%	0.2%	0.1%

* The route group “Intra EEA” relates to all flights between and within EEA countries (including EEA outermost regions).

** The route group “Extra EEA” relates to all flights between EEA countries and third countries included in EAS scenario.

Table F8. Effects R4: European Air Space; 25€/tCO_2; opportunity costs for freely obtained allowances fully passed on - % effects relative to BaU scenario CAEP8-M 2026.

Indicator	Unit	Route group and flight type							
		Intra EEA*	Extra EEA**	Intra EEA*	Extra EEA**	Intra EEA*	Extra EEA**	Intra EEA*	Extra EEA**
		Scheduled pax - network carriers		Non-scheduled pax / LCC carriers		Freighter flights		Total	
Aircraft km									
1. Aircraft km	Billion Ac-km	-2.1%	-0.4%	-5.5%	-2.6%	-2.6%	-0.8%	-3.5%	-0.8%
Demand									
2. Pax - first/business	Million Pax	-1.2%	-0.3%	---	---	---	---	-1.2%	-0.3%
3. Pax - economy	Million Pax	-1.7%	-0.5%	-4.5%	-2.3%	---	---	-3.0%	-0.9%
4. Pax-km	Billion Pax-km	-1.6%	-0.3%	-4.9%	-1.7%	---	---	-3.3%	-0.5%
5. Cargo	Million Tonne	-1.2%	-0.3%	---	---	-1.9%	-0.8%	-1.7%	-0.5%
6. Cargo-km	Billion Tonne-km	-1.4%	-0.3%	---	---	-1.7%	-0.7%	-1.6%	-0.4%
7. Revenue Tonne Km	Billion Tonne-km	-1.6%	-0.3%	-4.9%	-1.7%	-1.7%	-0.7%	-3.2%	-0.5%
Airline revenues									
8. Revenues pax - first/business	Billion €	0.4%	0.3%	---	---	---	---	0.4%	0.3%
9. Revenues pax - economy	Billion €	-0.1%	0.2%	-1.1%	-0.1%	---	---	-0.4%	0.1%
10. Revenues cargo	Billion €	0.5%	0.2%	---	---	0.8%	0.2%	0.7%	0.2%
Fuel use and emissions									
11. Fuel use	Billion Kg	-1.8%	-0.4%	-5.1%	-2.0%	-2.2%	-0.8%	-3.2%	-0.6%
12. CO_2 emissions.	Billion Kg	-1.8%	-0.4%	-5.1%	-2.0%	-2.2%	-0.8%	-3.2%	-0.6%
Operating efficiency									
13. Fuel/RTK	Kg/tonne-km	-0.2%	-0.1%	-0.2%	-0.4%	-0.5%	-0.1%	0.0%	-0.2%
14. RTK/aircraft km	Tonne-km/ac-km	0.5%	0.1%	0.7%	1.0%	0.9%	0.0%	0.3%	0.3%
15. Revenues/RTK	€ / tonne km	1.7%	0.5%	4.0%	1.6%	2.5%	1.0%	3.1%	0.6%
16 Fuel/aircraft km	Kg/ac-km	0.2%	0.0%	0.4%	0.6%	0.4%	-0.1%	0.3%	0.1%

* The route group “Intra EEA” relates to all flights between and within EEA countries (including EEA outermost regions).

** The route group “Extra EEA” relates to all flights between EEA countries and third countries included in EAS scenario.

Table F9. Effects R7: European Air Space; 50€/tCO2; opportunity costs for freely obtained allowances not passed on - % effects relative to BaU scenario CAEP8-M 2026.

Indicator	Unit	Route group and flight type							
		Intra EEA*	Extra EEA**	Intra EEA*	Extra EEA**	Intra EEA*	Extra EEA**	Intra EEA*	Extra EEA**
		Scheduled pax - network carriers		Non-scheduled pax / LCC carriers		Freighter flights		Total	
Aircraft km									
1. Aircraft km	Billion Ac-km	-2.2%	-0.5%	-6.0%	-2.8%	-2.8%	-0.8%	-3.7%	-0.8%
Demand									
2. Pax - first/business	Million Pax	-1.3%	-0.3%	---	---	---	---	-1.3%	-0.3%
3. Pax - economy	Million Pax	-1.8%	-0.5%	-4.8%	-2.5%	---	---	-3.2%	-0.9%
4. Pax-km	Billion Pax-km	-1.7%	-0.3%	-5.3%	-1.8%	---	---	-3.6%	-0.5%
5. Cargo	Million Tonne	-1.3%	-0.3%	---	---	-2.0%	-0.9%	-1.9%	-0.5%
6. Cargo-km	Billion Tonne-km	-1.5%	-0.3%	---	---	-1.8%	-0.8%	-1.7%	-0.4%
7. Revenue Tonne Km	Billion Tonne-km	-1.7%	-0.3%	-5.3%	-1.8%	-1.8%	-0.8%	-3.5%	-0.5%
Airline revenues									
8. Revenues pax - first/business	Billion €	0.5%	0.3%	---	---	---	---	0.5%	0.3%
9. Revenues pax - economy	Billion €	-0.1%	0.2%	-1.2%	-0.1%	---	---	-0.4%	0.1%
10. Revenues cargo	Billion €	0.5%	0.2%	---	---	0.8%	0.3%	0.7%	0.2%
Fuel use and emissions									
11. Fuel use	Billion Kg	-2.0%	-0.4%	-5.5%	-2.2%	-2.4%	-0.9%	-3.5%	-0.7%
12. CO_2 emissions.	Billion Kg	-2.0%	-0.4%	-5.5%	-2.2%	-2.4%	-0.9%	-3.5%	-0.7%
Operating efficiency									
13. Fuel/RTK	Kg/tonne-km	-0.3%	-0.1%	-0.2%	-0.4%	-0.5%	-0.1%	0.0%	-0.2%
14. RTK/aircraft km	Tonne-km/ac-km	0.5%	0.1%	0.7%	1.0%	0.9%	0.0%	0.3%	0.3%
15. Revenues/RTK	€ / tonne km	1.9%	0.5%	4.4%	1.7%	2.7%	1.1%	3.4%	0.7%
16 Fuel/aircraft km	Kg/ac-km	0.2%	0.0%	0.5%	0.6%	0.4%	-0.1%	0.3%	0.2%

