CE
Centre for
Energy Conservation
and Environmental
Technology
Oude Delft 180
2611 HH Delft
The Netherlands
Telephone: +31 15 2 150 150
Telefax: +31 15 2 150 151
E-mail: ce@antenna.nl
URL: http://antenna.nl/ce

A European environmental aviation charge

Feasibility study

Final report

Delft, March 1998

Authors: A.N. Bleijenberg
R.C.N. Wit

Colophon

This study was commissioned by:

The Netherlands Society for Nature and Environment (SNM)
Contact person: Mr T. Sledsens
Donkerstraat 17
3511 KB Utrecht
The Netherlands
fax: +31-30-2331.311

In close cooperation with:

The European Federation for Transport and Environment (T&E)
34 Boulevard de Waterloo
B-1000-Brussels
Belgium

This study has been conducted by:

Centre for Energy Conservation and Environmental Technology (CE)
Contact person: Mr R. Wit
Oude Delft 180
2611 HH Delft
The Netherlands
fax: +31-15-2150151

and, as subcontractors:

International Institute of Air and Space Law
Leiden University
Contact person: Mr P. Mendes de Leon
P.O. Box 9520
2300 RA Leiden
The Netherlands

Economics-Plus Ltd.
Contact persons: Mr D. Starkie &
Mr D. Thompson
45 Berkeley Street
Mayfair
London W1A 1EB
United Kingdom

This study has been financed by:

European Commission, DG XI
Contact person: Mr H. Arp
Rue de la loi 200
B-1049-Brussels
Belgium

Norwegian Ministry of Environment
Contact person: Mrs E.M. Åsen
p/o Box 8013 Dep.
N-0030-Oslo
Norway

Umweltbundesamt
Contact person: Mr N. Gorißen
Bismarckplatz 1
D-14193-Berlin
Germany

Bundesministerium für Umwelt, Jugend und Familie
Contact person: Mrs U. Hlawatsch
Stubenbastei 5
A-1010-Vienna
Austria

Danish Environmental Protection Agency
Contact person: Mr H. Nielsen
29, Strandgade
DK-1401-Copenhagen
Denmark

Dutch Ministry of Housing, Spatial Planning and the Environment
Contact person: Mr J. Peeters
P.O. Box 30945
2500 GX The Hague
The Netherlands

This is a free copy

Additional copies can be ordered from Milieuboek in Amsterdam, The Netherlands.

Telephone +31.20.6.244.989, fax: +31.20.6.235.203.

The price is NLG 63,00.

Preface

Flying..., ever since Icarus, the ultimate dream of mankind!
Every year, more and more people enjoy the benefits. Unfortunately, the rapid growth of air travel, as enjoyable as it may be, has a negative, but rather invisible side. It has negative consequences for the global environment.
Emissions of the aviation sector are increasing. Today, aviation accounts for 12% of global transport CO_2 emissions. Although the emissions of individual aircraft continue to fall, total CO_2 emissions expected to triple over the next three decades. Scientists (IPCC, 1994) indicate that the greenhouse effect of aviation-related NO_x emissions might be as high as that of CO_2 emissions.

Against this background, Stichting Natuur en Milieu, the Netherlands Society for Nature and Environment, in close cooperation with the European Federation for Transport and Environment (T&E), has taken the initiative to commission the present study on the feasibility of a European Environmental Aviation Charge. This focus reflects our experience that economic instruments are often more cost-effective than legal instruments, and that procedures at the global level take many, many years. We think that local, national and regional initiatives will catalyse a global approach.

Stichting Natuur en Milieu is very grateful for the financial support received from the European Commission and the governments of Austria, Denmark, Germany, the Netherlands and Norway, which made this large research project possible. Special thanks are due to their representatives for their valuable contributions in the steering committee, which enhanced the quality of this research. However, responsibility for the content of this report lies with the researchers of the Centre for Energy Conservation and Environmental Technology (CE, Delft, NL) and their subcontractors: the International Institute of Air and Space Law (IIASL, Leiden, NL) and Economics-Plus Ltd. (London, UK), who we thank for a difficult job well done.

This study shows that policy-makers have several options for a European Environmental Aviation Charge at their disposal which are feasible and which will be beneficial for the environment, while no convincing arguments have been found for economic disadvantages for the aviation sector arising on any substantial scale. The tourist industry may even benefit slightly in some countries, and will suffer only a minor set-back in other countries.

It is now urgent that national and European policy makers alike ensure that aviation - like other transport modes - develops in an ecologically sustainable manner. The results of this report put policy-makers in a better position to consider the advantages of introducing an environmental aviation charge. Let's not repeat the Icarus experience!

A.J.M. van den Biggelaar
Executive Director, Stichting Natuur en Milieu (Netherlands Society for Nature and Environment)

Contact at Stichting Natuur en Milieu:
Ton Sledsens, International Transport and Environment
Donkerstraat 17, NL-3511 KB Utrecht, The Netherlands
Fax: +31-302331311

Abstract

Air pollution from civil aviation is expected to triple in the period 1990-2015. This is due to the relatively high projected growth of air transport demand and despite substantial anticipated future environmental efficiency improvements to aviation.
In view of this, the study at hand investigates the feasibility of a European charge aimed at reducing air pollution from civil aviation. The main questions this study seeks to answer are: is it feasible to introduce an environmental charge on civil aviation in Europe only? And: what are the main advantages and disadvantages of different charge options?

The charge options considered are (i) a charge on emissions of flights in European airspace, (ii) a revenue-neutral emission charge, (iii) a charge on landing and take-off (LTO) emissions only, (iv) a fuel charge package and (v) a ticket charge.
The attractiveness of a European environmental aviation charge is determined both by its environmental effectiveness, being the aim of the charges considered in this study, and by its practical feasibility, which is in turn influenced by several different factors. The factors that are most important and considered in this study are: economic distortions, distributional complications and the juridical context.

The design of a European aviation charge has a substantial or even decisive impact on both its environmental effectiveness and its feasibility, as determined by the economic distortions, distributional complications and the juridical context. The study shows that a properly designed European environmental aviation charge is both environmentally effective and probably feasible.

An environmental aviation charge, applied on a limited geographical scale such as Europe, might lead to substantial economic distortions, which would in turn reduce the feasibility of such a charge. This study has therefore devoted considerable efforts to investigating potential economic distortions.
Two distributional issues are distinguished: a) among the participating countries and b) between the aviation industry and the public sector, or taxpayers. The distributional complications are identified in this report. No judgement has been made as to what would be a fair international distribution of revenues, as this is a political question.
A European environmental aviation charge would be less feasible if it conflicts with existing law. This study has therefore investigated possible legal obstacles, e.g. in connection with the Chicago Convention, bilateral Air Services Agreements (ASAs) and other international agreements, for the five charge options.

Contents

1 Introduction

1.1 Background and aim

The rapid growth in air traffic, worldwide, is of growing environmental concern. The combustion of aviation fuels gives rise to emissions of carbon dioxide (CO_2), water vapour (H_2O), sulphur dioxide (SO_2) and, if combustion is not complete, additional emissions of carbon monoxide (CO), volatile organic compounds (VOC) and particles. In addition, aircraft also emit NO_x, which is not directly related to fuel consumption, but to high temperatures in the combustion chamber. Finally, in the vicinity of airports, aircraft causes noise nuisance[1].

Aircraft emissions contribute to climate change (ozone depletion and the greenhouse effect), acidification and nuisance (local air pollution and odours). At present, CO_2 and NO_x can be regarded as the most important air pollutants. In both cases, aircraft accounted for between 2 and 3% of total world emissions from the combustion of fossil fuels in 1990. Emissions of CO_2 from aircraft have the same impact on the greenhouse effect as ground-level CO_2 emissions. NO_x emissions from aircraft contribute to all the aforementioned environmental effects. There is still uncertainty about the impact of NO_x emissions on the greenhouse effect. The Intergovernmental Panel on Climate Change (IPCC, 1994) presently estimates that the indirect effect on the enhanced greenhouse effect of aircraft NO_x emissions is of the same or a lower order of magnitude as the direct effect of aircraft CO_2 emissions.

Different sources[2] indicate that with current emission trends and without further policy measures, global aviation emissions in 2015 will be approximately three times those of 1990. As a result, the contribution of aviation emissions is set to increase significantly relative to total world anthropogenic emissions. This is due to the relatively high projected growth of air transport demand and despite substantial anticipated future environmental efficiency improvements to aviation.

---

[1] More information on air pollution by air traffic and its environmental impact can be found in Annex A (Environmental impact) of this report.

[2] Olivier (1995), Vedantham and Oppenheimer (1994) and Dings et al. (1997).

In view of this, more and more initiatives and studies are being undertaken on the need for and potential of charges to reduce aviation emis-sions. In 1995 the ICAO Assembly requested the ICAO Council to undertake a further study on the costs and benefits of charges to reduce emission levels[3]. The results of this study will be discussed at the fourth meeting of ICAO-CAEP[4], to be held in April 1998. On this basis, the Council will presumably send a report to the next Assembly of ICAO in September-October 1998.
In addition, the EU Council has asked the Commission to report on the possibility of a kerosine tax. To prepare this report, the Commission has launched a consultancy study on aviation fuel taxation, taking into account environmental and economic effects, legal issues and social aspects. Other important policy issues within the European Union are the harmonization of the Value Added Tax (VAT) for all transport modes and the possible abolition of the exemption of excise duties on fuel for air transport.
Finally, individual countries have introduced or are considering charges to reduce air pollution from civil aviation. Norway, Sweden and Switzerland have unilaterally introduced charges or taxes for environmental reasons. Germany recently announced a study into emissions-related landing charges.

In the development of an environmental policy for the aviation sector, economic instruments, such as charges to reduce emissions, form an attractive option as a complement to emission standards and other government regulations. The advantage of economic instruments is that they leave scope for the aviation sector to take measures to reduce emissions at least cost.

An effective environmental policy for the aviation sector should preferably be developed at the global level. However, it is already clear that international policy will be slow to develop, and a European initiative might therefore be desirable. In addition to the direct environmental benefits, a European charge on aviation will probably also provide a strong stimulus to policy development worldwide.

Against this background, the Netherlands Society for Nature and Environment commissioned the Centre for Energy Conservation and Environmental Technology to carry out a study into the feasibility of a European aviation charge. This research has been jointly financed by DGXI of the European Commission and by five national states: Austria, Denmark,

---

[3] During the meeting of ICAO-CAEP/3 it was agreed that the work on charges would be pursued by a Focal Point on Charges (FPC) with the assistance of members and observers. The FPC deals only with charges relating to emissions. The final draft version of the FPC's report to the CAEP/4 meeting was discussed on December 1997 (Emission charges and taxes in aviation, Report of the Focal Point on Charges -Outline and second draft- The Hague, 30 September 1997).

[4] The Committee on Aviation Environmental Protection (CAEP), which is charged with making recommendations on environmental policy to the Council of ICAO.

Germany, the Netherlands and Norway. Representatives of these organizations have participated in the Project Committee which guided this study. DGVII of the European Commission was represented on the project's steering committee but is not a co-funder.

The aim of this feasibility study can be formulated as follows:

> *To develop a number of variants for the introduction of an environmental charge on aviation in Europe, to study the feasibility of a charge of this nature, and to make proposals for its actual implementation.*

1.2 Demarcation

In this study there are a number of important points of demarcation of scope. Most of these points are discussed in greater detail in Chapter 2. The following points are important:

1. The principal aim of the aviation charges considered in this study is to reduce air pollution from aviation. Noise nuisance is not dealt with in this study.
2. The feasibility study does not consider military aviation and considers so-called 'small air traffic' only in passing. These types of aviation have their own specific characteristics, and environmental policy for these categories can probably be formulated at a national level.
3. A consequence of the choice to aim for a reduction of air pollution is that reduced growth in air traffic volume is not the prime aim of the charges considered in this study. The volume might, however, be affected by environmental charges. Fewer passengers and less freight are only economically efficient in so far as the associated costs are lower than the marginal costs of other types of abatement (technical and operational measures). In other words: reduced growth in air traffic is only considered in as far as it offers a cost-effective contribution to less pollution.
4. Choosing to focus on the reduction of emissions implies that the aim of the charge is certainly not to raise general revenue for governments. This is important to stress. Although not intended, an environmental charge may generate revenues, however. Use of these revenues is considered in this study.
5. For analyzing the feasibility of a European aviation charge it is essential to define which countries participate. In this project it is assumed that the aviation charge will be levied in the 15 Member States of the EU and Iceland, Norway and Switzerland. This area coincides with the European Economic Area (EEA) and is referred to in this report as both EEA and Europe.
6. This study considers, for obvious reasons, only so-called non-discriminative charges. This implies that both European and non-European airline companies are assumed to be subject to exactly the same charge. In other words, all airlines operating intra-EEA flights and flights from and to Europe have to pay the same charge.

7 This project is limited to environmental charges and does not focus on other policy instruments such as regulations, tradable permits, etc. It is evident, however, that environmental charges are not the only policy instrument available for reducing emissions from aviation. In fact, emission standards (e.g. for NO_x) are already applied for this purpose. This study does not focus on charges because they are the preferred policy instrument, but because little information is available about the feasibility of a European aviation charge. Once greater insight is gained, it becomes possible to assess the pros and cons of the different policy instruments and discuss a balanced policy package. However, this is not part of the study at hand.

8 The environmental aviation charge considered should be applied to all air transport, i.e. passenger, mail and freight transport. This study focuses on the passenger market. We emphasize, however, that all air transport causes air pollution and should therefore be subject to the same environmental policy measures.

1.3 Organization of the study

This report describes the final results of the Main Study on the feasibility of a European aviation charge. For the supervision of this research a Project Committee was formed with the following participants:
- Mr Henning Arp (European Commission, DG XI).
- Mrs Eli Marie Åsen (Norwegian Ministry of Environment).
- Mr Norbert Gorißen (Federal Environmental Agency, Germany).
- Mr Willem Jan van Grondelle (Netherlands Society for Nature and Environment).
- Mrs Ulrike Hlawatsch (Ministry of Environment, Youth and Family, Austria).
- Mr Hugo Nielsen (Danish Environmental Protection Agency).
- Mr Jochem Peeters (Dutch Ministry of Housing, Spatial Planning and the Environment).
- Mr Hans Pulles (Dutch Civil Aviation Authority).
- Mr Ton Sledsens (Netherlands Society for Nature and Environment and European Federation for Transport and Environment, Brussels).

Observer:
- Mr Jörgen Gren (European Commission, DG VII).

The main contractor for this background study was the Centre for Energy Conservation and Environmental Technology (CE), Delft, Netherlands. The legal part of this study (see Annex D) was carried out by the International Institute of Air and Space Law (IIASL), Leiden, Netherlands. Mr David Thompson and Mr David Starkie from Economics-Plus, London, UK, both acted as senior advisors to this project, making their knowledge and contacts available and giving their comments on the interim results. Specific contributions to the analysis of the potential economic distortions of the tourist industry were provided by the Netherlands Research Institute for

Recreation and Tourism in Breda. These are discussed in the Background Study on potential economic distortions[5].

The structure of this feasibility study is shown in Figure 1.1.

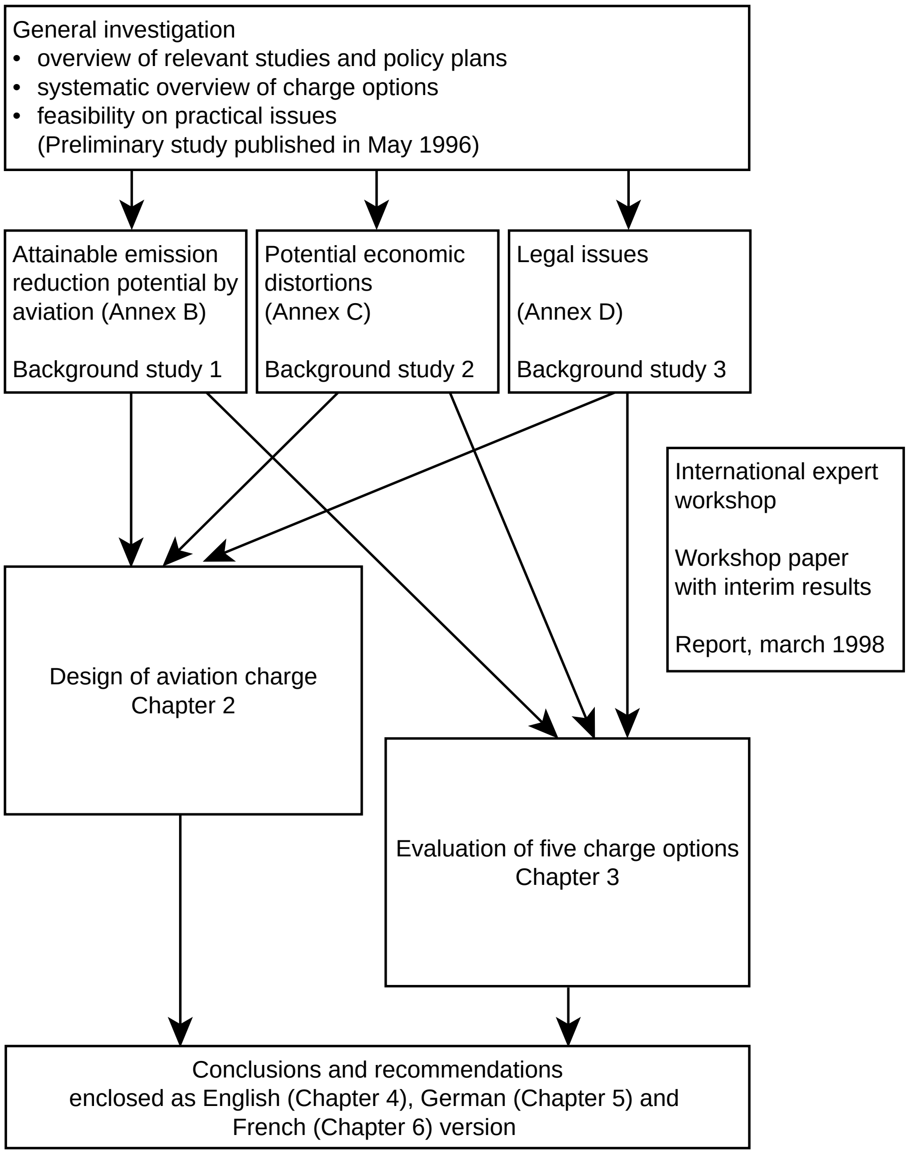


Figure 1.1 The structure of this feasibility study

[5] *Potential economic distortions of a European environmental aviation charge* (Wit and Bleijenberg, 1997).

The Preliminary Study was carried out between December 1995 and May 1996 and the results have been published[6]. This preliminary part provides a general investigation into the feasibility of a European environmental aviation charge.
In the next phase of this study the following three background studies were carried out, on the following topics:

1 European aviation emissions: trends and attainable reduction[7];
2 Potential economic distortions of a European environmental aviation charge[8];
3 Legal issues (included as Annex in this report)[9].

The aim of background study 1 is to elucidate clear what emissions reduction of world civil aviation, per unit of volume, can be expected in 2025 compared to 1992 in a 'Business as Usual' and a 'Technically Feasible' scenario and to indicate what part of the latter variant could be implemented under several possible charge options.
The aim of background study 2 is to evaluate whether a European environmental aviation charge would create potential economic distortions between the European and non-European aviation industry and tourist industry that would not occur as a consequence of a global aviation charge. This definition implies that a change in the competitive position of relatively clean airline companies compared to highly polluting ones is not considered as an economic distortion.
The aim of background study 3 is to assess whether different charge options, based on emissions, fuel or movements, would face serious legal obstacles, e.g. relating to the Chicago Convention, bilateral Air Service Agreements or other international agreements.

After completion of the three background studies an international expert workshop was organized on 28 October 1997 in Brussels. The aim of the workshop was to hold a constructive exchange of information, arguments and views regarding a European aviation charge and to inventory the pros and cons of different charge options. Workshop participants were representatives of the aviation sector, experts from the European Commission and national government agencies and representatives of environmental organizations. The report of the workshop has been published separately[10].

---

[6] *A European Aviation Charge, Preliminary study* (Bleijenberg et al., 1996).

[7] Summarized in Annex B of this report and published separately as *European Aviation Emissions: trends and attainable reductions* (Dings et al., 1997).

[8] Summarized in Annex C of this report and published separately as *Potential economic distortions of a European environmental aviation charge* (Wit and Bleijenberg, 1997).

[9] Annex D of this report and published previously in the Preliminary Study (Bleijenberg et al., 1996).

[10] *Report of the Workshop on the Feasibility of a European Aviation Charge* (Snape, 1998).

On the basis of the insights gained in the preliminary study, the background studies and the expert workshop, Chapters 2 and 3 of this final report were written. Finally, on the basis of these two chapters, the conclusions and recommendations were drawn up and are included in Chapter 4 of this final report.

1.4 Scope of the report

The content of the report is as follows:

Chapter 2 discusses important choices regarding the design of a European aviation charge with respect to:
- aim of the charge;
- charge base (2.3);
- level of the charge (2.4);
- allocation of the revenues (2.5).

Finally, Section 2.6 presents a brief overview of the relevant options.

Chapter 3 presents an evaluation of five representative options for a European environmental aviation charge. This chapter is built up as follows:
- overview and description of the five charge options (3.2);
- discussion of the evaluation criteria of environmental effectiveness, economic distortions, legal issues, implementation and distributive effects (3.3);
- evaluation of the advantages and disadvantages of five charge options based on these criteria (3.4 to 3.8);
- ranking of the five charge options and discussion of the conclusions regarding the feasibility of these options (3.9).

Chapter 4 contains a summary of the report and presents conclusions and recommendations. Chapter 5 contains the same summery, conclusions and recommendations in German, while Chapter 6 the French version contains.

In addition, this report includes eight annexes (A to I) which provide more detailed information on certain issues and summarize background studies that have been published separately from this report.

1.5 Acknowledgements

The authors thank the Netherlands Society for Nature and Environment for initiating this feasibility study and for commissioning CE, Delft to carry out this study. In addition, we acknowledge with gratitude the financial contributions from the sponsors - the European Commission and five national states: Austria, Denmark, Germany, the Netherlands and Norway - without which this study would not have been possible.
The authors wish to extend their special thanks to:

- Mr Pablo Mendes de Leon of the International Institute of Air and Space Law (IIASL), Leiden, Netherlands, who carried out the legal part of this study;
- Mr David Thompson and Mr David Starkie from Economics-Plus, London, UK, both senior advisors to this project, who made their knowledge and contacts available for the project and gave their comments on the interim results;
- Mr Ton Sledsens of the Netherlands Society for Nature and Environment, for his careful review of the work and his injection of ideas into this project;
- Mr Jochem Peeters of the Dutch Ministry of Housing, Spatial Planning and the Environment, for his specific contributions regarding the environmental impact of air pollution from aviation;
- Mr Hans Pulles of the Dutch Civil Aviation Authority (RLD), for making the AERO model available for this study as well as the expertise behind the model;
- Mr Jos Dings of CE for his specific contributions to the part of this study on trends and attainable reductions of international civil aviation emissions;
- The Netherlands Research Institute for Recreation and Tourism, Breda, for their specific contributions regarding the potential economic distortions for the tourist industry. Their results are included in a background study to this report.
- The members of the Project Committee of this project for their careful review of the results and their valuable advice;

The thinking and analysis underlying this study have benefited from the contributions of a number of discussion partners. These include Peter Newton of the British Department of Trade and Industry, Michael Mann of the British Ministry of Transport, Arne Karyd of the Swedish Civil Aviation Administration, John Crayston of the ICAO, Hans-Jochen Ehmer and Andrea Stader of the DLR, Germany, Paul Brok of the Dutch National Aerospace Laboratory, Harald Thune Larsen of the Norwegian Civil Aviation Administration, Wolfgang Gallistl of Vienna Schwechat Airport, Merlin Bruins of the Dutch charter Transavia Airlines, Jaap de Wit, Peter Uittenbogaart en Anneke de Wit of the Dutch Civil Aviation Authority, Frank Walle of Lufthansa, Hans Smeets and Jeroen Gemke of KLM, Hugh Sommerville of British Airways, Claudia Mäder of the Federal Environmental Agency of Germany, André van Velzen of Resource Analysis, Hugo van den Wall Bake of SNM, our colleague Gerrit de Wit of CE Delft and many others.