* The route group “Intra EEA” relates to all flights between and within EEA countries (including EEA outermost regions).

** The route group “Extra EEA” relates to all flights between EEA countries and third countries included in EAS scenario.

Table F10. Effects R4: European Air Space; 50€/tCO2; opportunity costs for freely obtained allowances fully passed on - % effects relative to BaU scenario CAEP8-M 2026.

Indicator	Unit	Route group and flight type							
		Intra EEA*	Extra EEA**	Intra EEA*	Extra EEA**	Intra EEA*	Extra EEA**	Intra EEA*	Extra EEA**
		Scheduled pax - network carriers		Non-scheduled pax / LCC carriers		Freighter flights		Total	
Aircraft km									
1. Aircraft km	Billion Ac-km	-3.9%	-0.8%	-10.3%	-4.9%	-4.8%	-1.5%	-6.5%	-1.4%
Demand									
2. Pax - first/business	Million Pax	-2.3%	-0.6%	---	---	---	---	-2.3%	-0.6%
3. Pax - economy	Million Pax	-3.3%	-0.9%	-8.6%	-4.5%	---	---	-5.8%	-1.7%
4. Pax-km	Billion Pax-km	-3.2%	-0.6%	-9.4%	-3.3%	---	---	-6.4%	-1.0%
5. Cargo	Million Tonne	-2.4%	-0.6%	---	---	-3.6%	-1.6%	-3.4%	-0.9%
6. Cargo-km	Billion Tonne-km	-2.8%	-0.6%	---	---	-3.3%	-1.4%	-3.1%	-0.8%
7. Revenue Tonne Km	Billion Tonne-km	-3.1%	-0.6%	-9.4%	-3.3%	-3.3%	-1.4%	-6.2%	-0.9%
Airline revenues									
8. Revenues pax - first/business	Billion €	0.9%	0.6%	---	---	---	---	0.9%	0.6%
9. Revenues pax - economy	Billion €	-0.1%	0.3%	-2.1%	-0.3%	---	---	-0.8%	0.3%
10. Revenues cargo	Billion €	0.9%	0.3%	---	---	1.5%	0.5%	1.3%	0.3%
Fuel use and emissions									
11. Fuel use	Billion Kg	-3.6%	-0.8%	-9.8%	-3.9%	-4.1%	-1.6%	-6.2%	-1.2%
12. CO_2 emissions.	Billion Kg	-3.6%	-0.8%	-9.8%	-3.9%	-4.1%	-1.6%	-6.2%	-1.2%
Operating efficiency									
13. Fuel/RTK	Kg/tonne-km	-0.4%	-0.2%	-0.5%	-0.7%	-0.8%	-0.2%	0.0%	-0.3%
14. RTK/aircraft km	Tonne-km/ac-km	0.8%	0.2%	1.0%	1.7%	1.6%	0.1%	0.4%	0.6%
15. Revenues/RTK	€ / tonne km	3.4%	1.0%	8.0%	3.1%	5.0%	1.9%	6.2%	1.3%
16 Fuel/aircraft km	Kg/ac-km	0.4%	0.0%	0.5%	1.1%	0.8%	-0.1%	0.4%	0.2%

* The route group "Intra EEA" relates to all flights between and within EEA countries (including EEA outermost regions).

** The route group "Extra EEA" relates to all flights between EEA countries and third countries included in EAS scenario.

References

Anger, A., Köhler, J. (2010). Including aviation emissions in the EU ETS: Much ado about nothing?: A review. Transport Policy 17 (1); 38–46

IATA (2008): Air Travel Demand. IATA economics briefing No 9.

BNEF (2011): Including aviation in the EU ETS: the burning question

Brons M., E. Pels, P. Nijkamp and P. Rietveld (2001): Price Elasticities of Demand for Passenger Air Travel: A Meta-Analysis.

CE Delft, Oeko-Institut, Manchester Metropolitan University (2005) : Giving wings to emission trading, Inclusion of aviation under the European Emission Trading System (ETS): Design and impacts.