Notwithstanding all the help received as mentioned above, the content of the report is the sole responsibility of the authors.

2 Design of an aviation charge

2.1 Introduction and criteria

2.1.1 Introduction

There are many different ways to shape a European environmental aviation charge. Choices with respect to design go a long way to determine its environmental impact, potential economic distortions, legal and institutional implications and distributional consequences. A balanced design will therefore improve the environmental effectiveness and feasibility of a European aviation charge. This chapter discusses important choices with respect to design:

- aim of the charge (2.2);
- charge base (2.3);
- level of the charge (2.4);
- allocation of the revenues (2.5).

Finally, Section 2.6 presents a brief overview of the relevant options.

The aim of this chapter is not to produce 'the best-designed European aviation charge'. It merely presents alternative options and discusses the main advantages and disadvantages of these alternatives. In doing so, this chapter makes use of the three background studies: one on environmental effects[11], a second on potential economic distortions[12] and a third assessing potential legal obstacles (see Annex D).

Before the design of a European aviation charge is discussed, a general overview is presented of criteria relevant for selecting policy instruments (Section 2.1.2). All these criteria play a role in the design of an aviation charge.

2.1.2 Criteria for selecting policy instruments

This section deals with criteria for selecting instruments for (environmental) policy in general. The criteria are not only relevant for evaluating different forms of charges as discussed in this report, but also apply to other types of instruments.

---

[11] *European aviation emissions: trends and attainable reduction* (Dings et al., 1997). This background study is summarized in Annex B.

[12] *Potential economic distortions of a European aviation charge* (Wit and Bleijenberg, 1997). This background study is summarized in Annex C.

There is a large body of scientific literature on criteria for the use of policy instruments, but it is beyond the framework of this study to elaborate on this. The recent Green Paper of the European Commission 'Towards Fair and Efficient Pricing in Transport' presents a short overview, which will be used here.
Two criteria have been added to this overview: enforcement and legal provisions.

Effectiveness
It is clear that any policy instrument should achieve its intended objectives, in this study a reduction in air pollution from civil aviation.

Cost-effectiveness
Cost-effectiveness is another key criterion, which requires finding an instrument that is able to achieve a predefined target at least cost. This implies a preference for economically efficient solutions. Administrative and transaction costs are also important here. To give an example with respect to aviation charges: a charge on emissions measured during each flight would be the most effective, but in-flight emission measurements are currently so expensive that this option is not
cost-effective.

Distributional equity
Considerations of fairness play a major role in devising policies. Principles such as the User Pays and the Polluter Pays are widely accepted and refer to the distributional issue. In some cases additional policy measures are needed to correct unintended and undesired distributional effects of environmental policy.

Transparency
To ensure that interventions are justified, understood and accepted, it is important that the necessary interventions be transparent. Preference should be given to simple instruments. Furthermore, it is important that use of the revenues of environmental charges be transparent.

Subsidiarity
Each level of government should deal with those issues with which it is most qualified to deal. A 'higher' level of government should be involved only if it is better suited to solving the problems than lower-level authorities. This is in fact the reason that this study focuses on a European charge rather than on national aviation charges. Subsidiarity relates not only to the EU versus national level, but applies also to the role of local and regional governments.

Side-effects
A variety of unintended side-effects may result from the use of certain policy instruments. These side-effects may be either positive or negative. One of the most important side-effects, economic distortions, is the subject of one

of the background studies for this study and will also be discussed in the present report.

Enforcement
It is important that measures can be enforced. A well-known problem in this respect is the enforcement of speed limits for road traffic. This criterion of enforcement can be regarded as part of the aforementioned effectiveness criterion. A speed limit - or any other measure - that cannot be adequately enforced is not effective in achieving the stated goals.

Legal provisions
The final criterion is whether given policy instruments are acceptable under current law. With respect to aviation charges the Chicago Convention and the bilateral Air Service Agreements between countries are of relevance (see Annex D). One option is obviously to change current law if it conflicts with the introduction of an attractive policy instrument. In most cases, however, this will not be easy. This is the main reason to include this criterion.

It is evident that some of the criteria conflict with one another and do not always point in the same direction with regard to the choice of policy instruments. Choices must be made and trade-offs assessed.

2.2 Aim of the charge

2.2.1 Introduction

In general, two types of argument are used in favour of introducing aviation charges. The first relates to a desired reduction in the environmental impact of aviation. The second argues that it is fair for aviation to pay general taxes, just as road traffic does, for example. These two types of argument are not mutually exclusive. As stated above (Section 1.1) the aim of the charges discussed in this report is to reduce air pollution. In pursuing this aim two different approaches can be adopted, which will be discussed in Section 2.2.2. Although the aim of the charges considered in this report is certainly not to raise government revenues, there exist important links with general taxation. These links are clarified in Section 2.2.3.

2.2.2 Reduce air pollution

A crucial choice for the design of any policy instrument is the aim to be pursued. The starting point of this study is that the charge is aimed at reducing air pollution from aviation, covering emissions during the whole flight. Air pollution from aviation contributes to several types of environmental impact. Relevant forms of *environmental impact* are climate change, destruction of the ozone layer, acidification, and ground-level ozone formation. These impacts are caused by *emissions* of various types of air pollutant.

Some air pollutants are directly related to the amount of fuel used: CO_2, H_2O and SO_2, the latter depending on the sulphur content of the fuel.
Emissions of VOC, CO and particulates are caused by incomplete combustion of the fuel, which occurs mainly during landing and take-off (LTO[13]) and very little during the flight at cruising altitude. Finally, emissions of NO_x depend on engine characteristics such as temperature and they occur both during LTO and flight. NO_x is formed in the engine from nitrogen and oxygen available in the atmosphere.
In general, the aim of the charges studied in this project is to reduce all the air pollutants mentioned here. However, in some cases there are trade-offs.

As stated above, the aim of the charges under discussion is to reduce air pollution. It is important to note that *environmental impact* is not the same as polluting *emissions*[14]. The emissions cause the environmental impact. To give an example: emissions of CO_2 cause climate change. Climate change is the environmental impact in this example. In general, a given type of emission may, under different circumstances, result in a different magnitude or even type of environmental impact. The resulting impact can depend on the site of emission, the time of emission and other circumstances, such as the combination of the emission with other emitted pollutants. In the case of aviation this is relevant for emissions of NO_x, the environmental impact of which may depend on the altitude of the emissions, the period of the year - summer versus winter - and the geographical area. This might imply that a charge to reduce the environmental impact of NO_x emissions needs to be differentiated with respect to time, altitude and location. However, there is currently a lack of scientific evidence to support such a differentiated NO_x charge. Still, some types of charge offer the option of adding a differentiation at a later stage and therefore have an advantage over charges without this option.
This having been said, in the remainder of this study it is assumed that the environmental impact is directly related to the emissions. For emissions of CO_2 this approach is correct and for the other pollutants this seems an acceptable assumption for the time being.

Two different approaches can be distinguished for the design of an aviation charge aimed at reducing air pollution. The first takes as its starting point emission ceilings for aviation which are set in a political process. Sweden, for instance, has fixed targets for CO_2, NO_x and VOC emissions in Swedish air space[15]. Once targets have been set, a package of policy measures can be designed to keep emissions below the set ceilings. Charges may constitute part of such a policy package.

---

13 See Annex G for a short description of the Landing and Take-Off cycle.

14 See also Annex A.

15 See Section 2.4.2 for more details.

The second approach is internalization of external costs. In this case the starting point is not an emission target but the notion that pollution is not incorporated into market processes. These so-called external effects distort the optimum allocation of resources and result in a loss of welfare according to economic theory. Internalization means that external effects - in this case air pollution from European aviation - are incorporated into market processes. Internalization of externalities improves the efficiency of the economy and results in a welfare gain. In recent years many international studies have been carried out to estimate the magnitude of externalities caused by transport and to develop internalization policies[16]. From these and other studies it is clear that transport gives rise to substantial external costs, in the order of magnitude of several per cent of GDP. Furthermore, it is argued that an effective internalization policy requires a policy package of which efficient pricing is only one element[17].
An internalization approach of this nature is based partly on estimated shadow prices for pollution. Shadow prices are estimated as the prices that would arise if a market for pollution were to exist. The calculation of shadow prices will be discussed in Section 2.4.3.

2.2.3 Links to taxation

Although the principal aim of the charges discussed in this report is to reduce air pollution from aviation, there are several links to taxation. For instance, in the public debate about aviation charges two arguments prevail and are used in combination: pollution needs to be reduced and it is only fair that aviation should pay taxes, as road traffic does. The following section explores the various links between environmental charges on aviation and taxation. These links exist even though there is no fiscal aim behind the charges discussed in this report. The economic arguments relating to taxation, which follow below, aim to clarify the links between taxation and environmental charges and point out several important political differences in the interpretation of some specific taxes. No choices will be suggested on these issues.

---

16 See e.g. *Getting the Price Right* (Kågeson, 1993), *The social costs of traffic* (Bleijenberg et al., 1994), *External effects of transport* (IWW/Infras, 1994) and *Towards Fair and Efficient Pricing in Transport* (European Commission, 1995).

17 This is elaborated, for example, in the work of the ECMT Task Force on the Social Costs of Transport. Their final report *Efficient Transport for Europe* is to be published in the spring of 1998.

Efficiency of taxation

Before the links with aviation charges are discussed, it is useful to summarize the main principles of taxation[18]. Taxes and duties are introduced primarily to finance public consumption, public investment and public transfers. A second main aim is to correct market failures. Thirdly, the tax system is an important instrument to achieve the desired distribution of income.

As an unintended and undesired side-effect, most types of taxes affect the functioning of the economy because they may lead to changes in the relative prices of goods, services and inputs. These distortions may generate unfavourable efficiency effects, because economic agents are stimulated to use resources in an economic sub-optimum manner. Taxes therefore not only constitute a purely financial transfer from the private to the public sector; there might also be real economic costs associated with taxation. The size of these costs depends on the design of the tax system and the intention is, of course, to minimize these economic costs.

The following main principles of an efficient tax system can be formulated:

1. Introduce first, as far as possible, *taxes and duties which promote efficiency*, i.e. taxes and duties which correct externalities. This include charges aimed at internalizing environmental costs, as discussed in the previous section.
2. Apply thereafter, to the extent that this is practically feasible, *neutral taxes and duties*. These taxes are characterized by the fact that the taxpayer cannot influence the amount of tax to be paid by changing his or her behaviour. These taxes are imposed as a fixed sum, independent of the taxpayer's income, wealth or consumption (fixed-sum taxes). A correctly formulated tax on rent - the economic value of scarce natural resources such as oil, fish, space and soil - is also a neutral tax, because it has no impact on the use of these resources[19].
3. Apply *distorting taxes*, to the extent that the taxes and duties referred to under points 1 and 2 do not generate the desired amount of tax revenue. Distorting taxes include the most common taxes such as income tax, VAT and company taxes. Formulate the distorting taxes in such a way that the overall efficiency loss due to taxation is as small as possible and the tax system has the desired equity profile.

---

[18] See e.g. *Policies for a better environment and high employment* by the Norwegian Green Tax Commission (1996).

[19] Neutral taxes are, in practice, hard to implement and are not discussed further in this chapter. If tradeable emission permits are preferred to charges as a policy instrument, a tax on the economic rent of the associated environmental resources could be implemented as a neutral tax. However, this lies outside the scope of the present study.

The perfect tax system would comprise only efficient and neutral taxes (types 1 and 2) and would therefore not involve efficiency costs. In practice, however, insufficient tax options of these two types are available to generate enough public revenues. Therefore, various distorting taxes are generally required:

Efficiency: internalization and taxation
These principles show a clear link between environmental charges and taxation. Environmental charges are in fact (to some extent) taxes which promote efficiency (type 1 tax). This has been discussed as the internalization approach in the previous section (2.2.2). Environmental charges designed to internalize external environmental costs cannot therefore be distinguished from efficiency-promoting taxes, even if there is no fiscal aim behind the charge.

It is generally considered to be both fair and economically efficient that each economic activity pays the full costs, including costs that are currently external. A crucial question is than what price should be paid for air pollution. This issue will be discussed further on in this chapter (Section 2.4.3). Secondly, the question arises of how the revenues of such environmental charges are to be used. From the angle of economic efficiency there is thus no reason to treat these revenues differently from those from other charges and taxes. There are no economic reasons for the sector paying such environmental charges - in this study the aviation industry - to claim the revenues. The issue is efficient and fair use of public funds. One attractive option is to reduce the amount of distorting taxes (type 3 taxes). This results in a tax shift instead of in an increase in government revenues, and generates additional economic efficiency. This approach is fully in line with the starting point of this study that the environmental charges have no fiscal aim.

If the environmental charge is designed to reach a specific emission target (see Section 2.2.2) things might be a little different. In this case, the charge level can be higher than that corresponding with the external costs. This surplus cannot be regarded as an efficiency-promoting charge but is, rather, a distorting charge (type 3 tax). Distorting charges and taxes are part of the overall tax system and the question then arises whether distorting aviation charges are part of the optimal tax system for minimizing the overall efficiency loss. This question will not be addressed in this study, because it would require research into the whole tax system.

Equity: intermodal competition and fuel taxes
The focus above was on economic efficiency. Next, the important and politically sensitive issue of equity or fairness will be discussed. An important consideration for the design of a tax system is that all economic agents should be treated in the same way. Similar activities should be similarly taxed. This is crucial for the acceptability of taxes.

This equity principle is, for instance, relevant for charges aimed at internalizing externalities. Although it is generally seen as both fair and efficient that every activity pays its full costs, it is not regarded as fair that some are forced to pay the full costs, while others are not treated in the same way. In the discussion on aviation charges this issue focuses on the equal treatment of different transport modes. The aviation and car industries often state that it is unfair that they should have to pay the full social costs, as long as rail transport does not have to pay for its infrastructure. In general, each transport mode points to the perceived or real advantages of the other modes, as an excuse for not charging themselves the full social costs. Here indeed lies a challenge for political decision-makers to develop a transparent policy that is regarded as fair to all transport modes. Crucial issues in this respect are the economic valuation of externalities, proper pricing for the use of infrastructure and the development of a transparent system of Public Service Obligations, contracted out by public authorities to transport companies. It falls outside the scope of this study to discuss the degree of cost coverage currently achieved by each mode of transport.

A directly related issue is the interpretation of existing fuel and vehicle taxes for road transport. According to the relevant tax laws, most countries regard these road transport taxes not as instruments for achieving part-internalization of external costs (type 1 tax), but as general (distorting) taxes (type 3 tax). This implies that any charges aimed at promoting efficiency (or internalization) come on top of the existing taxes for road transport. For aviation the consequence of this interpretation is that, on top of efficiency-promoting charges, a general tax can be considered, as is the case for road traffic. The question is whether this minimizes the efficiency loss of the overall tax system, as mentioned above.

Most studies have focused on internalizing transport externalities, while tax laws in some countries follow a different approach, regarding specific taxes on road transport, such as fuel and vehicle taxes, as (part) payment for the use of infrastructure and the generated external costs (type 1 tax). This implies that the level of additional efficiency-promoting charges will be much lower than in the case of the legal approach described earlier. Equal treatment for aviation would imply consideration being given only to efficiency-promoting charges (type 1 tax) and not to distorting taxes (type 3 tax).
The interpretation of existing and possible new fuel and vehicle taxes is thus another crucial element in the discussion about equal treatment of transport modes.

Tax exemptions
In the discussion around environmental charges for aviation, existing tax exemptions also play a role. Most international transport is not subject to VAT and tax-free sales are allowed at airports, in cabins and on international ferries. In general, such tax exemptions are both economically inefficient and unfair. For this reason the European Union has decided to end the facilities for tax-free sales associated with intra-EU travel in mid-

1999. Consideration is currently also being given to ending the VAT exemption for intra-EU travel as well. This latter discussion appears to be focused on technical implementation and on potential economic distortions between EU and non-EU companies.

2.3 Charge base and levy point

2.3.1 Introduction

Once the aim of the charge has been established (Section 2.2), a second important choice relates to the charge base. The charge base determines the volume on which the charge is to be levied. A charge on fuel bunkers is frequently mentioned. In this case the charge to be paid is proportional to the volume of fuel bunkered. Other charge bases can also be considered, such as an emission-based charge or a ticket charge.

The choice of charge base has a major impact on the environmental effectiveness of the aviation charge. In this section this criterion of environmental effectiveness is taken as the starting point for the discussion of possible charge bases. The choice of charge base also determines, to a large extent, the potential economic distortions and legal complications. These issues are discussed in the following sections: 2.3.3 and 2.3.4.
Finally, possible levy points for the different charge bases are considered (2.3.5).

2.3.2 Charge base and environmental effectiveness

The discussion about possible options for a charge base proceeds from the effectiveness criterion. This relates directly to the aim of the charge, which in this study is to reduce air pollution.
The most appropriate charge is one on actual emissions[20]. This generates an incentive for abatement measures in the total chain of activities, ultimately influencing all the factors that determine the emission level: technological development, aircraft purchase, operation and volume. At the same time it generates an incentive to choose the most cost-effective package of measures over the whole chain. A charge on actual emissions would therefore be the most effective and efficient.
In-flight measurement of emissions is not currently feasible on a large scale, however, and so this option is not cost-effective (second criterion from Section 2.1.2). For this reason several second-best options will be discussed. The aim is to stay as close as possible to the ideal of a charge on emissions, but at the same time to find solutions that are acceptable in terms of the other criteria.

---

[20] Even better would be a charge on environmental impact, but this option is not considered in this study (see Section 2.1.3).

Calculated emissions
Instead of measuring emissions, these can be estimated by calculation. It is obviously important that the calculated emissions correspond closely enough to the real emissions. This is discussed in more detail in Annex H. In general, the emissions of a flight depend on:
- engine;
- fuel quality;
- airframe;
- flight path;
- distance;
- load.

Some of these factors might not have to be included in the calculation, but could be approximated via average characteristics. An attractive option appears to be to calculate emissions with respect to engine, airframe and flight distance. Assumptions are then needed for the average flight path and load and for the quality of the fuel used. This approach is followed in the following parts of this report and is referred to as a charge based on calculated emissions.

A disadvantage of this charge base on calculated emissions is that it does not generate an incentive to choose the least polluting flight path, because an average path is assumed. However, from the background study on options for emission reduction it is concluded that the environmental benefits from changing the flight path are relatively minor (see Annex B).

Another simple approach is to calculate the average emissions per engine-airframe combination, corresponding with a *fixed* distance instead of with respect to the real flight distance. From an efficiency point of view this option is not optimum, because it charges short flights too much and long flights too little (relative to their respective emissions). This may, however, be politically acceptable, because for short trips other modes of transport can offer an alternative, which is not generally the case for long trips[21].

Fuel consumption
Another second-best option is to base the charge on fuel consumption. Fuel consumption is directly related to emissions of CO_2, H_2O and SO_2 (depending on the sulphur content of the fuel). For these emissions, therefore, a fuel charge forms an adequate incentive.
Emissions of CO, VOC - caused by incomplete combustion - and particulates occur mainly during the LTO phase[22,23]. Emissions of these pollutants during the flight might be neglected. This implies that charges for these

---

21 Longer trips might, however, cause a relative stronger environmental impact, because more sensitive flight altitudes are used.

22 Emissions of particulates are influenced both by fuel quality and by the combustion process.

23 See Annex G for a short description of the Landing and Take-off cycle.

emissions can be imposed on the landing fees to complement a fuel charge.
The situation for NO_x emissions is different. NO_x emissions occur during both LTO and cruising and are not closely correlated to fuel consumption. A package of policy instruments is therefore needed to bring about an efficient pollution reduction, because fuel charges or emission standards alone do not generate an adequate incentive for reducing emissions of NO_x in a cost-effective way.

The following package of instruments can be employed to arrive at an efficient reduction in air pollution:
- A fuel charge the level of which corresponds with the average emissions per kg fuel of CO_2, NO_x, H_2O and SO_2 during the entire flight.
- An additional landing charge per engine-airframe combination corresponding with the LTO emissions of CO, VOC and NO_x. From this landing charge should be deducted the share of the LTO emissions of NO_x that is already incorporated in the fuel charge. This charge generates an incentive to reduce the specific emissions during LTO of CO, VOC and NO_x. It is in fact an element of the charge base discussed earlier: calculated emissions.
- Emission standards for engines or possibly for engine-airframe combinations for the LTO, climb and cruise phases. These standards are needed to avoid potential negative side-effects of a fuel charge on NO_x emissions during the flight. Without such standards energy efficiency might be improved at the expense of higher NO_x emissions.

The above package of instruments appears to offer good incentives to reduce pollution effectively and efficiently. The fuel charge is the key instrument in this package, but emission standards and differentiated landing charges are also needed to prevent certain adverse effects that would result from introducing a fuel charge only. The main weak point of this policy package is that insufficient incentive is created to reduce NO_x emissions per kg fuel during the flight (excluding LTO). This disadvantage can be reduced partly by setting proper emissions standards.

In the remainder of this report the fuel charge will be considered in combination with the two other instruments and be referred to as the fuel charge package. The reason for this choice is that introducing a fuel charge only is unrealistic, because this might increase air pollution from NO_x and VOC. Furthermore, emission standards are already in force, as are landing charges related to LTO emissions at some airports.

Movements
A third possible charge base is on movements of passengers and freight. A passenger movement corresponds with one departure per person. A charge on movements can be shaped in different ways. Some suggestions are:
- a charge on all European departures with a European destination;

- a charge on all European departures, with a double tariff for destinations outside Europe[24]; as a consequence each return trip is charged at the same rate, irrespective of the destination.

This second option will be further discussed in the remaining parts of this report.

A major disadvantage of a movement-based charge is that such a charge is poorly related to the pollution caused. No incentives are created with respect to length of trip, operational measures, technical improvements or load factor[25]. A movement-based charge will therefore reduce air pollution only by reducing growth in traffic volume. For this reason, the environmental effectiveness of this option is only roughly one-quarter that of charges based on calculated emissions and on fuel bunkers in combination with standards and differentiated landing charges (see above).

Other charge bases

Other options for a charge base could be considered, but they do not appear to offer any advantages over those discussed. One example is a charge per flight. If the level of the charge is not differentiated with respect to engine-airframe combination, such a charge would not lead to an efficient reduction in pollution. If, on the contrary, the level is differentiated with respect to type of aircraft, the charge then corresponds with one of the options discussed under the charge base 'calculated emissions'.

Another option is a charge per seat, as an alternative for a movement-based charge. The advantage of a seat charge is that it generates an incentive to increase the load factor, which a movement charge does not. A seat charge, however, is a fixed charge per engine-airframe combination, which can be easily improved by setting the charge to correspond with the emissions instead of the number of seats. This leads to a charge based on calculated emissions, which has already been discussed.

Overview

This study will further investigate the advantages and disadvantages of three different charge bases:

- calculated emissions;
- a fuel charge in combination with differentiated landing charges and emission standards;
- movement-based charges, with a single tariff for departures with a European destination and a double tariff for destinations outside Europe (Norwegian system).

---

24 This approach is currently practised by Norway and minimizes incentives to avoid the charge.

25 For more details, see the background study *European aviation emissions: trends and attainable reduction* (Dings et al., 1997).

2.3.3 Charge base and economic distortions

The choice of charge base determines the scope of the charge, which in turn has a large impact on potential economic distortions[26]. Figure 2.1 illustrates the differences in scope of the charge. An emission based charge applies to all emissions in European air space[27]. A fuel charge is levied on all fuel bunkers at European airports and applies in practice to (almost) all flights departing from Europe. A movement based charge, finally, applies in practice to all departures and arrivals at European airports.

---

[26] Economic distortions are defined in this study as competitive disadvantages for European over non-European companies resulting from the limited geographical scale of the charge. Possible changes in the competitive position of energy- efficient airline companies relative to inefficient companies are not therefore considered to be economic distortions. Such changes would also result from a global charge and should be regarded as efficiency improvements.

[27] European air space is not exactly defined in this study. This needs, of course, to be done before implementation. The detailed definition of European air space might offer further opportunities to minimize economic distortions.

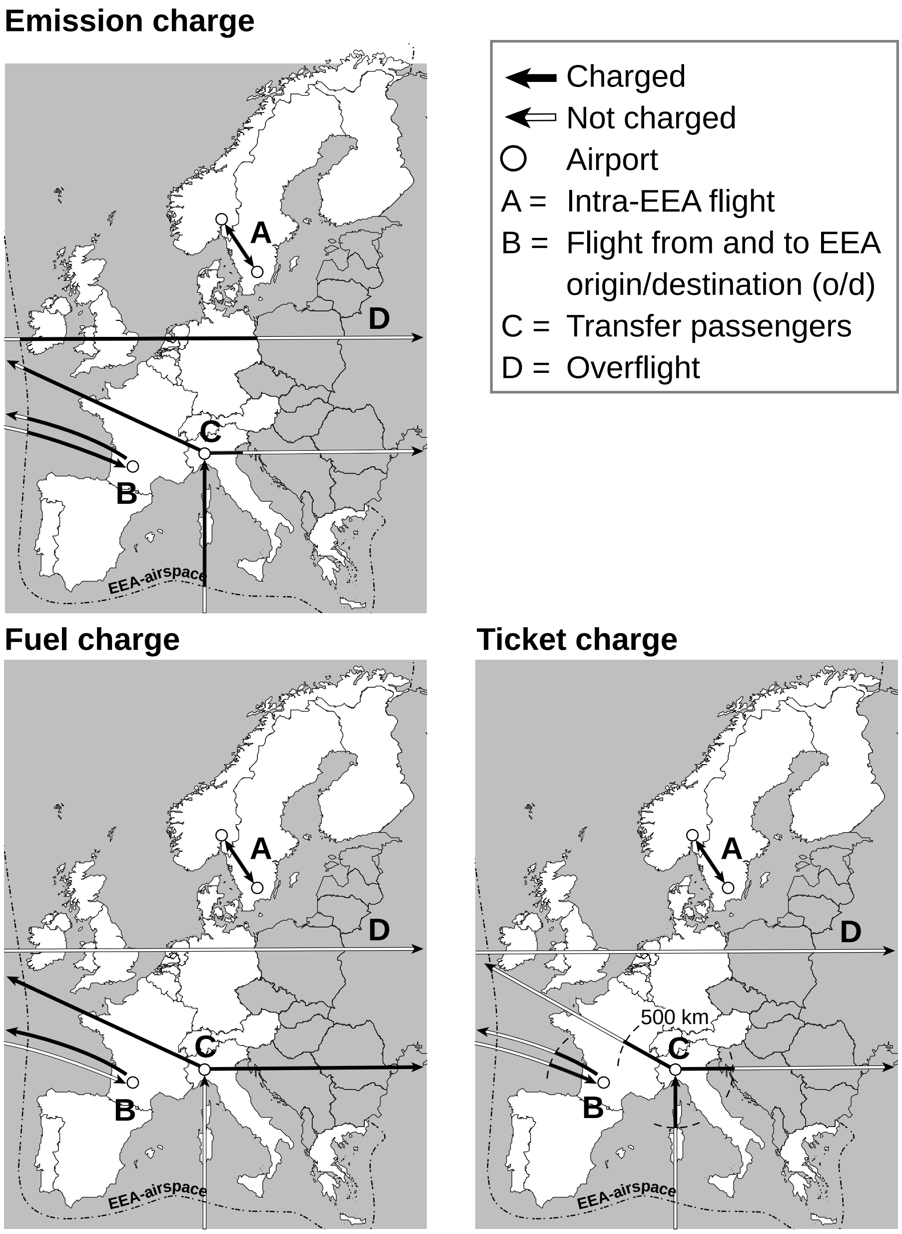


Figure 2.1 Scope of the three charge bases for four types of trips (A = intra-European; B = departure in Europe, destination outside; C Europe = only transfer in Europe; D = overflight)

The background study on economic distortions[28] concludes that an emission-based charge is least vulnerable to economic distortions. The main reason for this is that only a minor fraction of the charge can be avoided by changing the origin or destination of a flight to an airport outside Europe. For example, changing the departure airport from Vienna to

---

[28] *Potential economic distortions of a European aviation charge* (Wit and Bleijenberg, 1997).

Bratislava (outside EEA airspace) for a trip to Asia or North America only avoids paying the charge on LTO emissions or a little more. For a trip to Asia the emission charge for a flight departing from Vienna is very small, while in case of a trip to America European airspace will be used for a long stretch, irrespective of whether departure is from Vienna or Bratislava.
A potential economic distortion might occur for transfers at European airports having both their origin and destination outside Europe (flight type C). In this case choosing a transfer airport outside Europe might avoid all or a substantial part of the charge. However, this is of relevance for only a small part of the European aviation market and creating a new hub close to Europe will be difficult due to the economies of scale of existing hubs.

The risk of economic distortions is greater for a fuel charge. By changing the airport of departure to a location just outside Europe - e.g. Bratislava instead of Vienna - the charge on a one-way trip can be avoided. American or Asian visitors to Europe can avoid the fuel charge by choosing their airport of arrival just outside Europe. This might influence tourist visits to Southern Europe, for which alternative destinations are available. It is estimated that on European flights the potential economic distortion of a fuel charge is roughly 2 to 6 times greater than that of an emission-based charge for trips of 500 to 2000 km, respectively[29]. For intercontinental flights of, say, 6000 km the financial gain of choosing an airport outside Europe, where the fuel is not taxed, is much larger: up to roughly 30 US$ (fuel charge: 0.20 US$/l).

The economic distortions of a movement charge might be similar to those of an emission charge and are certainly less than those of a fuel charge. In the case of a movement charge a financial gain can be achieved for travellers and freight with a destination outside the EEA, if they shift their airport of departure to just outside Europe. In addition, arrivals from outside the EEA might shift their destination to an airport and tourist area outside Europe. In both cases, the entire movement charge can be avoided. Because the distortion generated by such a movement charge is limited to these two relatively small market shares, the resulting economic distortion is likely to be only slightly greater than that of an emission charge.

2.3.4 Charge base and legal issues

The choice of charge base is also relevant for the legal obstacles involved in implementing the charge. It is often argued that aviation charges are not permitted under the Chicago Convention. As part of this study the International Institute of Air and Space Law (IIASL), of Leiden, reviewed the main legal issues relating to introduction of aviation charges (see Annex D).

The conclusion drawn from their work is that emission and movement charges do not face severe legal obstacles. This is exemplified by the fact

[29] See Tables 2.9 and 2.10 in Section 2.4.5.

that Norway currently has a movement charge and that Zürich airport recently introduced an emission-based landing charge. Other countries and airports are considering introduction of similar emission-based landing charges.

While it is not yet clear, however, what legal provisions are needed to introduce an emission-based en route charge, there appears to be no conflict with the Chicago Convention, nor with so-called bilateral Air Service Agreements (ASAs). One potential problem might be that en route charges can only be levied in national territory, which includes the 12-mile zone but excludes the airspace above large marine waters such as the Baltic, the North Sea and the Mediterranean. If this were to remain the case, changes in route might be considered by carriers to avoid paying part of the charge. Such avoidance behaviour might be undesirable and might thus require international agreements to extend the airspace in which taxation is allowed. The present study did not investigate this possibility. Furthermore, it has not been assessed whether existing international law does or does not open up specific possibilities for taxation outside national territory. Additional research is needed to clarify these issues.

A fuel charge does pose certain legal problems. Although not in conflict with the Chicago Convention itself, introduction of a fuel charge is not permitted under the terms of many of the bilateral ASAs concluded between various pairs of countries. These often prohibit taxation of fuel bunkered and consumed in the signatory countries. Each ASA should be reviewed on its own merits, however, to allow specific conclusions to be drawn.

One option would be to adapt the bilateral ASAs. For ASAs between all pairs of EU Member States, this can be done by adopting an EU Directive on this matter that supersedes ASAs between EU countries. Changing an ASA between a Member State - or in a later stage the EU - and a non-EU country requires a renegotiation between the two authorities. Many ASAs should be reviewed. If they are not adapted to allow for an environmental charge, non-EU carriers would probably not be liable to a fuel charge, even on intra-European flights. This will generate a distortion of competition between EU and non-EU carriers.

A fuel charge limited to intra-EEA flights might face fewer legal obstacles than a fuel charge on all departing flights from Europe. This would have as a consequence, however, that the environmental effectiveness of this limited fuel charge is roughly one-quarter lower. Furthermore, economic distortions might be greater, but this is as yet unclear.

It is suggested that the relevant clauses in the standard texts for ASAs be reconsidered to create scope for possible introduction of fuel charges in the future. Each country has the freedom to do so, and international organizations can issue a recommendation to the individual states.

2.3.5 Levy point

Following the choice of charge base, a levy point has to be selected. The levy point determines where the charge is implemented and the choice has mainly practical implications. A fuel charge, for instance, can be imposed on the amount of fuel bunkered or on the measured fuel consumption after a flight. The choice of levy point seems hardly relevant for the feasibility of a European aviation charge. Table 2.1 presents an overview of possible levy points for the three charge bases distinguished.

Table 2.1 Levy points per charge base

Charge base	Levy point
1 Calculated emissions	1.1 Airport charges on planes 1.2 En route charges on planes 1.3 Charge per airline company 1.4 Airport charges on passengers and freight
2 Fuel	2.1 Fuel bunkers 2.2 Measured fuel consumption
3 Movement	3.1 Airport charges on passengers and freight 3.2 Ticket charges

2.4 Charge level

2.4.1 Introduction

Another important choice in designing an environmental charge for aviation is the level of the charge. In general, a higher charge will be more effective in reducing air pollution but might, on the other hand, generate larger economic distortions. This trade-off has not been investigated in this study, mainly because of a lack of quantitative information on the magnitude of possible economic distortions associated with different charge levels. This is a useful topic for further research.

Other considerations for fixing a certain charge level can be derived from Section 2.2, in which two approaches for environmental charges are distinguished and which also explored the link to general taxation. The first approach takes as its starting point an emission ceiling for aviation, corresponding with a political decision (2.4.2). Secondly, an internalization approach was discussed (2.4.3) and, thirdly, a fiscal approach in which the charge level is linked to existing fuel taxes for road traffic (2.4.4). Finally, an overview is presented of the discussed charge levels and some initial price changes are indicated (Section 2.4.5).

It is stressed that this section does not aim to draw any firm conclusions regarding the desired charge level. Many different considerations apply to this issue and the final choice is of a political nature. This section merely presents arguments in the discussion on charge level and does not choose from among the distinguished approaches. The section ends with a conclusion about the range in charge level subsequently used in the detailed assessment of charge options in Chapter 3. This is merely a research assumption and does not represent a policy recommendation.

2.4.2 Emission targets

This approach estimates the charge level required to achieve specified emission targets for civil aviation. Once emission targets have been set for aviation, this may be an attractive policy approach. To estimate the required charge level, additional information is needed about the expected growth in emissions and the price sensitivity of emissions or fuel.

An important question is, of course, what emission ceiling is to be assumed for aviation. Sweden is probably the only country that has set emission targets for the aviation industry. These are summarized in Table 2.2.

Table 2.2 Emission targets for civil aviation in Sweden[a]

		Target relative to base year		
	Base year	2005	2020	2050
CO_2	1990	+30%	0%	-20%
SO_2	1980	0%	0%	
NO_x	1980	+50%	+30%	
HC	1988	-50%	-50%	

a) All civil aviation within Swedish air space.
Source: Swedish EPA (1996).

As an illustration, the charge level is estimated that will bring CO_2 emissions in 2020 back to the level of 1990. The following assumptions are made:

- The growth trend in CO_2 emissions from civil aviation in Europe is estimated at 2 to 4% a year[30].
- A fuel price elasticity of -0.4 to -0.5 is used[31].

With these assumptions the required charge level is estimated at 200 to 1800% of current fuel prices. This corresponds with a charge of 0.40 to 3.60 $ per kg fuel. Such charges could bring CO_2 emissions from aviation in the year 2020 back down to the level of 1990.
More reliable data about both the growth trend in CO_2 emissions and the price elasticity are needed for a more accurate estimate of the charge level required to reach a given environmental target. Furthermore, it should be noted that it is most likely that a package of several different policy measures will be developed to attain an emission target. As a consequence, the required charge level might be lower.

2.4.3 Internalization of external costs

The starting point of this approach is economic theory. When prices correspond with the marginal costs, economic processes will lead to maximum welfare. Market prices correspond - in theory - with marginal costs and are thus generally accepted as the 'right' prices.

Air pollution, however, is not incorporated in the market mechanism. The main reason is that there are no established property rights and the atmosphere is therefore a so-called free good in the economic sense. As a consequence, pollution does not have a price and economic processes generate more pollution than the social optimum. This in turn calls for the development of environmental policy to reduce pollution levels. An economic approach to environmental policy is internalization: bring pollution into market processes. This aim can be pursued through a variety of instruments, such as government regulation, allocation of property rights, tradeable emission permits and environmental charges. The study at hand focuses on this last option. The crucial question is then what the proper price is for pollution. Because there are no established market prices for pollution, so-called shadow prices must be calculated.

---

30 This estimate is based on an annual growth of 4 to 6% in traffic volume and an annual increase of 1 to 2% in fuel efficiency and is in line with the Business as Usual projection in the background study on emission trends (Dings et al., 1997).

31 No reliable data have been found about the price elasticity of aviation fuel (see e.g. Michaelis, 1997). In theory, four different reactions can be engendered by a higher fuel price: efficient aircraft, efficient flight (route and speed), higher load factors and reduced transport growth. Information from the background study *European aviation emissions: trends and attainable reduction* can be used to arrive at an estimated long-term price elasticity of -0.4 to -0.5.

It is indeed possible to calculate shadow prices for pollution. The method used can be summarized as follows: what would be the equilibrium price if there were a market for pollution. Several economic techniques are employed for calculating shadow prices. In practice, the outcome depends to some extent on the environmental target used in the calculations, for an environmental target is sometimes taken as the supply curve of rights to pollute. This implies that a different target will result in a different shadow price.

Table 2.3 presents shadow prices that have been estimated and used by the ECMT[32] and earlier estimates by Kågeson (1993). Both estimates are based on many different international sources and are largely in line with the results of recent studies undertaken by our institute[33], as presented in Table 2.4.

Table 2.3 Shadow prices for air pollution (ECMT and Kågeson)

Pollutant	Shadow price	
	ECMT[34]	Kågeson (medium)
CO_2	0.06 $/kg	0.04 $/kg
NO_x (ground-level)	6.0 $/kg	5.0 $/kg
VOC	6.0 $/kg	5.0 $/kg

Sources: ECMT (1997) and Kågeson (1993).

32 European Conference of Ministers of Transport, *Draft report of the Task Force on the Social costs of Transport* (Paris, February, 1997). The final report, *Efficient Transport for Europe*, will be published in the spring of 1988.

33 For example, *The price of pollution* (Bleijenberg and Davidson, 1996) and *Optimizing fuel mix in road transport* (Dings et al., 1997).

34 The ECMT estimates correspond roughly with those of the European Commission (1995) in their White Paper *Towards fair and efficient pricing in transport.* The ECMT estimates the costs of air pollution at 16 $/1000 pkm for petrol cars and at 20 $/1000 tkm for trucks. The European Commission draws similar conclusions: 18 $/1000 pkm and 20 $/1000 tkm.

Table 2.4 Shadow prices for air pollution (CE)

Pollutant[35]	Recommended	Range
CO_2	0.05 $/kg[36]	0.02 - 0.10 $/kg[33]
NO_x (ground-level)	5.2 $/kg	3.7 - 7.9 $/kg
VOC	5.2 $/kg	3.7 - 7.9 $/kg
SO_2	4.1 $/kg	2.6 - 5.3 $/kg

Source: CE.

This report is not the place to discuss the assumptions and uncertainties with respect to the presented shadow prices. Their order of magnitude appears to be more or less accepted in Europe.

For NO_x emissions from aviation during LTO, the shadow price for ground-level emissions is applicable. NO_x emissions at higher altitude require special attention, because their contribution to climate change is still uncertain. Taking account of these scientific uncertainties, NO_x emissions at high altitude can be valued with a margin from zero to 3.5/17.5 $/kg. The upper bound is based on the worst situation, as-suming that NO_x emissions from aviation make the same contribution to climate change as CO_2 emissions[37]. Next, the margin in the shadow price for CO_2 is taken (Table 2.4), resulting in a shadow price for NO_x at high altitudes of from 3.5 to 17.5 $/kg[38]. The lower bound is based on the assumption that NO_x emissions at high altitude do not contribute to climate change. Next, it is assumed that they also do not contribute to acidification and ground-level ozone (smog). The small contribution to eutrophication is neglected. This results in a shadow price for NO_x at high altitudes of zero.

Next, these shadow prices are used to indicate a level of a possible aviation charge[39]. For this purpose the margin from Table 2.4 will be used, to

---

35 Shadow prices have been estimated for other pollutants as well (e.g. CO and particulates). Their relative importance is minor compared with the pollutants in Table 2.3.

36 The low value corresponds roughly with current policies and with the estimated economic damage caused by climate change. The medium (recommended) value is in line with stabilization of CO_2 emissions in West European countries. The high value is roughly in line with the recommendations of the IPCC on Climate Change Policy.

37 IPPC estimate (see also Section 2.4).

38 It is assumed that aircraft emissions of roughly 18 g NO_x per kg fuel correspond with the aforementioned IPPC statement. If current average NO_x emissions - around 14 g per kg fuel - were used, the shadow price for high-altitude NO_x would be higher.

39 All charge estimates assume that 67% of the Maximum Payload Weight (MPW) is used (passenger and freight). The estimates per passenger are made on the assumption that each passenger represents a weight of 95 kg (including luggage). A higher or lower load factor will of course have an impact on the emissions and the

indicate a range of uncertainty. Table 2.5 presents the estimated environmental charge for two flights: 500 km and 2000 km.

Table 2.5 Estimated charge level for two specific flights

Aircraft Load Distance	F50 67% 500 km		B747-400 67% 2,000 km	
Pollutant:	Low	High	Low	High
CO_2	46.7	234	1429	7145
NO_x	5.3 - 24.2	11 - 106	156 - 811	333 - 3615
VOC	5.2	11	68	146
SO_2	1.7	3.6	54	111
Total in $	59 - 78	260 - 354	1707 - 2364	7734 - 11017
Per km ($)	0.12 - 0.16	0.52 - 0.71	0.85 - 1.18	3.87 - 5.51
Per passenger ($)	1.4 - 1.8	6.1 - 8.3	3.1 - 4.2	13.9 - 19.7
Per 1000 pkm ($)	2.8 - 3.6	12.1 - 16.5	1.5 - 2.1	6.9 - 9.9
Per kg fuel ($)	0.08 - 0.11	0.35 - 0.48	0.08 - 0.10	0.34 - 0.49

Source: CE, based on emission data from NLR (Roos et al., 1997).

In Section 2.4.5 these estimates of charge level will be related to ticket prices and landing charges, for example, to illustrate the magnitude of the charge compared with other costs.

Table 2.5 shows that CO_2 has the greatest impact on the estimated charge level. Next comes NO_x, while the contribution of the other pollutants is small.

It should be noted that both aircraft types presented are 'modern' and that older types probably have higher emissions per passenger km. Table 2.5 also shows that the estimated charge level per passenger-km decreases somewhat with increasing distance and with increasing aircraft size.

Intermodal comparison

The internalization approach results in shadow prices that apply to all economic activities and thus to all transport modes. Table 2.6 gives an illustration of the resulting environmental charges for long-distance travel in Europe. Emission data are derived from a recent study[40], while the shadow prices for air pollution are taken from Table 2.4 (recommended value).

charge estimate per passenger.

40 *Energy and emission profiles of aircraft and other modes of passenger transport over European distances* (Roos et al., 1997).

Table 2.6 Energy use, emissions and environmental charges per passenger kilometre for long-distance travel

	Energy use MJ/pkm	CO_2 g/pkm	NO_x g/pkm	VOC g/pkm	SO_2 g/pkm	charge $/1000 pkm
Aircraft						
- 500 km[1]	2.2	160	0.47	0.06	0.05	11
- 1500 km[2]	1.6	115	0.40	0.03	0.05	8
Car						
- petrol[3], 2 passengers	1.5	110	0.08	0.03	0.02	6
- diesel[3], 2 passengers	1.3	100	0.39	0.05	0.03	7
- diesel[4], 1 passenger	3.2	235	0.76	0.09	0.07	16
Train						
- high-speed[5]	0.7	40	0.24	0.01	0.06	4
- conventional[6]	0.8	50	0.28	0.01	0.07	4
Long-distance coach[7]	0.3	20	0.29	0.02	0.01	3
Ferry[8]	0.6	50	0.92	0.04	0.98	12

Source: CE.

1 Average of two modern aircraft types (F50, B737-400), load factor 65%, detour factor 1.2.
2 Average of four modern aircraft types (B737-400, B757-200, B767-300ER, B747-400), load factor 65%, detour factor 1.15.
3 Modern, medium-sized petrol or diesel car, detour factor 1.3.
4 Modern, large diesel car, detour factor 1.3.
5 Average electricity production in North-West Europe (1990), load factor 65%, detour factor 1.25.
6 Conventional international train, average electricity production in North-West Europe (1990), load factor 40%, detour factor 1.35.
7 Modern touringcar on diesel, load factor 65%, detour factor 1.3.
8 Load factor 60%, detour factor 1.1.

Table 2.6 shows that the environmental performance of railways and long-distance coaches is superior to that of the other modes[41]. Therefore, the environmental charge for these two modes will be lower, although the same shadow prices are used per kg of air pollutant.

Creating a level playing field in the competition between different transport modes involves more than only environmental charges. In addition, no tax exemptions should be granted, proper prices should be charged for infrastructure use and a transparent and non-discriminatory system should be employed to contract out Public Services. Current practice deviates from these general principles, however. All the main transport modes prove to have specific uncovered costs. In the case of aviation, the existing VAT exemption and environmental costs are the most relevant. Road transport

41 Electricity generation gives rise not only to air pollution, but also to nuclear risks and wastes. These are not incorporated in the estimated environmental charges. However, this is offset by the relatively old data for air pollution due to power production (1990). In the Netherlands, for example, air pollution per kWh almost halved in the period 1990-1996.

involves substantial uncovered accident costs. With respect to rail traffic, uncovered infrastructure costs are most important.

It lies outside the scope of this study to estimate the market distortions existing for each transport mode. Based on work by a Task Force of the ECMT[42], it is estimated that the main effect of a policy aimed at internalizing all external costs will be to improve the economic and environmental efficiency of all transport modes. The resulting price increase is expected to be of the same order of magnitude for all modes. Consequently, the impact on the modal split is probably small.

2.4.4 Fuel tax

As has been discussed in Section 2.2.3, existing fuel taxes for road traffic can be interpreted in two different ways. According to the first approach, fuel taxes are regarded as general (distorting) taxes. This interpretation is in line with the relevant tax laws in most countries. If this approach is adopted, the question rises whether it is fair for aviation to pay a similar fuel tax to road traffic. It indeed seems reasonable for all transport modes to be subject to the same general taxes, including fuel taxes. A second question is whether introducing fuel taxes on aviation generates opportunities for reducing the efficiency costs of the entire tax system. This issue falls outside the scope of this study.
Only one side-remark is made here: sales taxes and annual registration taxes (such as vehicle tax) are probably less distorting than fuel taxes, because price elasticities are likely to be smaller. For this reason sales and registration taxes, as general (distorting) taxes, might be preferable to fuel taxes, as a way of minimizing the efficiency costs of the overall tax system.

Table 2.7 gives an overview of the average fuel taxes for road traffic in the European Union and of the harmonized minimum tax level. In the discussion on aviation charges it is often stated that aviation fuel should be taxed at the same minimum rate as diesel fuel. This corresponds with an increase in the price of aviation fuel of around 150%.

Table 2.7 Fuel taxes for road traffic in the European Union

	Unleaded petrol	Diesel
EU minimum	0.34 $/l	0.29 $/l
EU average January 1996	0.58 $/l	0.38 $/l

Sources: Directive 92/82/EEC and Dings and Bleijenberg (1996).

---

[42] ECMT Task Force on the Social Costs of Transport (Draft report February 1997, Final report *Efficient Transport for Europe* to be published in the spring of 1998).

According to the second interpretation of existing fuel taxes, these are regarded as a price for government services (infrastructure provision) and external costs (accidents and pollution). This approach is related directly to internalization of externalities, which was discussed in the previous section (2.2.3). Under this assumption, the existing fuel taxes for road transport do not constitute an argument for introducing fuel taxes in aviation. It is, rather, the level of external costs that constitutes a basis for introducing charges on aviation.