CE Delft (2007): Allocation of allowances for aviation in the EU ETS: The impact on the profitability of the aviation sector under high levels of auctioning.

CE Delft and MVA (2007): Implications of EU Emission Trading Scheme for Competition Between EU and Non-EU Airlines, DGTL

CE Delft (2011): The Inclusion of Aviation in the EU Emissions Trading System: An Economic and Environmental Assessment, ICTSD

Commissariat general à la stratégie et à la prospective (2013): Les compagnies aériennes européennes sont-elles mortelles ? – Perspectives à vingt ans.

EC (2006) : Impact Assessment of the inclusion of aviation activities in the scheme for greenhouse gas emission allowance trading within the Community, SEC(2006) 1684

EC (2009): Guidance for the Aviation Industry: Monitoring and Reporting Annual Emissions and Tonne km Data for EU Emissions Trading

Europäische Kommission (2012) : Die Luftfahrtaußenpolitik der EU – Bewältigung der künftigen Herausforderungen. Mitteilung der Kommission an das europäische Parlament, den Rat, den europäischen Wirtschafts- und Sozialausschuss und den Ausschuss der Regionen. COM(2012) 556 final.

EC (2013a): Proposal for a Directive of the European Parliament and of the Council. Amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in view of the implementation by 2020 of an international agreement applying a single global market-based measure to international aviation emissions. COM(2013) 722 final. Brussels, 16 October 2013.

EC (2013b): Commission staff working document. Impact Assessment. Accompanying the document "Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowances trading within the Community, in view of the implementation by 2020 of an international agreement applying a single global market-based measure to international aviation emissions". SWD(2013) 430 final. Brussels, 16 October 2013.

EC (2013c): Frequently Asked Questions. Revised and updated version. Commission proposal for a European Regional Airspace Approach for EU emissions trading for aviation. Brussels, 28 October 2013.

EU (2013): Decision No 377/2013/EU of the European Parliament and of the Council of 24 April 2013 derogating temporarily from Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community

EU (2014): Regulation (EU) No 421/2014 of the European Parliament and of the Council of 16 April 2014 amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in view of the implementation by 2020 of an international agreement applying a single global market-based measure to international aviation emissions

EEA (2011); Decision of the EEA Joint Committee No 93/2011 of July 2011 amending Annex XX (Environment) to the EEA Agreement

Entec (2008): MRV Guidance for aviation in the EU ETS – Annual Emissions, Draft Technical Report for European Commission, September 2008.

Ernst and Young and York Aviation(2007): Analysis of the EC proposal to include Aviation activities in the Emission Trading Scheme

Forsyth P. (2008): The impact of climate change policy on competition in the air transport industry, discussion paper no. 2008-18
Paris : Joint Transport Research Centre, 2008

Greenaironline (2010) ICAO Assembly resolution on climate change runs into trouble over de minimis exemptions for states

Greenaironline (2011): European airline chiefs reaffirm support for EU ETS but say obstacles could hinder effective implementation

INFRAS (2009): Emissionshandel CH-Luftverkehr: Abschätzung administrativer Aufwand verschiedener Szenarien. Kurzbericht.

Malina, Robert, Dominic McConnachie, Niven Winchester, Christoph Wollersheim, Sergey Paltsev, Ian A. Waitz, The impact of the European Union Emissions Trading Scheme on US aviation, Journal of Air Transport Management, Volume 19, March 2012, Pages 36-41, ISSN 0969-6997,
http://dx.doi.org/10.1016/j.jairtraman.2011.12.004.Netherlands Institute for Transport Policy Analysis (2012) Civil Aviation in the EU Emissions Trading Scheme: Effects on the aviation sector, consumers and the environment, The Hague

Özmen M. (2012): Using pass-through of fuel prices as a proxy for carbon taxation responses in the aviation industry
http://www.garsonline.de/Downloads/090705/papers/Mehmet%20Ozmen%20GARSBremen.pdf

Pels (2009): Airline network competition: Full-service airlines, low-cost airlines and long-haul markets

PWC (200): Aviation Emissions and Policy Instruments
S.l. : PriceWaterhouseCoopers (PWC), 2005

Schaefer M., Scheelhaase, J., Grimme, W., Maertens, S. (2010). "The economic impact of the upcoming EU emissions trading system on airlines and EU Member States - an empirical estimation" in European Transport Research Review 2 (4):189–200

Scheelhaase, Janina, Wolfgang Grimme, Martin Schaefer (2010) The inclusion of aviation into the EU emission trading scheme – Impacts on competition between

European and non-European network airlines, Transportation Research Part D: Transport and Environment, Volume 15, Issue 1, January 2010, Pages 14-25, ISSN 1361-9209, http://dx.doi.org/10.1016/j.trd.2009.07.003.Toru T. (2009) How do sustained changes in cost of airlines influence air traffic "https://www.eurocontrol.int/eec/gallery/content/public/document/eec/report/2010/Account%20Paper-TT290910.pdf"
Vivid Economics (2008). A study to estimate the impacts of emissions trading on profits in aviation: A report for Defra and DfT. London. UK.