2.4.5 Overview and initial price changes

This section first presents an overview of the charge levels corresponding with the different approaches discussed before (Table 2.8). To render the different estimates comparable, they are all expressed in US$ per litre fuel. This certainly does not imply that a fuel charge is the best policy option (see e.g. Section 2.3).

Table 2.8 Estimates of charge level

Approach	Main assumption	Level (expressed in $/l)
Internalization	Low estimate Medium estimate High estimate	0.06 - 0.08 0.14 - 0.20 0.28 - 0.39
CO_2 emissions from aviation in 2020 at the 1990 level	Trend: 2% annual growth in CO_2 emissions Trend: 4% annual growth in CO_2 emissions	0.37 - 0.54 1.52 - 2.86
General taxation	Minimum excise duty on diesel	0.29
Working assumption		0.10 - 0.40

Table 2.8 reveals a wide range in charge levels, corresponding with 0.06 up to as high as 2.86 $ per litre fuel. At various points in this study a charge level ranging from 0.10 to 0.40 $/l will be used as a working assumption.

To illustrate the initial increase in the price of air transport, a charge level equivalent to 0.20 $/l will be assumed. As a first step, this charge level will be converted to levels for the three charge bases distinguished. Next, these levels will be related to relevant price or cost components of civil aviation, such as ticket prices, fuel prices and landing charges.

In the case of an emission-based charge, the shadow prices per kg pollutant equivalent to 0.20 $/l are nearly 20% higher than the recommended values in Table 2.4 (medium estimate)[43]. With these higher shadow prices, the total charge is estimated for two flight lengths (500 and 2000 km) and for five different aircraft types. Table 2.9 shows the results.

Table 2.9 Estimated emission charge level for five aircraft types and two distances (load 67%, equivalent to 0.20 $/l fuel)

	Charge		
Aircraft and distance	in $	in $/passenger	in $/1000 pkm
500 km			
F50	189	4.4	8.8
B737-400	594	4.3	8.6
2000 km			
B737-400	1676	12.1	6.0
B757-200	2222	12.1	6.0
B767-300	2819	15.4	7.7
B747-400	5740	10.3	5.1

Source: CE, based on emission data from NLR (Roos et al., 1997).

The total charge can be compared with current landing charges. For the B737-400 the total airport charges are around 5,000 US$ at the major European airports. This implies that for short flights the charge is roughly equivalent to 10% of existing airport charges. For longer European flights this percentage rises to around 35%. Total airport charges for a B757-200 are around 8,000 $, which puts the assumed charge at almost 30% (2000-km flight).
The charge per passenger can be seen as the initial ticket price increase. This increase is around 4 $ for a short trip and between 10 and 15 $ for a long European flight (one-way).

Next, Table 2.10 presents the price increase if the charge applies only to emissions during the LTO cycle. This part of the emission charge could be levied on the landing charges, while the emissions during the flight might be included in the existing en-route charges. Another option is to charge only LTO emissions (see Chapter 3). This avoids problems with allocation of the revenues (Section 2.5) and minimizes potential economic distortions. On the other hand, the environmental effectiveness of a charge limited to LTO emissions is relatively low. Comparing Table 2.10 with Table 2.9 shows that a charge on LTO emissions corresponds with only 20 to 40% of a charge on the whole flight on short trips and only 10 to 20% on long European flights.

---

43 For the shadow price for NO_x emission at flight altitude it is assumed that the environmental impact is intermediate between the worst case according to the IPCC and a no-effect level. This implies that the shadow price for high-altitude NO_x is somewhat lower than that for ground-level NO_x.

Table 2.10 Estimated level of a charge on LTO emissions (load 67%, equivalent to 0.20 $/l fuel)

Aircraft	Charge	
	in $	in $/passenger
F50	46	1.1
B737-400	220	1.6
B757-500	448	2.4
B767-300	526	2.9
B747-400	966	1.7

Source: CE, based on emission data from NLR (Roos et al., 1997).

If the charge is based on fuel bunkers, a 0.20 $/l charge corresponds with a 125% increase in fuel price. For intra-European flights this implies an average increase of around 9% in total operating costs. For intercontinental flights the operating costs will increase by more: on average by about 15%.

Finally, a charge on movements is considered. For this purpose it is assumed that the charge level per movement corresponds with the fuel consumption or emissions during a flight of 500 km. From Table 2.7 it can be seen that the movement charge would then be around 4 $ per passenger (load: 67%). This applies to intra-European flights (one-way). For flights with a destination outside the EEA, the movement charge would be doubled to around 9 $.

It needs to be stressed that the cited price increases are *initial* or maximum changes. Depending on the charge base, the charge will generate incentives to reduce the amount of pollution and to improve fuel efficiency. These responses will absorb part of the initial price increase, resulting in smaller price changes in the longer run.
Furthermore, it should be noted that the aircraft types for which estimates are presented are all modern ones. Older aircraft will consume more fuel and generate more air pollution, and the price increases will therefore be higher in the case of fuel- and emission-based charges.

2.5 Allocation and use of revenues

2.5.1 Introduction

In addition to the charge base and the charge level, a further crucial choice in the design of a European aviation charge is the allocation and use of the ensuing revenues. The sensitive issue is: who is to receive the money generated by a European aviation charge? It is evident that decisions on this matter have major distributional consequences: both between the aviation sector and the public sector (Section 2.5.2) and among participating national states (Section 2.5.3).
In addition to the distributional consequences, institutional complications arise if the revenues are allocated to the European level (Section 2.5.2).

The following section (2.5.2) discusses the three main options for allocation of the revenues: national states, European level and airline companies (so called revenue-neutral charge). Next, some distributional consequences among participating countries are indicated (Section 2.5.3). Finally, the use of the revenues is discussed in the case of allocation to public authorities (Section 2.5.4).

2.5.2 Three main options for allocation

This section discusses three main options for the allocation of financial revenues generated by a European charge on aviation. An initial choice is whether the revenues go to the public or the private sector. It is common practice for the revenues of environmental charges to go to public authorities. In this case the revenues can be allocated to national states or to the European level. Although revenues generally go to public authorities, however, in some cases they are refunded directly to the private sector involved. This results in three main options for the allocation of revenues from a European aviation charge:
- national states;
- European level;
- airline companies (revenue-neutral charge).

These options are discussed below.

National states
It is very common for national authorities to collect the revenues from environmental charges and decide on their actual use. This allocation option poses no specific problems. Charges on fuel and on movements can accrue to the national states where the fuel is bunkered and where passengers and freight depart. In the case of an emission-based charge, the revenues go to the country in whose airspace the emissions occurred. This means that the charges paid on all emissions in a country's airspace - including those from flights without a stop - go to that country.
Each different charge base in combination with allocation of revenues to national states results directly in a specific international distribution of

revenues. This politically sensitive issue will be discussed further in the following section (2.5.3).

European level

Allocation of the revenues to the European level leads to institutional complications. If the revenues go to a European body, for instance connected to the EEA, a political problem arises. As yet, the Member States of the EU have been very reluctant to transfer taxes from the national to the European level. In fact, no international taxes exist to date[44]. Until now, generating tax revenues and deciding on their use has fallen under national competence. It is to be expected that similar political arguments will form a bottleneck for the allocation of revenues to a European body. This might even fully block this option, as being politically unrealistic.

One possible way out of this problem is to decide on a mechanism for redistribution of the revenues in parallel with the introduction of a European aviation charge. Such a mechanism should contain precise rules for allocating the overall revenues to, say, the participating countries. In this case, an international treaty is needed to govern both the charge and allocation of the ensuing revenues. This avoids the need to establish an international body to decide on use of the revenues.

It goes without saying that the allocation mechanism is subject to conflicting national interests. Decisions can be taken by unanimity only, because all participating countries must sign the treaty.

Revenue-neutral charge

In some cases, revenues from environmental charges go directly to the private sector. This can be the result of self-regulation by a sector, as is currently under discussion in the chemical industry in the Netherlands. Another option is for the government to prescribe an environmental charge, the revenues of which are recycled to the sector involved. An example here is the Swedish charge on NO_x emissions from power plants, which is refunded to the electricity companies in proportion to the number of kWh they produce. This generates an incentive to improve environmental performance - i.e to minimize NO_x emissions per kWh produced - while it does not impose a financial burden on the electricity sector as a whole.

A similar approach can be considered for civil aviation in Europe. The airline companies pay a charge proportional to their (calculated) emissions and the revenues are refunded in proportion to their production of passenger- and tonne-kilometres. This creates an incentive to reduce emissions per pkm and tkm by means of technical and operational measures. Airline companies with a better than average environmental performance receive higher refunds than they pay as a charge. On the other hand, carriers with higher than average emissions are faced with a nett financial burden. This pro-

---

44 Import duties might be regarded as EU taxes, because the Member State into which the goods are imported must transfer the revenues of the customs duties to the EU.

motes environmental competition among airline companies, while the sector as a whole is not confronted with an extra financial burden.
However, this latter point can also be regarded as a disadvantage of such a revenue-neutral charge. It is sometimes argued that it is only fair that aviation pays for its external costs or pays taxes like other sectors (see Section 2.2). A related disadvantage of such a revenue-neutral charge is its lower environmental effectiveness, because it scarcely creates any incentive to reduce volume growth (see also Section 3.4).

Each airline company is free to use the refund in any way they want. In practice, carriers will focus their attention on the nett result of charge and refund. If an airline company foresees a positive nett result, they might lower their tariffs, thus generating a shift of passengers and freight to companies with a good environmental performance. In addition, all companies will seek cost-effective ways to reduce their pollution in order to minimize the nett loss or maximize their nett gain.

In the case of a revenue-neutral charge on aviation, it must be decided which airlines and which flights are subject to the charge. The best choice appears to be for all air traffic within European airspace to be subject to the charge and thus also to the refund[45]. This implies that European and non-European carriers are treated the same way, which avoids distortion in competition. Both emissions and passenger- and tonne-kilometres produced in European air space therefore need to be registered in order to impose the charge and to calculate the refund for each carrier.

2.5.3 International distribution

Choices with respect to charge base and allocation of the revenues determine the international distribution of the revenues. If, for instance, the revenues are allocated to national states, each charge base results in a specific distribution of the revenues over the participating countries. Section 3.8 presents some estimates of the consequences for the countries involved. A charge on fuel bunkers appears to be attractive for the Netherlands and Luxembourg, for example, while a ticket charge seems to be in the interests of, say, Norway.

If the revenues are allocated to the European level, international distribution is determined by the redistribution mechanism that is developed. It is evident that decisions about such a mechanism are subject to conflicting national interests.

This study does not attempt to indicate what a fair international distribution of the revenues might be. It only points out the distributional complications

---

[45] Differentiated landing charges related to air pollution can be regarded as a revenue-neutral charge on LTO emissions.

that arise in relation to the possible introduction of a European aviation charge.

2.5.4 Public use of the revenues

This last section discusses the use of the revenues once they have been allocated to the participating national states[46]. It is not the aim of this section to draw conclusions about specific use of the revenues. The sole purpose is to offer some considerations on this point. Furthermore, it should be noted that in the case of a revenue-neutral charge, no public revenues will be generated.

If the aviation charge is regarded as a general tax (see Section 2.2.3), the revenues go the state budget and decisions about their actual use are made in the context of the entire government budget. In general, therefore, the revenues can be used to cut back the budget deficit, to reduce the rates of other taxes and to increase government expenditure. Neither the first nor the last option are in line with the purpose of the charges that are the subject of this report, for the aim is to reduce air pollution and not to raise government revenues, nor to cut back the budget deficit or increase government expenditure. It therefore seems most appropriate to use the revenues for a reduction of other taxes, resulting in a tax shift rather than a tax increase. A reduction of labour taxes is suggested by many national governments and by the European Commission, as a contribution to the fight against unemployment in Europe. A so-called ecological tax reform is consequently expected to reduce the efficiency costs of the entire tax system[47].

Some specific claims on part of the revenues will now be discussed that might become an element of the policy package to implement environmental charges on European aviation.

Firstly, the aviation industry claims that revenues from environmental charges should be used within the aviation industry. This position is evidently in line with their commercial interests, but it is not supported by considerations of economic efficiency, nor by arguments relating to equal treatment of transport modes. This has been discussed in earlier sections of this report (mainly Sections 2.2.6 and 2.4.3). However, consideration might be given to using part of the public revenues to promote environmental

---

[46] This can be achieved either directly or via a European redistribution mechanism (see Section 2.5.2).

[47] See, for example, *The effects on employment of a shift in taxation from labour to the environment* (De Wit, 1994), *Integrating environment and economy* (OECD, 1996) and *Policies for a better environment and more employment* (Norwegian Green Tax Commission, 1996).

improvements to civil aviation in Europe[48]. Research and development work on less polluting aircraft and engines might be supported, for example. Another option is to create a financial incentive for purchase of the least polluting aircraft types. Introducing such incentives probably involves a complication, because both European and non-European carriers pay the charge, which makes it hard to accept that only the European aviation industry would profit from the revenues[49].

A second claim on the revenues is put forward from the environmental side. It is argued that using the revenues for additional environmental measures would increase the environmental effectiveness of the policy package. In general terms, this is indeed true. As a consequence, however, total government revenues will increase, which heightens the impression that one aim of the charge is to generate revenues. This will probably reduce public and political acceptance of possible introduction of an aviation charge. Furthermore, there are no reasons of economic efficiency or equity for such an approach. We therefore prefer to separate the two policies. One is concerned with introduction of an emission charge, as an element of a shift in taxation. The second relates to the level of government expenditure on environmental policy, as part of decisions about the overall government budget. This distinction improves the transparency of policy, which in turn increases its acceptance.

Another argument sometimes put forward is that the revenues from environmental charges should be used partly to compensate individuals and companies faced with environmental damage. This argument does not serve economic or environmental efficiency, but aims at fairness. Considering emissions of CO_2 and NO_x from civil aviation, large geographic areas are affected and it seems unfeasible to identify all those involved and compensate them accordingly. A general tax shift, as discussed above, might be a reasonable approach.

Finally, part of the revenues might be used to compensate economic sectors that are harmed by introduction of an aviation charge. The background study on economic distortions[50] discusses compensation for the tourist industry in Southern Europe. The need for compensation depends largely on the chosen charge base and on mode of revenue allocation. In the case of an emission-based charge, there might be no or only a small need for compensation, related, for example, to average LTO emissions per passenger.

---

48 In the case of a revenue-neutral charge, no public revenues are generated. This charge option therefore falls outside the scope of this section, although similar arguments hold against a revenue-neutral charge (see, for example, Section 2.5.2).

49 It is outside the scope of this study to discuss whether such a combination of charge and revenue use is in conflict with international agreements on free trade (WTO).

50 *Potential economic distortions of a European aviation charge* (Wit and Bleijenberg, 1997).

2.6 Overview

The earlier sections of this chapter have discussed four important choices with respect to the design of a European aviation charge. These can be summarized as follows:

1 The aim of the charge (2.2). This report focuses only on charges aimed at reducing air pollution from civil aviation.
2 The charge base (2.3). Three relevant charge bases have been distinguished and are the subject of this study: calculated emissions, fuel bunkers and movements.
3 The level of the charge (2.4). As a working assumption, a level equivalent to 0.10 to 0.40 $ per litre fuel has been assumed.
4 The allocation of the revenues (2.5). Three main options are: to national states, to the European level and to the airline companies (revenue-neutral charge).

Table 2.11 summarizes the main choices in the design of a European aviation charge.

To a large extent, the design of the charge determines its feasibility. Charge base, level and revenue allocation all have an impact on the potential economic distortions. By choosing an appropriate charge base and mode of allocation, legal and institutional complications can be largely avoided. Any design will have distributional consequences. And last but not least, the environmental effectiveness is determined mainly by the choice of charge base and charge level.

The next chapter of this report will select five possible charge options and will assess their pros and cons in more detail.

Table 2.11 Main choices in the design of a European aviation charge

Charge base	Charge level (expressed as fuel charge)	Allocation of revenues
Calculated emissions	↑	National states
Fuel bunkers	0.10 $/l	European level
	|	
Movements (ticket charge)	| 0.40 $/l	Airline companies (revenue-neutral)
	↓	

3 Evaluation of five charge options

3.1 Introduction

The aim of this chapter is to evaluate five options for a European aviation charge and discuss their respective advantages and disadvantages. The aim is certainly *not* to arrive at any final pronouncement on what might be the best charge option. The focus, rather, will be on a clear overview of information, arguments and possibilities with respect to the feasibility of the various options for a European aviation charge.

The structure of this chapter is as follows. Section 3.2 presents a brief overview of the five charge options to be evaluated in this chapter. Section 3.3 sets out five criteria (environmental effectiveness, economic distortions, legal issues, implementation and distributional complications) for evaluating these options for a European aviation charge. Subsequently, in Sections 3.4 to 3.8, the results of the evaluation are presented. Section 3.9, finally, summarizes the advantages and disadvantages of the five options for a European aviation charge, as presented in the previous sections.

3.2 Review of the five main charge options

This section briefly reviews five options for a European aviation charge, which will be evaluated in the following sections. These five options stem mainly from the discussion of Chapter 2 (design of the charge) and have been chosen to represent the whole range of possibilities and cover the most promising ones. The choice of these five options is elucidated in Annex E of this report, which describes the selection process adopted to limit the number of charge options to be evaluated further in this chapter. The five selected charge options are:

1 Calculated emission charge (revenues to European level)
This charge will be levied on each kg pollutant (CO_2, NO_x etc.) emitted by an aircraft in European airspace. This emission-based charge would require some sort of classification of aircraft according to their performance in standard emission tests. One method might be to calculate the emissions of each engine/airframe combination for a certain route[51]. As this charge

---

[51] One possible starting point for aircraft certification might be the ICAO database on engine emissions during the Landing and Take-Off cycle (LTO cycle). Assumptions must then be made with respect to average flight path and load and quality of fuel used. Another very simple approach is to calculate the average emissions per engine-airframe combination corresponding with a given flight distance. From an efficiency point of view this option is sub-optimum, because it charges short flights too much and long flights too little (relative to their respective emissions). This may be politically acceptable, however, because for short trips other modes of transport may

option will be levied in European airspace, a route charge or a route charge combined with a landing charge on LTO emissions seems to be an appropriate levy point.
The revenues of this charge option will be allocated to the European level. Redistribution of these revenues could be based on allocation rules as defined in an international treaty. The revenues could be used for any of the purposes described in Section 2.5.4.

2 Revenue-neutral emission charge (revenues to airline companies)
This charge will be levied on each kg pollutant (CO_2, NO_x etc.) emitted by an aircraft in European airspace. It differs from the first charge option in that the revenues will be allocated to the airline companies instead of the participating EEA countries (international treaty). Recycling the revenues to the carriers implies that the charge is revenue-neutral. The levy point is a route charge levied, e.g. by Euro Control, on the calculated emissions of each specific engine/airframe combination during a flight. In addition, Euro Control or another organization will have to register the production of passenger-kilometres and tonne-kilometres by each aircraft in EEA airspace.

A transparent and simple form for a revenue-neutral charge is for all (European and non-European) carriers to pay a charge related to their emissions in European airspace, with the revenues being recycled to the same carriers in proportion to the number of passenger- and tonne-kilometres produced in the same geographic area[52]. Carriers with a good environmental performance thus receive more revenues than the charge they pay. On the other hand, carriers with above-average emissions per passenger- and tonne-kilometre are faced with a nett financial burden. Obviously, a revenue-neutral charge does not generate revenues for the treasuries.

3 Calculated emission charge on LTO only (revenues to national states)
This charge will be levied on each kg pollutant (CO_2, NO_x etc.) emitted by an aircraft during the Landing and Take-Off cycle (LTO cycle) at airports in the EEA. This charge will be levied at the same time as a landing charge. The revenues of this charge will be allocated to the national states in proportion to the LTO emissions of all (European and non-European) aircraft in the national territory of those states. The revenues can be used for any of the options mentioned in Section 2.5.4.
4 Fuel charge package (revenues to national states)
This option is a package of three instruments in which a fuel charge constitutes the key instrument. The 'fuel charge package' comprises the following instruments:

---

offer an alternative while for long trips they generally cannot.

52 A similar approach is followed in Sweden with respect to NO_x from electrical power generation. Each power plant pays a charge per kg NO_x, with the revenues being fully recycled to the electricity producers in proportion to the number of kWh generated.

- A charge levied on each litre of fuel bunkered by an aircraft in the EEA. The charge level corresponds with the average emissions of CO_2, NO_x, H_2O and SO_2 per litre fuel during the entire flight. Each country receives the revenues from the charge on the fuel bunkered in its territory.
- An additional landing charge per engine-airframe combination corresponding with the LTO emissions of CO, VOC and NO_x. From this landing charge is deducted that share of the LTO emissions of NO_x that has already been incorporated in the fuel charge. This charge generates an incentive to reduce the LTO-specific emissions of CO, VOC and NO_x. It is in fact an element of the charge base discussed earlier: calculated emissions.
- Emission standards for engines or possibly for engine-airframe combinations for the LTO, climb and cruise phases. These standards are needed to avoid the potential negative side-effects of a fuel charge on NO_x emissions during the flight. Without such standards energy efficiency might be improved at the expense of higher NO_x emissions.

Contrary to the other options, we have opted to evaluate a 'fuel charge package' rather than merely a fuel charge. Introduction of a simple fuel charge would be unrealistic, because this might increase air pollution from NO_x and VOC. A fuel charge complemented with differentiated landing charges and emission standards would obviate certain adverse effects that would result from introducing a fuel charge only.

5 Movement-based ticket charge (revenues to national states)

This is a charge added to the ticket price. A suitable tariff structure for the ticket charge appears to be a single tariff for each departure on an intra-European flight and a double tariff for each departure with a destination outside the EEA[53]. It seems logical in this option for each country to receive the revenues from the ticket charge on movements departing from their own airports.

Table 3.1 presents an overview of the five options for a European aviation charge. These options represent the whole range of possibilities, each in the most promising variant.

---

[53] This structure is used by Norway for its national ticket charge.

Table 3.1 Overview of five selected options for a European aviation charge

Option	Charge base	Charge level[a]	Allocation of revenues
1 Emission charge	Calculated emissions	0.03-0.12 \$/kg CO_2 3.10-12.40 \$/kg NO_x (low) 2.60-10.40 \$/kg NO_x (high) 2.40-9.80 \$/kg SO_2 3.10-12.40 \$/kg VOC	To European level. Redistributed to national states via allocation rules.
2 Revenue-neutral emission charge	Calculated emissions	See option 1	To airline companies. Proportional to their production in EEA airspace.
3 LTO emission charge	Calculated emissions during LTO	See option 1	To national states
4 Fuel charge package[b]	Fuel bunkers	0.10-0.40 \$/l	To national states
5 Ticket charge	Movements	2.00-9.00 \$/passenger for EEA departures 4.00-18.00 \$/passenger for non-EEA departures	To national states

[a] Working assumption, equivalent to 0.10-0.40 US\$ per l fuel.

[b] The package includes a charge on LTO emissions and emission standards. These additional instruments are needed to avoid a higher fuel efficiency being achieved at the expense of higher emissions of NO_x and VOC.

In evaluating each of these five charge options, the associated charge level will be expressed in \$ per litre fuel. The charge level in this chapter corresponds with a fuel price increase of 0.20 \$ litre. Assuming a current average fuel price of about 0.16 \$/l fuel, the charge thus leads to a fuel price increase of about 125%. In Section 2.4.5 it was estimated that this would lead to an initial ticket price increase of around 4 \$ for a short one-way trip and between 10 and 15 \$ for a long European flight[54]. A charge (equivalent to 0.20 \$/l fuel) applied only to LTO emissions would lead to an initial ticket price increase of about 2 \$ (see Table 3.2).

[54] It is assumed that the cost increase to airlines as a result of the charge will be passed on in its entirety to passengers.

Table 3.2 Estimated average ticket price change (one-way) in the short and long term after introduction of an emission or fuel charge (load 67%; equivalent to 0.20 $/l fuel)

	LTO only	Total flight 500 km	Total flight 2000 km
Initial price change (without environmental efficiency improvement)	+2$	+4-5$	+10-15$
Long-term price change (with environmental efficiency improvement)	+2$	+3$	+8-12$

In the long run the ticket price change will be smaller, however, because part of the initial price increase will be absorbed by energy and environmental improvements. In a background study to this report, on aviation emissions[55], it was calculated that a charge of 0.20 $/l would lead to an extra reduction of fuel consumption compared to Business as Usual of about 30% in 2025 compared to 1992. In the long run, as a result of improved environmental and energy efficiency, the ticket price increase would be about 25% lower, compared with the initial price change[56]. Table 3.2 shows the long-term ticket price increase (one-way) for average flights of 500 km and 2000 km and for the Landing and Take-off cycle (LTO).

It should be stressed that on flights from and to the EEA the ticket price change may differ between the three types of charge bases, because of differences in the area of validity (see Figure 2.1 in Section 2.3.3). An emission charge has to be paid only on the part of the flight over EEA airspace. This implies that the price increase depends very much on the precise borders of EEA airspace, but in most cases it will be below the levels shown in Table 3.2. In the case of a fuel charge, about 50% of the fuel consumption on a return flight between the EEA and another region is charged. The initial price increase then depends very much on the distance flown. For an Atlantic flight the price increase associated with a fuel charge is consequently greater than in the case of an emission charge.
In Section 2.4.5 it was already assumed that a charge on movements will be based on emissions for a fixed flight distance of 500 km. Compared with the emission and fuel charges, the ticket price increase will then be relatively higher for flights shorter than 500 km and relatively lower above this fixed distance. In addition, the long-term ticket price change following from

---

55 *European aviation emissions: trends and attainable emission reduction* (Dings et al., 1997). This background study is summarized in Annex C.

56 Obviously, implementation of emission reduction measures would increase total operating costs. It is assumed that the investment costs needed to achieve 30% emission reduction will be about 0.10 $/l (50% of the charge level) per litre fuel reduction. This implies that, in the long run, the total operating costs rise by around 12% instead of the initial increase of 15% (assuming an average 12% share of fuel costs in total operating costs). If the costs increase is passed on fully to customers, ticket prices will be raised by the same percentage.

the movement charge will be equal to the initial price change because the movement-based charge will generate no incentives to improve energy and environmental efficiency.
Obviously, the different types of charge bases may have a different impact on environmental effectiveness and fair competition. This is discussed further in Sections 3.4 and 3.5.

3.3 Criteria for evaluating the five charge options

In the previous section (3.2) five options for a European aviation charge were described. This next section deals with the main criteria for evaluating these options. In Chapter 2 a list of relevant criteria for evaluating different policy instruments has already been discussed. Evaluation of the charge options is based on only five of the criteria on that list: those that appear most relevant in view of current knowledge on aviation charges to reduce emissions.

The attractiveness of a European aviation charge is determined both by its environmental effectiveness, being the aim of the charges considered in this study, and by its feasibility or possible negative side-effects or attendant obstacles. The feasibility is in turn influenced by several different factors, of which the most important are: economic distortions, distributional complications and conflicts with existing law. These five criteria will now be considered.

Environmental effectiveness
Since the aim of the charge options considered in this study is to reduce emissions from aviation, the charges should obviously achieve their intended purpose[57]. In this study the environmental effectiveness of a charge option is considered optimum if (i) the charge option provides sufficient *incentives* for the implementation of all types of emission reduction measures and (ii) the *area of validity* of the charge covers the whole flight.

A charge option might provide an incentive for implementing the following measures to reduce emissions:
a technical improvements (engine, empty weight and drag);
b change of aircraft size and average distance flown;
c new aircraft design optimization;
d improvement of load factor;
e operational improvements (flight path, speed, flight-handling procedures);
f reduced growth in passenger and freight volume.

---

57 It should be stressed that the most cost-effective (N.B.: this criterion is not considered in the evaluation below) environmental policy requires that the cheapest combination of all possible measures be taken to achieve the emission targets decided on.

It is important to stress that measures a to f are not all equally important, because they differ substantially in their potential contribution to emission reduction. These differences will be discussed in the next section (3.4), in which the environmental effectiveness of the five charge options is evaluated. In general, however, improvement of aircraft technology (a), design optimization (c) and reduced growth (f) have the greatest potential for reducing aviation emissions[58]. Based on the importance of these measures it can be concluded in advance that a given charge option can have a high environmental effectiveness only if it at least provides incentives for introduction of these measures.

Another aspect of influence on the environmental effectiveness of a charge is the charge's area of validity, which depends mainly on the design of a charge. The environmental effectiveness of a calculated emission charge levied only on the LTO (option 3), for example, is obviously relatively small, because the charge is not levied on the cruise phase of the flight.

Potential economic distortions

An aviation charge that covers only Europe (or the EEA) might distort fair competition among airlines, airports or other economic sectors and might consequently reduce economic efficiency. In addition, a European aviation charge is less viable if it creates serious competitive disadvantages for European over non-European countries. These distortions to fair competition arise when circumstances make it unfeasible to apply the charge equally to all potential competitors (e.g. airports inside and outside Europe; holiday suppliers inside and outside Europe). The appropriate policy is to select charge options that minimize these distortions.

It should be stressed that introduction of a European or global aviation charge will change the relative competitive position of different suppliers in favour of those that are environmentally efficient (and against those that are environmentally inefficient). This does not distort fair competition, but will instead **increase** economic efficiency. Changes in relative competitive strength will arise where a charge applied equally to all competitors has a differentiated impact upon them (e.g. between airlines with more, or less, environmentally efficient aircraft, or between holiday suppliers making more, or less, use of air transport). Clearly there will be winners and losers and the appropriate policy response may therefore be to provide transitional support to the losers to provide a period of time, following introduction of an aviation charge, over which they can improve their environmental efficiency.

Legal issues

The criterion is whether policy instruments are acceptable according to current law. With respect to aviation charges, the Chicago Convention and the bilateral Air Service Agreements between countries are of relevance. One option, of course, is change current law if it conflicts with the introduc-

---

58 *European aviation emissions: trends and attainable reduction*, background study to this report (Dings et al., 1997).

tion of an attractive policy instrument. In most cases, however, this will not be easy. This is the main reason for including this criterion.

Implementation

It is important that a charge option be easy to implement[59]. Complications with implementation could, for example, arise if measurement or calculation of the charge base is difficult or if it is complex to design a transparent allocation mechanism for the charge revenues. It is important to know whether a charge option could readily be implemented in the existing institutional and administrative framework of the aviation sector. The current practice of existing taxes and charges (landing charges, route air navigation services charge, ticket taxes, etc.) provides a good indication as to whether implementation of an environmental charge is feasible.

Distributional complications

Considerations of fairness play a major role in devising policies. Principles such as the User Pays and the Polluter Pays are widely accepted and refer to the distributional issue. In some cases additional policy measures are needed to correct unintended and undesired distributional effects resulting from environmental policy.

Furthermore, a given charge option may be considered politically less feasible if the distributional effects among sectors or countries is felt to be unfair.

3.4 Environmental effectiveness of the charge options

3.4.1 Introduction

This section evaluates the environmental effectiveness of the five options for a European aviation charge in the long term. The impact of these charges on emissions from European aviation is addressed on an approximate basis[60]. This rough quantification is based mainly on a review of international literature undertaken as a part of a background study[61] to this report. In this background study it was analyzed what emission reduction of world civil aviation, per unit of volume, can be expected in 2025 compared to 1992 in a 'Business as Usual' (BaU) and a 'Technically Feasible' (TF) scenario. In addition, it was analyzed what part of the extra 'technically

59 See also the Preliminary study (Bleijenberg et al., 1996).

60 In the project plan for this feasibility study, an environmental and economic evaluation of charge options using the AERO model was envisaged. During the project we therefore carried out an evaluation of the AERO model in order to assess the extent to which the AERO model might contribute to our study. On the basis of this evaluation we concluded that calculations with the AERO model could not provide any major contribution to this feasibility study. A detailed discussion of the arguments leading to this conclusion are given in Annex F of this report.

61 *European aviation emissions: trends and attainable reduction* (Dings et al., 1997). This background study is summarized in Annex B.

feasible' emission reduction might be realized if an emission-, fuel- or movement-based charge corresponding to $ 0.20 per litre were to be introduced.

Assumptions: fare adjustment behaviour and price elasticity
Several assumptions must be made in order to estimate the impact of a charge on emission reduction. In the first place, the environmental effectiveness of a charge depends to a large extent on the reaction of the airlines (see also Section 3.5). A number of questionnaire surveys and interviews[62] carried out in order to investigate the likely reaction of airlines to environmental charges indicated that the dominant reaction of charters and low-cost carriers in the short term would be to pass the entire charge on to customers. In the long run, part of the charge will be absorbed by environmental efficiency improvements. Besides these reactions, scheduled carriers would, to a limited extent, also reduce costs elsewhere or lower profit margins, depending on the market situation on each specific flight stage. In estimating the environmental effectiveness of the different charges in the long run, it is assumed in this study that airlines will pass the entire charge on to customers. In addition, part of the charge will be absorbed as airlines find new cost optima by improving the environmental efficiency of their fleet. This implies that the volume effect of emission and fuel charges will decrease over time.

In order to calculate the volume effect it is necessary to examine how demand for air transport changes as a function of change in air transport fare. This relationship is called the price elasticity of demand for air transport. Table 3.3 shows the results of a brief review of the literature[63] on these price elasticities.

Table 3.3 Price elasticity of demand for air transport

	AERO model	Oum *et al.* (1990) Most likely range	ICAO (1995b)[b]
Leisure travel	-1.0	-1.10 to -2.70	-
Business travel	-0.1	-0.40 to -1.20	-
Mixed	-0.5	-0.70 to -2.10	-0.66
Freight	-1.0	-0.80 to -1.60[a]	-0.51

a Freight, Aggregate Commodities.
b Outlook for Air Transport to the year 2003 (ICAO, 1995b).

62 See the background study *Potential economic distortions of a European environmental aviation charge* (Wit and Bleijenberg, 1997) for a more detailed discussion of the possible reactions of airlines to environmental charges. This background study is summarized in Annex C of this report.

63 A more detailed discussion of the results of the literature review on price elasticities of demand can be found in the background study on economic distortions.

Since the aim is to indicate the approximate environmental effectiveness of the five charge options, an average price elasticity of demand of -0.8 is used below. In this average price elasticity, fare sensitivity over short distances due to surface competition has been taken into account.

Impact on emissions in the long run
Table 3.4 gives an estimation of the impact of an emission- and movement-based charge (equivalent to 0.20 $/l) on volume (in passenger-km), fuel consumption (in million tonnes) and CO_2 emissions (in million tonnes and per passenger-km) compared to Business as Usual in 2025.

Table 3.4 Impact of the introduction of an emission and movement charge (equivalent to 0.20 $/l) on fuel consumption and CO_2 emissions from EU aviation in 2025 compared with Business as Usual[1]

		1992	2025		
	Unit	Base	Business as Usual	Emission charge	Ticket charge
pax.km	billions	386	** 1,789	1,635	1,574
	index	100	463	424	408
growth in % p.a.			4.0%	3.7%	3.6%
	Mtonnes	28.5	82.2	57.5	72.4
fuel consumption	% change rel. to 1992	-	190%	101%	154%
CO_2 emission total	Mtonnes	89.8	261	181	228
	index	100	290	201	254
	% change rel. to 1992	-	190%	101%	+154%
CO_2 emission per pax.km	grams	232	146	110	145
	index	100	63	47	62
	% change rel. to 1992	-	-37%	-53%	-38%

1 The data are based on the data of the unified database of the AERO Modelling system. These are based on the fuel consumption of all intra-EU flights and 50% of all flights from and to the EU. The data for the year 2025 have been extrapolated from the 2015 AERO data. The data for the emission and ticket charge in 2025 have been estimated by CE and are based on the fuel efficiency forecasts found in the literature review by Dings et al. (1997).

To estimate the change in passengers-kilometres due to the emission charge in the long term, i.e. following the attendant energy efficiency improvement, it is assumed that the ticket price change will be around +12% in the long run (see Section 3.2). Given a price elasticity of demand of -0.8, the volume effect of such a cost increase would be about -9.5% in the period between 1992 and 2025. This leads to a decrease of growth by about 0.3% per annum compared with a Business as Usual trend (see Table 3.4). Total fuel consumption and CO_2 emissions are about 30%[64] lower in 2025 as a result of the emission charge compared with Business as Usual in 2025. Table 3.5 shows the contribution of the different emission reduction measures to this reduction of 30%.

Table 3.5 Contribution of different types of reduction measures to the total potential long-term emission reduction due to an emission charge equivalent to 0.20$ per litre fuel

type of measure	estimated reduction range
- Technical improvements	10-14%
- size/distance	0-1%
- new aircraft design optimization	6-9%
- improvement of load factor	1-2%
- operational improvements	0%
- reduced volume	8-10%
emissions reduction potential	25-35%

Source: Dings *et al.* (1997)

Despite the anticipated emission reduction due to the emission charge compared with Business as Usual, CO_2 emissions still increase by about 100% between 2025 and 1992. Without introduction of an emission charge this growth would be almost 200%, which implies that an emission charge could roughly half expected growth in emissions between the baseline year 1992 and 2025 (see Table 3.4).
In the long run a ticket charge will lead to a slightly greater change in passenger-kilometres, because in the longer term the ticket price increase will be greater than in the case of an emission charge. This is because part of the emission charge will be absorbed by efficiency improvements, which is not the case for the ticket charge. Given the price increase of around 15% after a movement charge and a price elasticity of demand of -0.8, growth in passenger-kilometres is 12% lower in 2025 compared with Business as Usual. This is equivalent to a decrease in growth by about 0.4% per annum (see Table 3.4). Following introduction of a movement charge, total fuel consumption and CO_2 emissions will be about 25% higher in 2025 compared with the emission charge, because a ticket charge is not assumed to generate any incentives for energy and emission reduction measures.

64 See the background study *European aviation emissions: trends and attainable reduction* (Dings et al., 1997) for a detailed elucidation of the 30% reduction in aviation emissions due to a 0.20 $/l charge.

The environmental effectiveness of the five charge options
Table 3.6 gives an indication of the incentives generated by the five charge options with respect to all six categories of measures to reduce emissions. From the point of the environmental effectiveness criterion, an aviation charge should preferably generate incentives for all measures.

Table 3.6 Qualitative indication of possible effects of five charge options (equivalent to $ 0.20 per litre)

aspect	Reduction potential 1992-2025[a]	Effect of charge on emission[b]				
		emission charge	revenue-neutral charge[c]	emission charge, LTO only	fuel charge package	ticket charge
technology	high	xx	xx	x	xx	0
size/distance	low	0/x?	x	0	0/x?	0
optimized design	moderate	xx	xx	x	xx	0
load factor	moderate	x	xx	x	x	0
operational	low	0	0	0	x	0
volume	high	x	0/x	0/x	x	xx
total reduction potential compared with BaU in 2025		25-35%	20-30%	5-10%	25-35%	10-15%

[a] This column indicate the emission reduction potential.
Low 5% or less
Moderate 5-10%
Medium 10-20%
High 20% or more

[b] These columns indicate the effectiveness of the five charge types with respect to the aspects mentioned.
xx high effect
x moderate effect
0 no effect

[c] This is a calculated emission charge with a refund of revenues to the airlines in proportion to pax.km performance.

Below, the environmental effectiveness of the five charge options as indicated in Table 3.6 is elucidated.

3.4.2 Emission charge (option 1)

Emission-based charges generate positive incentives for the four types of emission reduction measures having the greatest reduction potential. In addition, the area of validity of the charge is fairly optimal, because all the pollutants emitted by all aircraft in EEA airspace are charged, irrespective of whether or not they land in the EEA[65]. Overall, the environmental effectiveness of charge option 1 can be deemed high.

The emission charge will provide a direct incentive to airlines and manufacturers to develop and purchase more environmentally and energy-efficient aircraft, in order to minimize the cost increase due to the charge. As already noted, the impact of a 0.20 $/l emission charge on the energy reduction of the four measures (volume, technology, optimized design and load factor) is estimated at about 25% to 35% between 1992 and 2025 compared with Business as Usual.
The emission charge does not generate any incentive to take operational measures (speed, flight altitude), because for practical reasons this charge type will be based on calculated emissions during a standard flight. It is currently too expensive and complicated to carry out in-flight measurement of actual emissions. Actual emissions during a given flight may therefore differ from those of the presumed standard flight. Derivation of the standard flight will not affect the level of charges to be paid. The potential contribution of operational measures to reducing emissions is relatively small, however, compared with the other emission reduction measures. Based on the literature review[66], it is estimated that this potential is at most 3% of the energy intensity reduction between 1992 and 2025.
Finally, it should be noted that an emission charge generates a relatively small adverse incentive with regard to specific energy use (per tonne.km), owing to a relative shift to short-haul flights. In general, an emission charge will have a relatively large impact on long-distance flights, because the share of fuel costs in total operating costs is higher on such flights. A shift to short-haul flights will consequently lead to somewhat higher average emissions per tonne.km, because specific fuel use is relatively higher on short flights. This shift to short-haul flights has been estimated to cause a 2% increase in average energy intensity.

3.4.3 Revenue-neutral emissions charge (option 2)

This emission-based bonus/malus approach generates incentives for five possible types of emission reduction measures. In addition, the area of validity of the charge is the same as that of the calculated emission charge. However, there is a substantial difference between the calculated emission charge and the revenue-neutral calculated emission charge (refunded per unit performance). The first will reduce volume substantially (by about 8-10%), while the second will have only a minor effect on volume, because

[65] The borders of the EEA, where the emission charge is valid, have not yet been exactly defined. Obviously, the greater the area of EEA airspace, the greater the attainable reduction potential of this charge option.

[66] *European aviation emissions; trends and attainable reductions,* Dings et al., 1997.

the extra costs to airlines will be limited[67]. The revenue-neutral emission charge will, however, provide an extra incentive for 'clean' performance by raising load factors[68] and by flying less over short distances in small aircraft compared with the first option. Flight operations are not affected by the revenue-neutral charge.

Overall, the environmental effectiveness of charge option 2 can be deemed somewhat lower than that of option 1, because the advantages of the revenue-neutral charge are dominated by the much smaller volume effect. We estimate that the revenue-neutral charge will reduce emissions by about 20 to 30% between 1992 and 2025 compared with Business as Usual. The environmental effectiveness of this second option can be considered quite high, but somewhat lower than that of option 1 (calculated emission charge).

3.4.4 LTO emission charge (option 3)

This option generates the same positive incentives with regard to possible avenues of emission reduction as the calculated emission charge (option 1). The area of validity of the charge is limited, however, because only pollutants emitted in the Landing and Take-Off phase (LTO) of each aircraft in the EEA are charged. The environmental effectiveness of charge option 3 can therefore be deemed considerably lower than with both the previous options.

To estimate the relative environmental effectiveness of this charge option, the share of LTO emissions in total emissions in EEA airspace must be estimated. To provide an indication, below the contribution of LTO to total energy use is given for two types of aircraft and two distances. This share is one-third (36%) for a 500-km flight by a Boeing 737-400 and about 10% for a 3000-km flight by a Boeing 747-400.

If an average share of LTO emissions of about 25% is assumed for intra-EEA flights and for flights from and to the EEA, this implies that the area of validity of the LTO emission charge is roughly one-quarter of that of the calculated emission charge in EEA airspace (option 1). This means that the emission reduction potential of the LTO emission charge ranges between 5 and 10% between 1992 and 2025 compared to Business as Usual.

---

[67] Costs in the form of extra capital and labour to buy and fly cleaner and more efficient aircraft. We estimate that if these extra costs are passed on to customers this would lead to a volume effect of less than 3%.

[68] In general, a fuel- or emission-based charge will give an extra incentive to airlines to increase load factors, as direct operating costs (DOC) increase relative to indirect operating costs (IOC). The incentive to raise the load factor increases further if the revenues of the emission or fuel charge are returned to the airlines per tonne- or passenger-km (the proposed 'revenue-neutral charge' discussed here). The order of magnitude of this extra increase in load factor is as yet difficult to estimate. In Dings et al. (1997) a first, rough estimate yielded a figure of 1% extra increase in load factor, or less than 1% reduction in energy intensity between 1992 and 2025.

3.4.5 Fuel charge package (option 4)

A fuel charge generates incentives for all types of measures. One advantage of the fuel charge is that it is the only charge that generates an incentive for operational improvements (flight altitude, speed, etc.), because the charge is linked to real fuel consumption and not to fuel use on a standard flight.
One disadvantage of a fuel charge in isolation is that fuel consumption is not closely related to emissions of NO_x, VOC and CO. It is expected that a fuel charge in combination with emission standards and differentiated landing charges (related to NO_x and VOC emissions per airframe-engine combination) may just about approach the optimum in terms of an incentive to reduce all air pollutants. The environmental effectiveness of a fuel charge combined with standards and differentiated landing charges can therefore be considered as near-optimal and comparable with the effectiveness of charge option 1.

What impact the difference in area of validity between a fuel charge and an emission charge in EEA airspace will have on effectiveness is hard to assess, because both options have advantages and disadvantages. The difference occurs on flights from and to the EEA and flights over the EEA ('overflights'). A fuel charge covers half the fuel consumption of flights from and to the EEA, while an emission charge in EEA airspace covers less than half the emissions of most of those flights (the exact figure depending on the definition of EEA borders). This difference in the area of validity might lead to a substantial difference in environmental effectiveness, in favour of the fuel charge. Contrary to the emission charge, a fuel charge is not applied to overflights, however. Depending on the response of airlines, this may have a substantial counter-effect.
In addition, a fuel charge could be (partly) avoided. Airlines might be encouraged to take more fuel on board than necessary at non-participating countries outside the EEA in order to avoid refuelling in Europe. This so-called 'tankering' phenomenon results in extra energy use, because of the extra weight of fuel transported by air. In the case of a fuel price increase of 125% (0.20 $/l charge) this 'tankering' effect might lead to a decrease in the environmental effectiveness of a European fuel charge.

In view of these uncertainties, we consider the environmental effectiveness of a European fuel charge package as high as that of the emission charge (option 1). This implies a reduction in emissions in 2025 by about 25% to 35% compared with Business as Usual. It should be noted, however, that limiting the EEA airspace to, for example, national territory, including the 12-mile zone, would limit the area of validity of the emission charge and thus the emission reduction potential compared with that of the fuel charge.

3.4.6 Ticket charge (option 5)

A ticket charge only influences transport volume. As a ticket charge is added directly to fares, airlines cannot influence the level of the ticket charge. The ticket charge does not generate an incentive for any other emission reduction options (improvements in technical performance, operations and flight). The environmental effectiveness must therefore be deemed rather low. Tables 3.4 and 3.6 show that the environmental effectiveness of a movement charge depends only on the volume effect. This effect was estimated to be about 10% to 15% after introduction of a ticket charge equivalent to 0.20 $/l. If a movement charge is based on a fixed distance of 500 km, the volume effect and hence the environmental effectiveness would be even less.

As a ticket charge generates no incentives for implementing technical and operational measures to reduce emissions (which is the prime aim of a European aviation charge, as considered in this study), the environmental effectiveness of a ticket charge is roughly one-third (volume effect only) that of the calculated emission charge.

3.4.7 Overview of the environmental effectiveness of the 5 charge options

Figure 3.1 indicates the long-term environmental effectiveness of the five evaluated charge options.

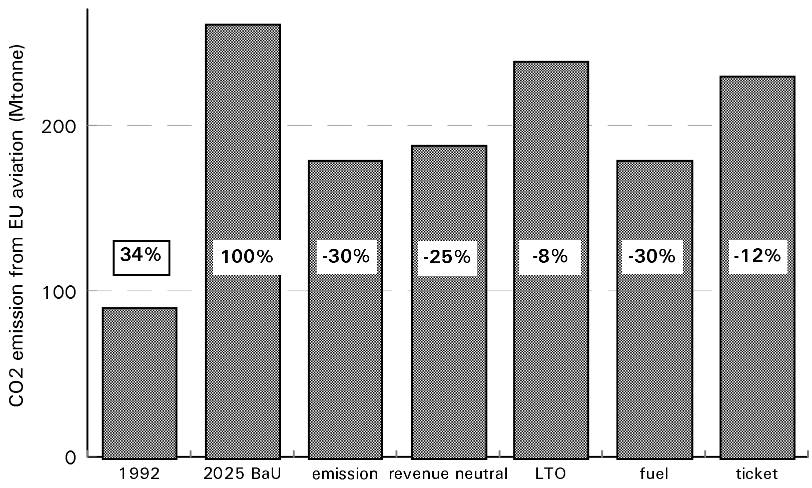


Figure 3.1 Indication of the environmental effectiveness of the five charge options

3.5 Potential economic distortions

3.5.1 Introduction

As mentioned at the beginning of this report, a separate background study[69] was carried out in order to assess whether a European aviation charge would create a competitive disadvantage for European companies compared to non-European companies. Annex C of this report contains an extended summary of the results of this background study.

The background study evaluated whether introduction of an emission, fuel or ticket charge in the EEA would distort fair competition. To this end, three potential forms of distortion were evaluated:

1 competitive distortions between European and non-European airlines;
2 competitive distortions between European and non-European airports;
3 competitive distortions between the European and non-European tourist industry, as far as aviation constitutes the dominant transport mode[70].

Economic distortions are defined in this study as distortions in competition between European and non-European companies caused by the limited geographical scale of a European aviation charge. This definition implies that changes in the competitive position of companies that would also occur as a consequence of a *global* aviation charge are not considered to be economic distortions in this study. A change in the competitive position of

---

69 *Potential economic distortions of a European environmental aviation charge* (Wit and Bleijenberg, 1997).

70 The reason for focusing only on effects on the tourist sector, besides the impact on the aviation industry, is that the tourist sector is expected to be hit relatively hard compared to other sectors of the economy. This is because about 50% of the total European air passenger market consists of charters (EC, 1996).

relatively clean airline companies compared to highly polluting ones is not therefore considered to be an economic distortion. This is, rather, an efficiency improvement, although companies might require a transitional period to give them enough time to adapt to the new circumstances.

On the basis of the results of the background study, it has been assessed whether one or more of the aforementioned distortions would occur following introduction of the five charge options. Table 3.7 gives a qualitative indication of the potential for distortion of competition between European and non-European companies.

Table 3.7 Qualitative indication of possible economic distortions due to the five charge options (charge level equivalent to 0.20 $/l)

Charge option	Potential economic distortion[a]		
	Airlines companies	Airports	Tourist sector
1. Emission charge	-	0	-
2. Revenue-neutral emission charge	0	0	0
3. LTO emission charge	0	0	-
4. Fuel charge package	-	--	--
5. Ticket charge	-	-	-

[a] These columns indicate the potential distorting effect of the different charge options.
--- major effect
-- moderate effect
- minor effect
0 negligible effect

Below, the potential for economic distortion indicated in Table 3.7 is clarified for each of the five charge options.

3.5.2 Emission charge (option 1)

The starting point for analyzing the potential economic distortions between European and non-European companies is the long-term price change following a 0.20 $/l charge, as calculated in Section 3.2. Table 3.8 shows this price change and the cost increases resulting from such a charge.

Table 3.8 Estimated average long-term change in ticket price (one-way) and cost increase following introduction of an emission or fuel charge (load 67%; equivalent to 0.20 $/l fuel)

	Total flight 500 km/	Total flight 2000 km	LTO only
Charge for total flight	445$	1257$	165$
Percentage increase of current airport charges[a]	4-19%	9-40%	2-9%
Long-term ticket price change	+3$	+8-12$	+2$

a Average of major European airports.
Results for a Boeing 737-400

The following evaluation focuses on a charge of the above level.

Potential economic distortions among airlines
The question here is whether a European emission charge on aviation will create competitive disadvantages for European airline companies compared with non-European airline companies that would not occur as a consequence of a global environmental aviation charge.
In order to answer this question it is important to know whether, given a certain efficiency level, the profit margin per unit of European airlines will increase relatively more than the profit margin per unit of non-European airlines following introduction of a European aviation charge. The crucial issue is then: to what extent might both European and non-European airlines pass on the cost increase due to the European charge to passengers and freighters.

First, it should be stressed that all carriers, both European and non-European, are assumed to be subject to exactly the same charge. Because our study considers only non-discriminative charges, this means that all carriers providing the same service are charged in the same way. This implies that both European and non-European carriers would face the same cost increase on the same flight stage[71]. In fully liberalized international markets for air transport, and given keen competition, both European and non-European carriers will then pass on the entire charge to their customers. The first-order effect would then be that the European environmental aviation charge does not directly affect the operating costs per unit of European and non-European carriers differently.

[71] In practice, there will be winners and losers because airline companies with relatively old and inefficient aircraft have to pay higher total charges per flight. However, this effect is not an economic distortion between European and non-European carriers, but an intended aim of the charge: to give an incentive to increase environmental efficiency. It should be stressed that this change in the relative competitive position of airlines in favour of those that operate more efficient aircraft would also occur if a global environmental aviation charge were applied.

At the present time, however, there is no fully liberalized market in many regions of the international market for air transport. In order to assess whether European and non-European airlines will pass on the charge to their customers, it is therefore necessary to take the specific market situation of different type of carriers into account. Consequently, below we discuss the fare-adjustment behaviour of charters and low-cost carriers on the one hand and scheduled carriers on the other. After arriving at conclusions on the fare-adjustment behaviour of the different types of carrier, we shall discuss whether competitive disadvantages for European carriers are likely to occur.

Fare-adjustment behaviour of charters and low-cost carriers

From the literature and interviews it was found that charter and low-cost carriers are likely to pass the entire cost increase due to the charge on to customers. The main reason is that these markets are highly competitive and consequently have small profit margins that do not permit higher costs. The Dutch charter Transavia stated[72] that they would pass the whole charge on to customers, because the margins are too small to absorb the cost increase. This is confirmed by two studies[73]: one on the impact of the abolition of intra-EU duty- & tax-free allowances on charter airlines and another on the impact on low-cost scheduled airlines. In both studies a majority of airlines surveyed believed it would not be possible for them to absorb any increased costs. A questionnaire survey of airlines carried out by Alamdari and Brewer (1994) also indicated that the dominant reaction of charters, besides improving environmental efficiency, would be to increase fare levels. Based on these results we therefore conclude that charters and low-cost carriers will pass on the full charge to their customers.

Fare-adjustment behaviour of scheduled carriers

Again, it should be stated that in a situation of perfect competition in the international markets for air transport, both European and non-European scheduled carriers will pass on the whole of the charge to their customers. This can be explained by the fact that in a perfect market there is no scope for airlines to absorb the charge (and reduce their fares) by reducing their profit margin or by cross-subsidizing[74].

In the real world, where not all markets are liberalized and monopolistic or oligopolistic markets exist, the question remains whether scheduled airlines will pass on the whole of the charge to customers. To answer this question we distinguish the following three types of market protection:

---

72 Personal communication.

73 SH&E International Air Transport Consultancy (June 1997); Symonds Travers Morgan (June 1997).

74 Cross-subsidizing is defined as the situation whereby an airline company uses profits earned with activity A to finance a reduction of the fares of activity B.

1 Intra-European market
Currently, European carriers could set somewhat higher fares and thus achieve relatively higher profits on certain flight stages in Europe, because competition on these flight stages is presently limited. A European aviation charge would reduce these extra profits due to limited competition somewhat because of the reduced growth of the European market or somewhat lower fares. This trend of decreasing extra average profits on European flight stages is already an ongoing process, however, given the liberalization of the EU air transport market.

2 Cross-subsidizing of routes from and to Europe
The question here is whether non-European carriers would be encouraged by a European aviation charge to engage in (extra) cross-subsidizing of flight stages to and from Europe. If this were to happen, European carriers would then be forced to reduce air fares as well and not pass on the whole of the charge to customers in order to hold their market share.
It should be noted that cross-subsidizing of *intra-European routes* is not possible, because non-European airlines are not allowed to operate between city pairs in Europe. Furthermore, it should be noted that carriers are not allowed, by international trade law, to offer fares below the cost price of an air service ('anti-dumping law'). This provides a baseline for the potential of cross-subsidizing.
The most striking argument for not expecting extra cross-subsidizing by non-European carriers, however, appears to be that a European aviation charge provides no extra incentive for it. This is mainly because charge will not affect the profits of non-European airline companies, freeing no extra funds for cross-subsidizing from protected markets.
On the basis of these arguments we therefore conclude that it seems unlikely that any substantial part of the European environmental aviation charge will be absorbed by European carriers because of cross-subsidizing by non-European carriers.

3 Hubbing more expensive in Europe
A European aviation charge would make an air network with direct connections relatively more profitable than one based on a hub-and-spoke system in Europe. This implies that carriers with a hub in Europe would have a small competitive disadvantage compared to those without. In the case of an emission charge of 0.20 $ per litre fuel this disadvantage would be about 2 $ for a transfer passenger at a hub in Europe. This small amount is not significant compared with current differences in airport costs.

On the basis of the above arguments we conclude that both European and non-European scheduled carriers will also pass on the whole of the charge to their customers. Below, we discuss whether competitive disadvantages among the different types of European carriers are to be expected, assuming full fare adjustment.

Charters and low-cost carriers

A possible second-order effect is that higher air fares might slow down the growth of the European air transport market somewhat, resulting in a smaller home market for European carriers as compared to non-Europeans. In theory, this may weaken the competitive position of European carriers because of the lower economies of scale that can be achieved, and the consequent higher production costs for those companies operating mainly on the European market. Charters and low-cost carriers, however, operate direct flights on origin/destination markets. Doganis (1991) indicates that airlines operating direct flights on origin/destination markets have little scope for achieving economies of scale or economies of density. This implies that reduced growth of the European market would not result in lower operating profits per unit on an isolated flight for European charters and low-cost carriers compared with those of non-European countries.

A probably even more convincing argument for not expecting competitive disadvantages for European charters after introduction of a European aviation charge is that non-European carriers hardly compete with European charters.

On the basis of both arguments above, we conclude that a European environmental aviation charge would not create potential competitive disadvantages for European charters and low-cost carriers.

Scheduled carriers

In Table 3.4 it was estimated that on the European market the average growth per annum will decrease from 4.0 to 3.7% between 1992 and 2025 following gradual introduction of a charge corresponding to 0.20 $/l.

As already mentioned, a smaller home market might lead indirectly to reduced economies of scale and thus in higher production costs for those companies operating mainly on the European market. This might, indirectly, affect the operating margins of European scheduled carriers and thus the competitive position of those carriers. Above, it has already been mentioned that European market growth will slow down by about 0.3% per annum. Contrary to charters, which operate origin/destination services, scheduled carriers can often be regarded as multi-product firms because they offer both direct and indirect destinations, which implies that they operate on both origin/destination markets and transfer markets. Multi-product firms can achieve economies of scope and economies of information. A smaller European home market due to the charge would then reduce these scale advantages for European scheduled carriers to a relatively greater extent.

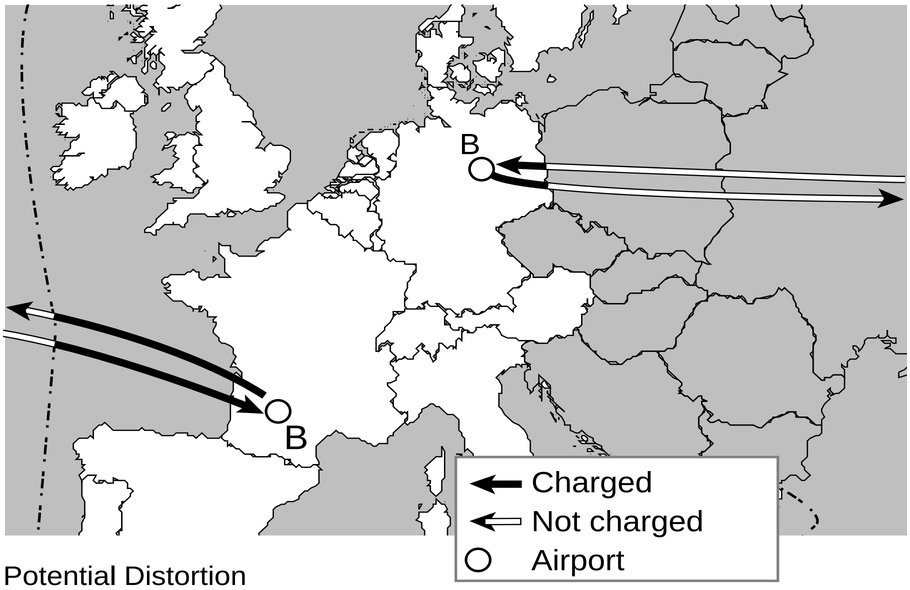
The somewhat smaller home market for European carriers should be seen in the light of international developments in aviation. Firstly, the European aviation sector is in the process of consolidation, to achieve economies of scale. One extra merger compared to Business-as-Usual might be sufficient to counterbalance the smaller home market and achieve the same scale efficiency. Rather than reducing the efficiency of European carriers, therefore, a European aviation charge is more likely to lead to a decrease in the number of independent carriers.

The second international trend is towards global alliances. Because all global alliances have to be present on the European market, no distortion in competition will arise among them.

Competitive distortions among airports
One potential distortion that may arise after introduction of an emission is that *origin/destination passengers (O/D)* from or to the EEA may shift their origin or destination airport just outside the EEA. Obviously, such adaptive behaviour is only relevant for passengers originating around the borders of the EEA. Moreover, as reasonable alternative airports are only available at the Eastern border, this so-called 'border effect' is likely to be relevant only at this border (see Figure 3.2).

Emission Charge

Situation B: flight from and to EEA (origin/destination)



Potential Distortion

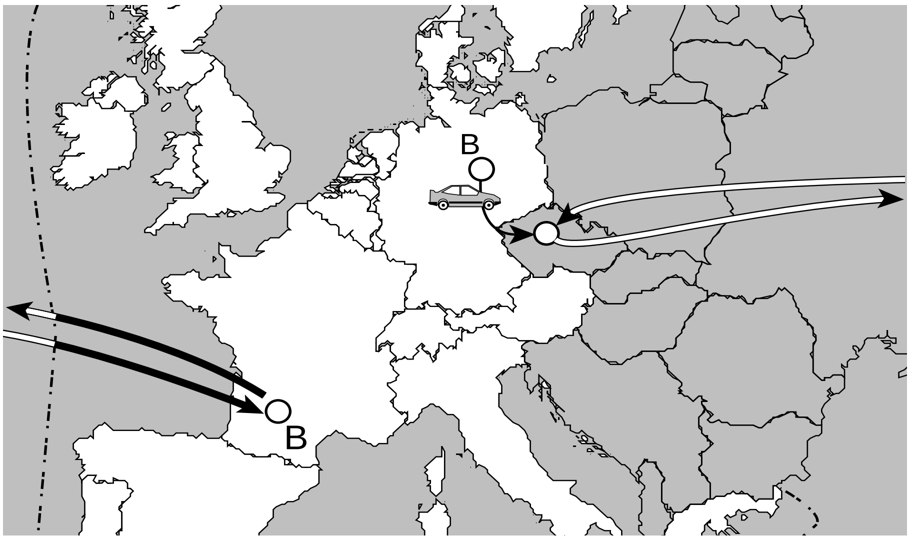


Figure 3.2 Potential economic distortions among airports: 'the border effect'

How much of the charge can be avoided by such adaptive behaviour? As we are considering an emission charge levied en route, this question boils down to the question of how much lower emissions in EEA airspace will be because of such adaptive behaviour.

Obviously, the *distance* travelled through EEA airspace is hardly affected by changing to an airport just outside the EEA. Thus, emissions will hardly be lower because of fewer miles being travelled in EEA airspace. Nevertheless, emissions in EEA airspace will still be somewhat lower because the landing and take-off cycle (LTO cycle) - that causes relatively high emissions - will take place outside EEA airspace because of the adaptive behaviour.

Thus, as Table 3.8 shows, changing to an airport just outside the EEA generates a financial gain of approximately 2-9% on airport costs, which is roughly 2$ on a two-way ticket.

Having established this, we conclude that the considered emission charge in EEA airspace will not lead to any significant shift from origin/destination services towards airports outside the EEA, for the following reasons.

1 The relative increase in EEA airport costs is much smaller than current differences in airport charges among the major European airports and the major airports just outside the EEA. The latter generally charge more than 50% less, which does not apparently result in any major shift of traffic. This indicates that travellers are not willing to travel any great distance to their airport of departure, preferring an airport nearby, even if this is more expensive.

2 Time-related variables ('access time' and 'frequency') appear to be dominant in the airport choice behaviour of business travellers.
To facilitate interpretation of the importance of the variable 'access time to an airport', in the background study on economic distortions[75] this variable was expressed in terms of value of time in dollars per hour. It was concluded that business travellers would accept an additional access time of one hour to a non-EEA airport if the level of the aviation charge amounted to $ 77 or higher, while non-business travellers would accept one hour of extra travel to an alternative airport if the aviation charge were over $ 23. As avoiding the emission charge by using non-EEA airports generates a financial benefit in the order of $ 2 per ticket, travellers would only accept an extra travel time of between 2 and 6 minutes to an airport just outside the EEA. This indicates that the travel time to the nearest main airport in countries bordering the EEA is probably too long and the financial benefit per ticket of avoiding the charge too small.

Another potential distortion that may arise between EEA and non-EEA airports is that *transfer* passengers might shift to airlines that can offer cheaper ticket prices because they have flight connections with a transfer outside EEA airspace. Consequently, in the long run airline companies might choose to locate their hub outside the EEA instead of inside. This potential economic distortion among airports is presented in Figure 3.3.

---

75 *Potential economic distortions of a European environmental aviation charge* (Wit and Bleijenberg, 1997).

Emission Charge
Situation C: transfer passengers

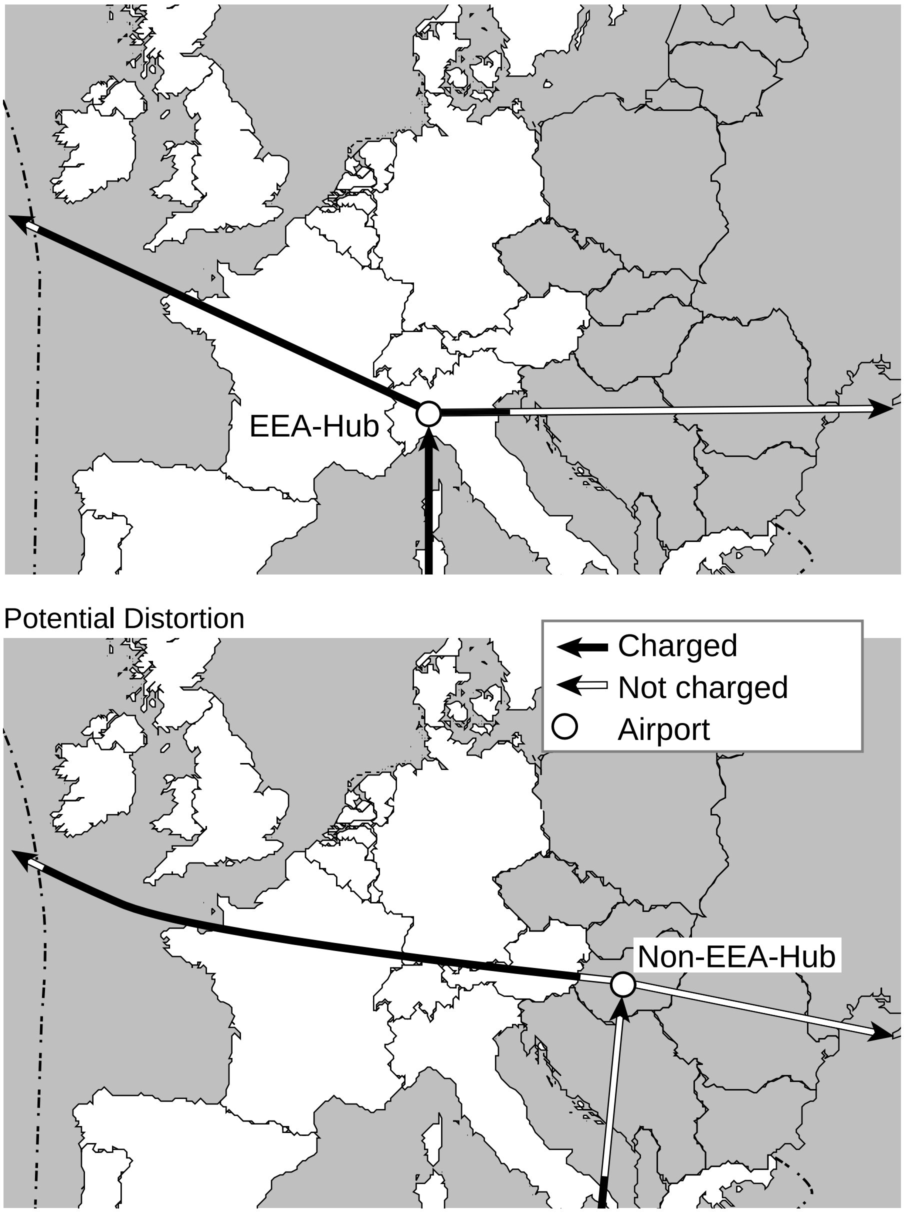


Figure 3.3 Potential economic distortions by transfer passengers

The likelihood of transfer passengers shifting to connections with hubs outside the EEA depends very much on the geographical situation. Hubs outside the EEA are probably not a suitable alternative for hubs oriented towards the Atlantic route, because airlines still have to fly through EEA airspace. A large detour around EEA airspace is probably too costly. Hubs oriented towards the Asian route, however, do have potential locations outside the EEA, mainly in Central Europe and Turkey.

The incentive for airlines to choose a hub outside the EEA is counterbalanced by the economies of scale achieved at the airports within the EEA, owing to their much further developed home market. In addition, locations in Eastern Europe might not be very suitable for use as a hub airport, because their location is not central for many routes, which means that the overall journey time of flights would be too great.

Competitive distortions in international tourism
If tourist destinations inside the EEA were to become more costly than destinations outside the EEA solely because of the charge being levied only on emissions in EEA airspace, this would constitute a competitive distortion. Below, we investigate the extent to which this effect would occur.

The majority of intra-EEA charter passengers[76] originate in Northern Europe and travel to Mediterranean holiday destinations. This charter flow from Northern Europe constitutes over 80% of the total EU charter market. These travellers go to Spain and Greece mainly because of the sun and the beaches, which are not available in their home countries. Their first reaction might therefore be to shift to destinations outside the EEA instead of travelling to destinations nearer by: from Greece to Turkey, for example, or from Spain to Tunisia (see Figure 3.4).

---

[76] The share of the European charter market in the total European air passenger market (EC, 1996) is about 50%.

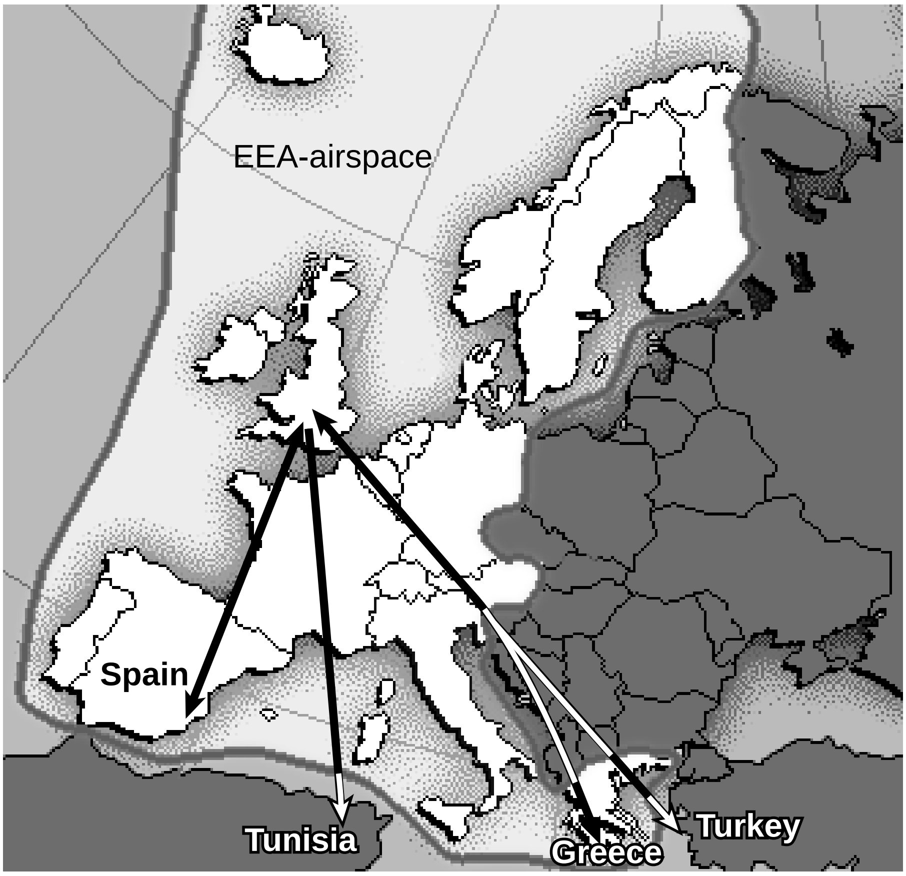


Figure 3.4 Potential economic distortions in international tourism

Such behaviour might be induced if the aviation charge makes European destinations more costly than non-European tourist areas. To what extent is this the case, however? At first sight, one would not expect European destinations to become more costly compared with non-EEA destinations, because the distance travelled through EEA airspace for European destinations will, on average, not be systematically greater than for alternative destinations outside the EEA. Nevertheless, European destinations are expected to become systematically somewhat more costly, because for such destinations there is one more LTO cycle taking place in EEA airspace compared with non-European destinations. Thus, return tickets to European destinations are expected to become about 2$ more costly than those to non-European destinations (see Table 3.8). This ticket price increase would therefore lead to an increase in total holiday package price of less than 1%, assuming an average package price of about 300$ for Mediterranean destinations. It can be concluded that such a price differential would not lead to any substantial shift in tourist destinations.

If competitive disadvantages for European tourist destinations are expected, however, consideration might be given to compensating certain sensitive tourist destinations in Europe for financial losses using part of the charge revenues.

A competitive distortion of a European aviation charge might also arise if tourists from outside the EEA change their destination from a European to a non-European country or region. It can be argued, however, that this distortion will probably be small, because many people tend to go to Europe to visit a capital city such as London, Paris or Rome. Obviously, it is difficult to find such an alternative outside Europe.

3.5.3 Revenue-neutral emission charge (option 2)

The revenue-neutral charge generates even less competitive disadvantages for European aviation companies and the European tourist industry than option 1, because the total operating costs of the average airline would increase less through this charge option. As the revenues are paid back to the airlines, total operating costs rise only because of the extra costs of implementing emission reduction measures. This effect will lead to an increase of less than 5% in total operating costs. Consequently, this slows down the average growth of passenger kilometres by less than 0.1% per annum during the period 1992-2025 (compared with 0.3% per annum in the case of option 1: the calculated emission charge). In addition, the financial benefit of avoiding the LTO cycle is less than 1$ per ticket on a return flight. It can therefore be concluded that this option is feasible with regard to the criterion 'economic distortions'.

3.5.4 LTO emission charge (option 3)

As the volume effect of this charge option is low, no competitive disadvantage is to be expected for European airlines through diseconomies of scale.
This charge option might, however, lead to the same (small) competitive disadvantage for the European tourist sector as charge option 1, if tourists shift their destination from a European to a non-European region. This is because they can still avoid the charge on LTO emissions.

3.5.5 Fuel charge package (option 4)

Under the assumption that the volume effect of the fuel charge equals the volume effect of the emission charge (option 1), it can be concluded that the potential economic distortions between EEA and non-EEA airlines are in the same order of magnitude. In Section 3.5.2 it was concluded that this potential distortion would probably be negligible for charters and low-cost carriers. European scheduled carriers might face a somewhat smaller improvement of economies of scale owing to the 'home market effect'. As noted before, in view of the ongoing liberalization and process of consolidation (to achieve economies of scale) on the European air transport market, we expect no relevant distortions in competition between European and non-European carriers.

A fuel charge will cause larger distortions for both airports and tourist destinations compared with the emission charge, because roughly half the charge on a two-way trip can be avoided by shifting the origin or destination outside the EEA. This generates a price gain of about 3$ for a flight of 500 km and 8-12$ for a flight of 2000 km. This is 2 to 6 times more than in the case of an emission charge[77]. This is shown in Figure 3.5.

---

[77] In Section 3.5.2 it was elucidated that avoiding an emission charge in EEA airspace by shifting to an airport just outside the EEA could generate a financial gain equal to a charge on LTO emissions, which is about 2$.

Fuel Charge
Situation B: flight from and to EEA (point-to-point)

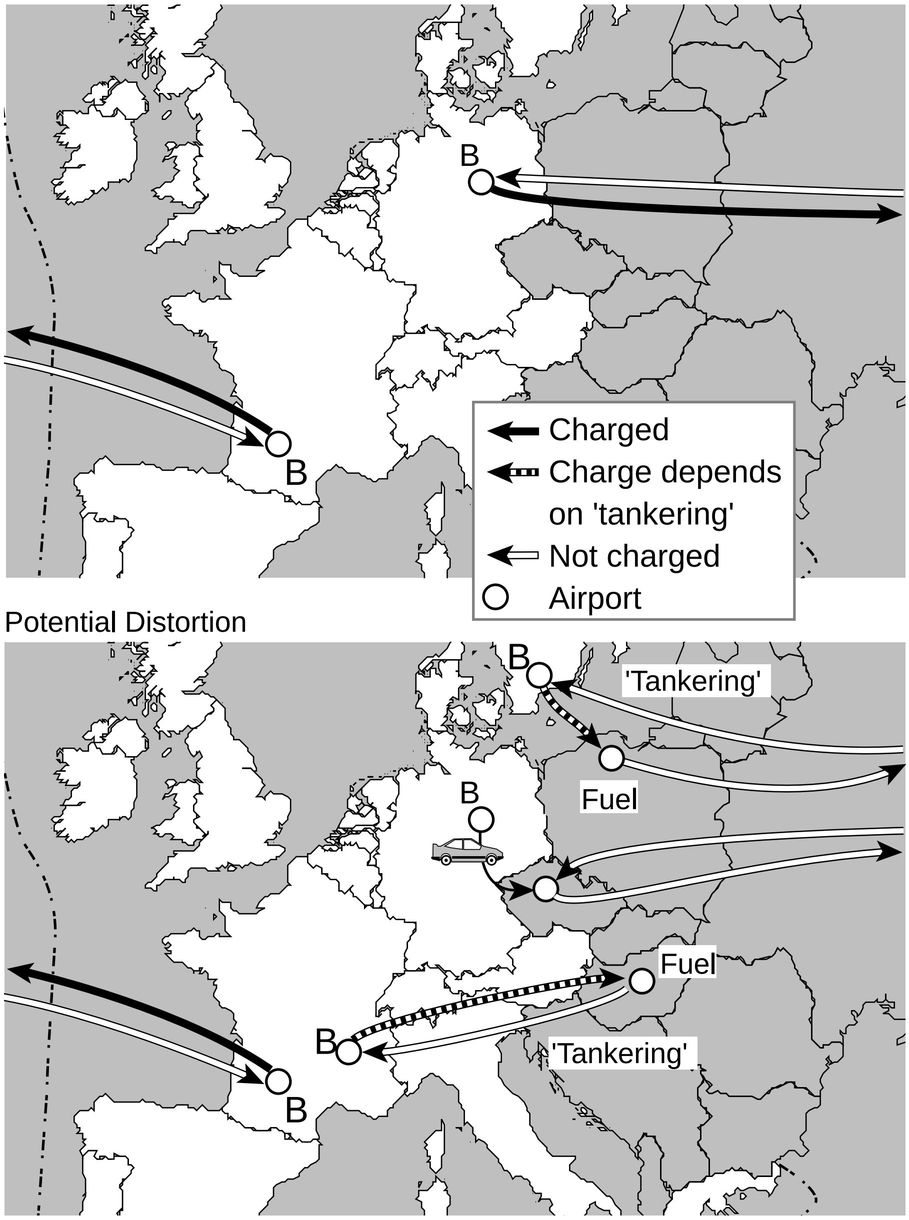


Figure 3.5 Potential economic distortions of origin/destination connections following introduction of a fuel charge

The figure shows that an intra-European flight at the Eastern border gives airlines the possibility (dependent on the flight distance, maximum take-off and landing weight, and safety regulations) to take extra fuel on board in third countries in order to avoid part of the fuel charge. This so-called phenomenon of 'tankering' implies that not only the incoming flights to the EEA are uncharged, but also some of the outgoing flights. A relatively high charge (e.g. a charge equivalent to 0.20 $/l; hence a fuel price increase of over 100%) might be expected to provide a strong incentive to airline companies to find operational schedules and connections that substantially avoid the fuel charge compared to the situation without distortions.

Another possible distortion is that airlines might choose to locate their hub airport outside the EEA instead of inside. The financial gain of such a shift might be much larger compared with the regime of an emission charge in the EEA, because the entire charge would be avoided.

Having established this, we estimate that a fuel charge may lead to relatively higher potential economic distortions between EEA airports and airports outside the EEA compared with the emission charge. Below, the arguments for this position are summarized.

1. The 'border effect': passengers or freight could easily avoid the fuel charge by shifting origin or destination outside the EEA. A fuel charge is roughly 2 to 6 times more vulnerable to economic distortions among airports and tourist areas than an emission charge (corresponding with a flight distance of 500 to 2000 km). On intercontinental flights the sensitivity to these potential economic distortions is even greater. On a flight of 6000 km, the potential gain of shifting origin or destination to an airport just outside Europe is estimated at 30 US$ or higher. It is hard to judge whether such a gain will have any substantial impact on travel behaviour. A fuel charge is more vulnerable to such economic distortions than an emission charge, because choosing the airport of origin or destination outside Europe means avoiding paying the bunker charge on a whole flight.
2. The 'tankering effect': airlines are encouraged to avoid the charge by taking on board more fuel than necessary at non-participating countries outside the EEA in order to avoid refuelling in the EEA. The order of magnitude of this possible effect is hard to assess on the basis of current tankering practice, because of the relatively large increase in fuel price after the charge considered[78].
3. A fuel charge might give airline companies a significant incentive to choose a hub airport outside the EEA in the long term. The financial gain is of the same order of magnitude as the first argument.
4. As mentioned during discussion of the potential distortions of an emission charge, time-related variables ('access time' and 'frequency') are dominant in the airport choice behaviour of business travellers. It was noted that business travellers would accept an additional access time of one hour to a non-EEA airport if the level of the aviation charge amounted to $ 77 or higher, while non-business travellers would accept one hour of extra travel time to an alternative airport if the aviation charge were over $ 23. This implies that for long-haul flights, non-business travellers originating from the border area might possibly shift to an

[78] The extra amount of fuel that can be taken on board to avoid refuelling at an EEA airport is limited, owing to the permissible Maximum Landing Weight (MLW) of an aircraft. The MLW depends on aircraft type, weather conditions, specific airport circumstances such as runway length, load, etc. In practice, this often means that a maximum of about 10% of tank capacity is available for 'tankering'.

airport outside the EEA if the financial gain to be achieved exceeds the value of one hour travel (23 $).

The above arguments indicate that a fuel charge might also give rise to greater competitive disadvantages for the tourist industry in the EEA than in the case of the emission charge. Tickets to popular South European holiday destinations will increase by 8 to 12 $ relative to tickets with a destination outside the EEA, assuming a flight distance of 2000 km. This implies, in this example, an increase in the holiday package price for EEA destinations relative to non-EEA destinations of about 2.5% to 4% (again assuming an average holiday price of 300 $).
Given the high income elasticity of demand for holidays of the North European countries, however, potential distortions of the European tourist industry are likely to be small in absolute terms, but greater than in the case of an emission charge.

3.5.6 Ticket charge (option 5)

If a ticket charge is structured as a single tariff for each departure for an intra-European flight and a double tariff for each departure with a destination outside the EEA[79], travellers and freight could only avoid the ticket charge by shifting their origin *and* destination airport outside the EEA. In that case a financial gain can be achieved equal to the total charge otherwise to be paid. Figure 3.6 shows potential economic distortions between European and non-European airports after a ticket charge.

79 This structure is used by Norway for its national ticket charge.

Ticket Charge

Situation B: flight from and to EEA (origin/destination)

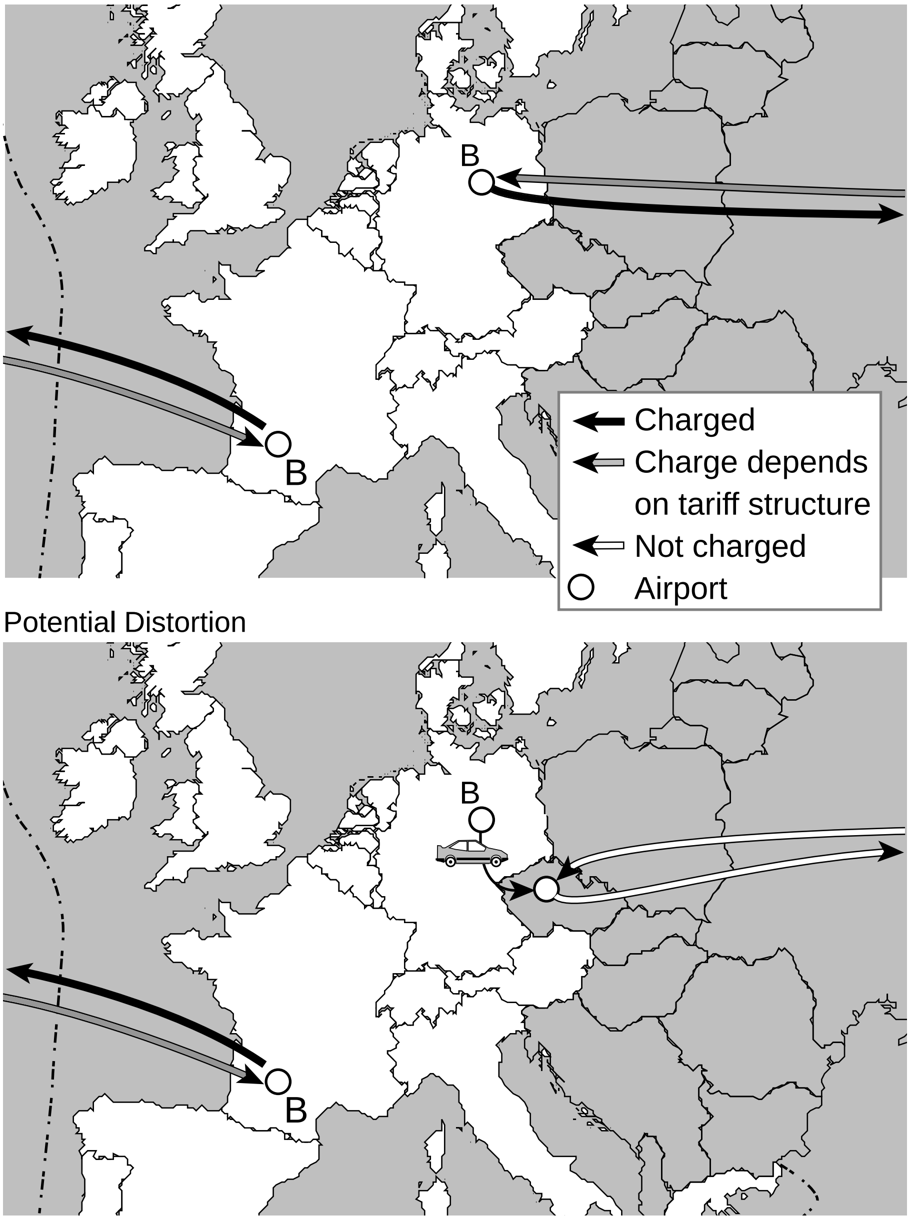


Figure 3.6 Potential economic distortions among airports after a ticket charge

There are two important advantages of a ticket charge. First, as remarked, the ticket charge can only be avoided if both origin and destination are outside the EEA. Obviously, this is only relevant for a small market share of passengers originating from along the border of the EEA and for non-European passengers travelling to the EEA border area. In addition, as pointed out in option 1, time-related variables (access time and frequency) are dominant in the airport choice behaviour of travellers.

Overall, based on the criterion 'potential economic distortions, one can conclude that this charge options is feasible[80]. The relatively small potential for economic distortions of a ticket charge is probably close to that of an emission charge and is certainly less than that of a fuel charge.

Feasibility of the 5 charge options on the criterion 'economic distortions'

Table 3.9 Indication of the feasibility of the five charge options with respect to the criterion 'economic distortions'

Charge option	Economic distortions[1]
1 Emission charge	++
2 Revenue-neutral emission charge	+
3 LTO emission charge	++
4 Fuel charge package	++++
5 Ticket charge	+++

1 This column indicates the potential for occurrence of economic distortions
+ negligible potential
++ very low potential
+++ low potential
++++ moderate potential
+++++ high potential

3.6 Legal issues

This legal analysis addresses the regulations relevant to implementing a European aviation charge in order to reduce emissions. The results of this legal evaluation are based mainly on a study carried out by the International Institute for Air and Space Law, of Leiden, as part of the Preliminary study of this project[81]. The following analysis focuses on the relevant national and international provisions, including the Chicago Convention, bilateral Air Service Agreements (ASAs) and European Union legislation.

The Chicago Convention is the fundamental treaty on international civil aviation. Most nations of the world, including the 15 EU member states, are parties to this treaty. Its provisions form binding international law, superseding bilateral ASAs and national air codes. Bilateral ASAs regulate the

80 If a shift of transfer passengers to carriers flying on hubs is expected, potential competitive disadvantages for EEA airports can be avoided if these passengers are exempted from paying the ticket charge. Obviously, this will limit the area of validity of the ticket charge and would consequently reduce its environmental effectiveness.

81 See Annex D for the complete results of the legal analysis by the International Institute for Air and Space Law.

operation of air services between pairs of countries. They supersede national regulations. EU aviation law replaces the bilateral ASAs between the EU member states in areas in which it covers matters dealt with by these ASAs. It follows from this that EC aviation law does not replace, or supersede, the provisions of the Chicago Convention. EU member states are committed to respect these provisions. EU aviation law applies only to relations between the member states of the European Union. Each EU member is still responsible for conducting its own aviation relations with non-EU members. Therefore, these relations continue to be governed by bilateral ASAs concluded between an EU member and a non-EU member, so long as the superseding competence of the EU in the field of external relations does not apply.

On the basis of these regulations, the legal feasibility of the charge options is discussed below. The starting point of this discussion is the fuel charge, because the regulations are more explicit on this charge than on the emission- and movement-based charges.

Fuel charge
It is often stated that charging aviation fuel is not permitted under the Chicago Convention. However, this international agreement only prohibits the taxation of fuel - and other goods - *in transit*. This means that fuel entering a country in an aircraft and leaving that country again cannot be charged. Charges on the intake or consumption of fuel are not prohibited by the Chicago Convention itself, but by many so-called bilateral Air Service Agreements (ASAs), which are concluded between various pairs of countries. They often exclude the taxation of fuel bunkered and consumed in the signatory countries. Each ASA should be reviewed on its own merits, however, to allow specific conclusions to be drawn.

One option would be to change the bilateral ASAs. For ASAs between all pairs of EU Member States, this can be done by adapting the EU Directive on this matter, which supersedes ASAs between EU countries. Changing an ASA between a Member State and a non-EU country requires a renegotiation between the two countries. Many ASAs should be reviewed. If they are not adapted to allow for an environmental charge, non-EU carriers would probably not be liable to a fuel charge, even on intra-European flights. This might generate a distortion of competition between EU and non-EU carriers.

It is suggested that the relevant clauses in the standard texts for ASAs be reconsidered to create the opportunity for a possible introduction of fuel charges in the future. Each country has the freedom to do so, and international organizations can give a recommendation to the individual states.

Limiting the fuel charge to only intra-EU flights might face less legal obstacles, because the adaption of the EU Directive could supersede the ASAs between the Member States. From the point of view of the non-discrimination principle it is then necessary that airlines from non-EU countries be prohibited from operating intra-EU flights. At the moment, however, a limited number of non-EU airlines are allowed to make a transfer stop at an EU airport and to extend their flight to another airport within the EU. The latter could form an obstacle for the feasibility of a fuel charge applied only to intra-EU flights.

Emission charge
From the point of view of international aviation law, there are no explicit obstacles facing introduction of a non-discriminative emission-based charge in Europe.
Furthermore, with regard to the two levy points for the emission-based charge, the most commonly used clauses in ASAs also do not prohibit emission charges on landing fees and on tariffs for route air navigation services. This is confirmed by the fact that at a number of airports in the world noise charges, as part of landing fees, have been in effect for many years now.

An open question is whether an emission charge in European airspace should be limited to national territory, including the 12-mile zone, or whether airspace above large seas and part of the ocean might also be included in the charge regime. The latter is preferable, to avoid possible changes in routes as a consequence of an emission charge.

Charge on movements (tickets)
A ticket charge on movements for environmental purposes is also not prohibited by international aviation law in so many words. The IATA Manual of ticket taxes and charges, which lists over 1000 levies throughout the world, shows that for years now there have been levies on tickets for a variety of purposes. On 1 January 1995 Norway introduced a passenger ('Green') tax on all domestic flights for which there is a rail alternative and on all international flights from Norway to destinations abroad. The revenues of the tax are not earmarked for specific uses. This Norwegian tax illustrates the feasibility of a movement charge.

3.7 Implementation

The implementation of a charge on LTO emissions, fuel or tickets by national governments could probably be based on existing institutional infrastructure. Serious obstacles with regard to implementation are thus not to be expected for these three charge options.
With respect to the fuel charge, petroleum companies currently routinely act as tax collectors for governments, and all major international companies have the accounting infrastructure and capability to extend this function to an aviation fuel charge.
The fact that ticket taxes or charges have been in effect throughout the world for many years now shows that this charge option would not give rise to any implementation problems. See, for example, the Norwegian environmental tax on all national and international flights.

Implementation of a charge on LTO emissions can also be readily be organized, because the charge could be based on established ICAO standards for emissions from engine/airframe combinations during the landing and take-off cycle (LTO)[82]. These standards are widely accepted by international civil aviation.

Implementation of an calculated emission charge in EEA airspace (charge option 1) is probably less easy, because no internationally accepted method is yet available for calculating emissions in the cruise phase (in contrast to LTO). This being worked on by a number of international institutes. Based on the ICAO database of emissions for the LTO cycle, in combination with modelling work, however, these institutes can already give fairly reliable and accepted estimates of flight emissions. It is important that further study be undertaken on cruise emissions, because an emission-based charge would be more feasible if certified data on cruise emissions for engine/airframe combinations were available and internationally accepted.

Obviously, the above evaluation of charge option 1 also holds for charge option 2, the revenue-neutral charge based on calculated emissions. In this case, further study is required in order to assess whether the recycling of the revenues to airline companies in proportion to the number of passengers and tonne-kilometres produced in the EEA could be implemented in a straightforward manner without serious obstacles. On first sight, no problems are expected. Overall, this charge option could be considered slightly more difficult to implement than the other options.

3.8 Distributional complications

The potential distributional complications of a charge depend mainly on the chosen charge base and the method of allocation. In Chapter 2 three main options for allocating the revenues were distinguished:

1. to national states;
2. to European level;
3. to the airline companies paying the charge (revenue-neutral charge).

International distribution of the revenues is a politically sensitive issue. Any national charge (point 1) implies an international distribution of the revenues. If the revenues go indirectly to national governments, via a European treaty, additional decisions are needed about redistribution to the participating countries. All these three basic options for allocating the revenues have specific advantages and disadvantages with respect to distributional equity which will be discussed below.

---

82 *Annex 16 to the Convention on Civil Aviation, Volume II, Aircraft Engine Emissions*, Second Edition, ICAO, Montreal, July 1993.

Charge option 1: emission charge

It appears feasible for national states to charge the LTO emissions of aircraft on national territory. Allocation of revenues to the European level is more complicated, because countries need to agree on a mechanism for redistributing the revenues (see Chapter 2).

One possible way out of this problem is to decide on a mechanism for redistribution of the revenues at the same time as introducing a European aviation charge. Such a mechanism must lay down accurate rules for the allocation of overall revenues to, for example, the participating countries. In this case an international treaty is needed to govern both the charge and allocation of the revenues. This avoids the establishment of an international body to decide on use of the revenues.

It goes without saying that the allocation mechanism is subject to conflicting national interests. Decisions can only be taken by unanimity, because all participating countries have to sign the treaty.

Charge option 2: revenue-neutral emission charge

Based on the Polluter Pays Principle, the revenue-neutral charge can be regarded as unfair.

It is generally considered both fair and economically efficient for every economic activity to pays its full costs, including external costs. It can therefore be regarded as fair and efficient for each transport mode to pay the full price of the air pollution they cause (see Section 2.2.3). Furthermore, it was argued in Chapter 2 that there are no economic reasons to treat a charge aimed at internalizing externalities any differently from other charges and taxes that promote efficiency. It can therefore be considered unfair to recycle the charge revenues back to the airline companies instead of using them for public funds. In addition, it is unfair if other modes are obliged to pay for the environmental damage they cause.

A major advantage of this option, however, is that a potentially difficult discussion and choice on redistribution of the revenues among countries can be avoided, because the revenues are recycled to the aviation sector.

The revenue-neutral charge also implies that the charge will not cause adverse distributional effects on economic sectors.

Charge option 3: LTO emission charge

An advantage of this charge is that it seems feasible for national states to receive the charge revenues of the emissions charged during the LTO of aircraft on national territory. Adverse distributional effects among countries are therefore not to be expected.

From the angle of the Polluter Pays Principle, one disadvantage of this type of charge is that airlines pay the charge on a relatively small part of overall flight emissions. Hence, airlines do not pay for a substantial part of the environmental damage caused.

Table 3.10 International distribution of the revenues from a charge on LTO emissions (charge equivalent to 0.20 $/l)

Country	Revenues		
	in million $	in $ per capita	in ‰ GDP
Belgium	46	5	0.21
Denmark	73	14	0.54
Germany	330	4	0.17
England	269	5	0.26
France	219	4	0.17
Greece	43	4	0.56
Ireland	50	14	1.11
Italy	116	2	0.10
Luxembourg	16	44	1.73
Netherlands	97	6	0.30
Portugal	30	3	0.34
Spain	170	4	0.32
Finland	31	6	0.32
Norway	51	12	0.46
Austria	32	4	0.17
Iceland	13	46	1.90
Sweden	51	6	0.24
Switzerland	88	12	0.35
Total/average	1725	4	0.22

Sources: Cranfield University (1994), ICAO (1995) and WRI (1997).

Table 3.10 shows the international distribution of the revenues of a charge on LTO emissions. It is shown that countries with a relatively small population receive relatively more of the revenues per capita. A redistribution based on LTO emissions appears to be rather fair, however.

Charge option 4: fuel charge

In the case of a fuel charge it seems reasonable for each country to receive the revenues from the charge on the fuel bunkered on their territory at their airports. Table 3.11 shows the distributional effects if the revenues are allocated to the country where fuel is bunkered. As can be seen, some countries profit more than others from this approach, which seems unfair. This charge option would be particularly inequitable to countries where, for reasons of geography, relatively low fuel prices or other considerations, a disproportionate amount of fuel is loaded.

Table 3.11 International distribution of the revenues from a charge on fuel bunkers (charge equivalent to 0.20 $/l)

Country	Revenues		
	in million $	in $ per capita	in ‰ GDP
Belgium	199	20	0.91
Denmark	147	28	1.08
Germany	950	12	0.50
England	1038	18	0.99
France	845	15	0.65
Greece	230	22	3.01
Ireland	58	16	1.29
Italy	524	9	0.46
Luxembourg	32	86	3.40
Netherlands	509	33	1.59
Portugal	130	13	1.44
Spain	515	13	0.96
Finland	64	12	0.65
Norway	20	5	0.18
Austria	50	6	0.27
Iceland	18	68	2.78
Sweden	103	12	0.48
Switzerland	253	35	1.00
Total/average	5684	15	0.74

Sources: UN (1995) and WRI (1997).

Charge option 5: ticket charge

Table 3.12 presents the international redistribution of charge revenues from a ticket charge. The distributional effects are comparable to those of a distribution based on LTO emissions and seems to be rather fair as well.

Table 3.12 International distribution of the revenues from a ticket charge (charge level based on 500 km)

Country	Revenues		
	in million $	in $ per capita	in ‰ GDP
Belgium	56	6	0.26
Denmark	75	14	0.55
Germany	470	6	0.25
England	537	9	0.51
France	349	6	0.27
Greece	81	8	1.06
Ireland	47	13	1,03
Italy	198	3	0.17
Luxembourg	6	15	0.58
Netherlands	120	8	0.37
Portugal	54	5	0.60
Spain	331	8	0.62
Finland	31	6	0.31
Norway	62	14	0.56
Austria	35	4	0.19
Iceland	5	19	0.76
Sweden	77	9	0.36
Switzerland	125	17	0.50
Total/average	2657	7	0.35

Sources: Cranfield University (1994), ICAO (1995) and WRI (1997).

3.9 Conclusions

This final section summarizes the main advantages and disadvantages of the five options for a European aviation charge, as discussed in the previous sections. In Table 3.13 all five charge options are ranked on the five criteria considered. The aim of the ranking is to provide an overview of the strengths and weaknesses of the different charge options. The ranking exercise does not include a final judgement in terms of the best option, nor does it attempt to generate a combined ranking for the five criteria taken together. The latter is not possible, because the weight of the various criterion scores differ substantially.

Table 3.13 Relative ranking of five charge options on five criteria (1=best; 5=worst)

Charge option	Criteria				
	Environmental effectiveness	Economic distortions	Legal issues	Implementation	Distributional complications
1. Emission charge	1	3	1	4	3
2. Revenue-neutral emission charge	3	1	1	5	4
3. LTO emission charge	4	2	1	3	1
4. Fuel charge package[a]	1	5	5	1	5
5. Ticket charge	5	4	1	1	1

a The fuel charge package includes a charge on fuel bunkering in the EEA, a charge on LTO emissions and NO_x standards.

The following conclusions proceed from the environmental effectiveness of the charge options, because the aim of the aviation charges considered is to reduce emissions. The following conclusions can be drawn based on the evaluation of the five representative charge options[83]:

1 The environmental effectiveness of the emission charge in EEA airspace (option 1) and the fuel charge package (option 4) is high, because both generate sufficient incentives for the introduction of (almost) all types of emission reduction measures. Both options result in a reduction of European aviation emissions between 1992 and 2025 estimated at about 25 to 35% compared with a business as usual (BaU) scenario.

2 The environmental effectiveness of the revenue-neutral emission charge is somewhat lower than that of the emission charge and fuel charge package (20-30% emission reduction between 1992 and 2025 compared with BaU). This difference can be explained by two opposing effects. The first is that the revenue-neutral charge will have only a small effect on volume, because the average costs of aviation will only be increased by the extra costs of emission reduction measures. The second effect is an extra incentive for 'clean' performance by raising the load factor and by flying less over short distances in small aircraft compared with the emission charge.

3 The environmental effectiveness of the charge on LTO emissions is substantially lower than that of the emission or fuel charge, because of the limited area of validity. A rough estimate of the emission reduction after an LTO charge is about 5% to 10% between 1992 and 2025 compared to BaU.

83 All estimates are based on a charge equivalent to 0.20 $/l.

4 The environmental effectiveness of the ticket charge (option 5) can be considered low (about one-third that of the emission charge), because it generates no incentives for implementing technical or operational measures.
5 The main advantage of the revenue-neutral charge is that it leads to no economic distortions, because the revenues are returned to the aviation sector.
6 The potential economic distortions of the emission charge (option 1) and the charge on LTO emissions (option 3) are small.
7 A fuel charge can be considered relatively less attractive from the economic distortion point of view. From the evaluation it can be concluded that a fuel charge may lead to relatively higher competitive disadvantages for EEA airports compared with airports outside the EEA.
8 On the basis of the criterion 'potential economic distortions', it can be concluded that a ticket charge is feasible. The potential economic distortions among airports of a ticket charge are relatively small, because the ticket charge can be avoided only by shifting both origin and destination to outside the EEA. Overall, it can be concluded that the potential for economic distortions of a ticket charge might be similar to that of an emission charge and is certainly less than that of a fuel charge.
9 The focus of the legal evaluation is on the relevant national and international provisions, including the Chicago Convention, bilateral Air Services Agreements (ASAs) and European Union legislation. Based on this evaluation, all charge option seem feasible, with the exception of the fuel charge. The fuel charge can be introduced only if many of the so-called bilateral Air Service Agreements (ASAs) concluded between various pairs of countries are adapted. This is because these ASAs often prohibit taxation of fuel bunkered and consumed in the signatory countries. A fuel charge on intra-EU flights might face fewer legal obstacles if the EU directive on this matter, which supersedes ASAs between EU countries, were to be adapted.
10 Evaluation on the criterion 'implementation' indicates that all five options are feasible. The charges on LTO emission, fuel and tickets are relatively easier to implement, because implementation could be based on existing institutional infrastructure. Implementation of a calculated emission charge and a revenue-neutral charge is likely to be more difficult, because no internationally accepted method is yet available for calculating emissions in the cruise phase (in contrast to LTO). In addition, further study is required on the revenue-neutral charge in order to assess whether the recycling of the revenues to aviation in proportion to the number of passengers and tonne-kilometres produced in the EEA can be implemented in a straightforward manner without serious obstacles.
11 The fuel charge and the revenue-neutral charge give rise to some distributional complications, while the other options appear to be feasible from the distributional point of view. A fuel charge seems particularly inequitable in the case of countries where, for reasons of geography, relatively low fuel prices or other considerations, a disproportionate

amount of fuel is loaded and thus a disproportionate level of revenues is received.
A revenue-neutral charge might be considered unfair, because aviation does then not pay for much of the environmental damage it causes.

4 Summary, conclusions and recommendations

4.1 Feasibility study

Background and aim

Air pollution from civil aviation is expected to triple in the period 1990-2015. Projected growth in passenger and freight transport is substantially higher than anticipated environmental improvements to engines, aircraft design and operations. Although emissions of CO_2 and NO_x from civil aviation presently account for only 2 to 3% of worldwide emissions, this share is set to increase in the years ahead. Against this background several policy initiatives have been taken or are under consideration aimed at reducing the growth in air pollution from civil aviation.

One of the policy options discussed is a fuel or environmental charge on aviation. The environmental benefits of such charges will be greatest if they are introduced worldwide. At the same time, a global charge avoids potential economic distortions, which may arise from introduction of a charge in a limited geographic area, e.g. in Europe. Although the advantages of a worldwide charge are obvious, international decision-making is anticipated to be slow and might need a push from regional initiatives. For this reason the study at hand investigates the feasibility of a European[84] charge aimed at reducing air pollution from civil aviation. The main questions this study seeks to answer are: is it feasible to introduce an environmental charge on civil aviation in Europe only? And: what are the main advantages and disadvantages of different charge options?

Project organization

This research has been jointly financed by the European Commission and by five national States: Austria, Denmark, Germany, the Netherlands and Norway. Representatives of these authorities have participated in the Project Committee which guided this study.
The Netherlands Society for Nature and Environment (SNM) initiated the study and contracted CE in Delft, the Netherlands, to act as principal consultant. Specific contributions have been made by the International Institute of Air and Space Law in Leiden, the Netherlands and by Economics-Plus in London, UK, and by the Netherlands Research Institute for Recreation and Tourism, in Breda.

---

[84] The 15 Member States of the EU and Iceland, Norway and Switzerland. This is referred to as both Europe and the EEA (European Economic Area).

The study was structured as follows. First, three background studies were carried out on the following topics:

- The effectiveness of environmental charges in reducing air pollution from aviation[85].
- Potential economic distortion of a European environmental aviation charge[86].
- Legal issues, e.g. related to the Chicago Convention and to bilateral Air Service Agreements[87].

Based on these and other sources of information, the design of a European aviation charge is discussed (Chapter 2). Choices regarding the design of the charge go a long way to determining both the environmental gain and the feasibility in terms of economic distortions and legal complications.
Next, the feasibility of five specific charge options is investigated (Chapter 3). These five options have been selected to represent the whole range of possibilities and cover the most promising ones.
Finally, the conclusions and recommendations of the entire study are formulated (Section 4.3).

Main criteria
The attractiveness of a European environmental aviation charge is determined both by its environmental effectiveness, being the aim of the charges considered in this study, and by its feasibility or possible negative side-effects. The feasibility is in turn influenced by several different factors, of which the most important are: economic distortions, distributional complications and conflicts with existing law. The main findings of this study will be structured around these four topics:

- Environmental effectiveness (Section 4.2.2);
- Potential economic distortions (Section 4.2.3);
- Distributional complications (Section 4.2.4);
- Legal issues (Section 4.2.5).

Before these topics are discussed, it should be stressed that the design of a European aviation charge has a major impact both on its environmental effectiveness and on its feasibility. Considerations relating to the design of such a charge will therefore be presented first, in Section 4.2.1.

---

85 Summarized in Annex B of this report and published separately as *European aviation emissions: trends and attainable reduction* (Dings et al., 1997).

86 Summarized in Annex C of this report and published separately as *Potential economic distortions of a European environmental aviation charge* (Wit and Bleijenberg, 1997).

87 Annex D of this report and published previously in the Preliminary report of this study (Bleijenberg et al., 1996).

4.2 Main findings

4.2.1 Design of charge

With respect to the design of an aviation charge aimed at reducing air pollution, three important choices can be distinguished. First, the charge base needs to be determined. This study focuses on three different charge bases:

- charge on calculated emissions of a flight in European air space;
- charge on fuel bunkered at European airports;
- charge on passengers and freight departing from European airports (movement or ticket charge).

The second choice relates to the level of the charge. Different arguments for a certain level are discussed, but the final choice is of a political nature. Achieving a stabilization of CO_2 emissions from European aviation might require a charge in the order of magnitude of 0.80 to 1.30 $/l fuel[88]. Next, internalization of external costs is expected to increase fuel prices by roughly 0.14 to 0.20 $/l. Finally, taxing aviation fuel according to the harmonized minimum level for road diesel in the EU corresponds with 0.29 $/l kerosine. This study considers charge levels in the range of 0.10 to 0.40 US$ per litre fuel, compared to current fuel prices of around 0.16 $/l. The initial ticket price increase is roughly 2-9 US$ for short flights (500 km, one way) and 6 to 25 $ for long European flights (2000 km, one way). Table 4.2 presents estimates of the resulting price changes after realization of the induced efficiency improvement.

The third choice with respect to the design of an aviation charge relates to the allocation of the revenues. Three main options are considered:

- to national states;
- to the European level;
- to the airline companies paying the charge (revenue-neutral charge).

Any choice with respect to revenue allocation obviously has major distributional consequences. Total charge revenues are estimated at around 5 to 6 billion US$, assuming a charge level equivalent to 0.20 US$/l.

With the knowledge gained in the background studies, five charge options were selected for further analyses (Chapter 3). Table 4.1 presents an overview of these five options, which represent the whole range of possibilities, each in the most promising variant.

---

88 Assumed annual growth trend in CO_2 emissions of 3% and fuel price elasticity of -0.4 to -0.5.

Table 4.1 Five charge options

Option	Charge base	Charge level[a]	Allocation of revenues
1 Emission charge	Calculated emissions	0.03-0.12 \$/kg CO_2 3.10-12.40 \$/kg NO_x (low) 2.60-10.40 \$/kg NO_x (high) 2.40-9.80 \$/kg SO_2 3.10-12.40 \$/kg VOC	To European level. Redistributed to national states via allocation rules.
2 Revenue-neutral emission charge	Calculated emissions	See option 1	To airline companies. Proportional to their production in EEA air space.
3 LTO emission charge	Calculated emissions during LTO	See option 1	To national states
4 Fuel charge package[b]	Fuel bunkers	0.10-0.40 \$/l	To national states
5 Ticket charge	Movements	2.00-9.00 \$/passenger for EEA departures 4.00-18.00 \$/passenger for non-EEA departures	To national states

[a] Working assumption equivalent to 0.10-0.40 US\$ per l fuel.
[b] The package includes a charge on LTO emissions and emission standards. These additional instruments are required to avoid higher fuel efficiency being achieved at the expense of higher emissions of NO_x and VOC.

4.2.2 Environmental effectiveness

Both the emission charge and the fuel charge package are expected to be effective in reducing air pollution from aviation (charge options 1 and 4). Based on a review of available research, it is estimated that a gradual increase in fuel price of 0.20 $/l, or an equivalent emission charge, will reduce air pollution by around 30% in the long run, compared with current growth trends to 2025. Such a charge could roughly half the expected growth in emissions. The positive environmental impact of these two charges is high, because both these types of charge generate incentives with regard to most kinds of environmental improvement. These relate to aircraft technology, optimized aircraft design, aircraft size, load factor and volume growth. Relatively modest improvements in each link of the chain together result in a substantial reduction in air pollution (relative to current trends).

The environmental effectiveness of the revenue-neutral emission charge (option 2) is somewhat lower, because this option hardly reduces volume growth, in contrast to the emission and fuel charges. It is estimated that this charge option will reduce emissions by around 25% relative to current growth (charge level equivalent to 0.20 $/l).

The LTO emission charge (option 3) impinges on only about one-quarter of the total air pollution from aviation in European airspace and its environmental effectiveness is consequently roughly proportionally lower than that of the emission charge.

The movement or ticket charge has a relatively low environmental effectiveness: roughly one-third that of the emission or fuel charge. This is because a movement-based charge only creates an incentive to reduce volume growth, with no incentives being generated to increase the environmental efficiency of civil aviation, where the largest gains are to be expected.

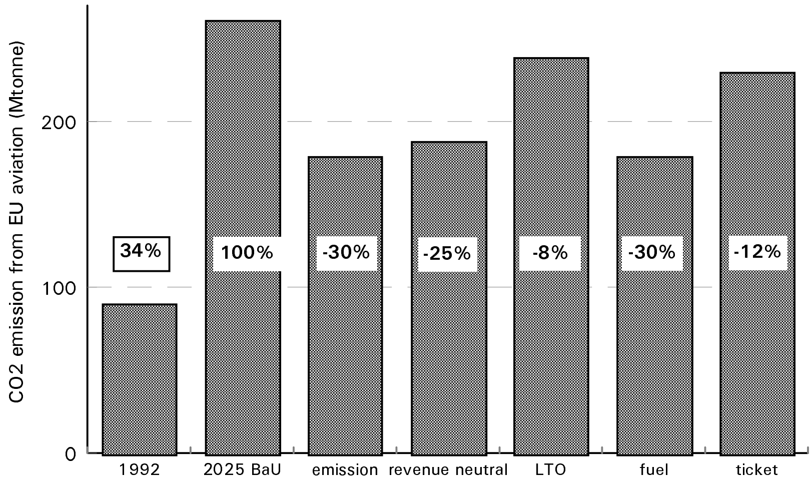


Figure 4.1 This figure gives an overview of the estimated CO_2 emission reductions of the five charge options (equivalent to 0.20 $/litre fuel) in 2025 as compared to Business as Usual

4.2.3 Potential economic distortions

If a European environmental aviation charge leads to substantial economic distortions, the feasibility of such a charge will be reduced. This study has therefore devoted considerable efforts to investigating potential economic distortions. Economic distortions are taken to mean distortions in competition between European and non-European companies resulting from the limited geographical scale of a European aviation charge. This definition implies that changes in the competitive position of companies that would also occur as a consequence of a *global* aviation charge are not considered to be economic distortions in this study. A change in the competitive position of relatively clean airline companies compared to high-polluters is thus not considered to be an economic distortion, but rather an efficiency improvement. Changes in policies should allow companies enough time to adapt to the new circumstances.
This study focuses on potential distortions in competition between airline companies, between airports and between tourist areas. It is assumed that

these economic activities are most vulnerable to distortions caused by a European aviation charge.
The analysis in this part of the study is based mainly on interviews and discussions with economic experts from the aviation and tourist industries. Furthermore, the scarce international literature relevant to this topic and some statistical data have also been used.

As a first step, the price increase is considered more closely. A charge corresponding with 0.10 to 0.40 US$ per litre fuel will, in the long run, after environmental improvements, lead to an increase in total operating costs. This cost increase can be expressed as an increase in the ticket price and can be compared with existing airport charges (see Table 4.2).

Table 4.2 Estimated long-term price increase due to an environmental aviation charge equivalent to 0.10-0.40 US$ per litre fuel

Price increase	Flight 500 km	Flight 2000 km
Per ticket (one way)	1.50 - 6.50 $	4.50 - 19.00 $
Expressed as percentage of current total airport charges[a]	4 - 20 %	10-45%

[a] Average of major European airports.

Table 4.2 indicates that modest price increases can be expected to result from a charge in the range considered. The price increase per ticket will be more than outweighed by projected price cuts originating from ongoing market efficiency improvements. Furthermore, the price increase as a percentage of total airport charges is smaller than existing differences among airports.

Next, it is important to stress that the charge is non-discriminative. Both European and non-European carriers are faced with the same charge on the same service provided. One difference, however, is that some airline companies achieve a greater share of their production in Europe than others. It is therefore important to know whether carriers will transfer the cost increase due to the charge into a price increase or, otherwise, whether they will be compelled to reduce their profit margin. This study did not identify any convincing arguments for air fares not being raised. As a first-order approximation, therefore, no distortion in competition among airline companies is expected.

A second-order effect is that increased air fares may slow down the growth of the European air transport market somewhat, resulting in a smaller home market for European compared with non-European carriers. This might weaken the competitive position of European airlines. It is estimated that the European market will, in the long run, be about 9% smaller compared to the current growth trend after introduction of an emission or fuel charge

equivalent to 0.20 US$ per litre. This implies that average annual growth will be reduced from 4% without a charge to 3.7% over a period of 30 years, following stepwise introduction of such an aviation charge. This somewhat smaller home market might lead to reduced economies of scale for European compared with non-European airline companies. This should, however, be seen in the light of international developments in aviation.
Firstly, the European aviation sector is in the process of consolidation, to achieve economies of scale. One extra merger compared to Business as Usual might be sufficient to counterbalance the smaller home market and achieve the same scale efficiency. This does not mean that the efficiency of European carriers will be reduced, but that the number of independent carriers will become smaller as a consequence of a European aviation charge.
The second international trend is towards global alliances. Because all global alliances have to be present in the European market, no distortion in competition will arise among them.

According to this study it is unlikely that relevant economic distortions among airline companies will arise as a consequence of a European environmental aviation charge in the range considered. No convincing arguments have been heard for expecting relevant distortions in competition between European and non-European carriers.

Possible economic distortions among airports and tourist areas are influenced by the choice of charge base. An emission charge in European air space is least vulnerable to these economic distortions and will not result in significant economic distortions. In most cases the financial gain of shifting the origin or destination of a trip to an airport outside Europe is limited to an average of around 2 US$ per passenger (charge level equivalent to 0.20 $/l). Such a small financial gain is insufficient to justify departure from an airport outside Europe and thus a longer distance and travel time. In the highly competitive tourist market in Southern Europe - 'sun trips' - small price changes might influence the choice of destination, e.g. from Greece and Spain to Turkey and Tunisia. However, the financial gain of such a shift is, in general, 0.3 to 0.6% of the total average holiday package price. It therefore seems unlikely that a charge level equivalent to 0.20 $/l will generate any substantial shift towards tourist areas outside Europe. Furthermore, consideration might be given to introduction of mitigating measures for some tourist areas in the event of significant distortions.

A fuel charge is roughly 2 to 6 times more vulnerable to economic distortions among airports and tourist areas than an emission charge (corresponding with a flight distance of, respectively, 500 and 2000 km). On intercontinental flights the sensitivity with respect to these potential economic distortions is even greater. On a flight of 6000 km the potential gain of shifting origin or destination to an airport just outside Europe is estimated at around 30 US$. It is hard to judge whether such a gain will have a substantial impact on travel behaviour.

A fuel charge is more vulnerable to such economic distortions than an emission charge, because choosing the airport of origin or destination outside Europe means avoiding paying the bunker charge on an entire flight. In the case of an emission-based charge, flying in European air space is always charged, irrespective of the origin or destination of the flight.
Based on this study, it is not possible to indicate the feasibility of a fuel charge with respect to potential economic distortions.

The potential economic distortions of a movement-based charge are somewhere intermediate between those of an emission and fuel charge. Paying the movement charge can only be avoided if the airports of both origin and destination are located outside Europe. This is only possible for European travellers with a destination outside Europe and a departure close to the European border and for non-European travellers avoiding an arrival in Europe. These two market segments are relatively small. Furthermore, the financial gain of such shifts is only about 9 US$ (charge level equivalent to 0.20$/l related to a fixed flight distance of 500 km).
A movement-based charge is not anticipated to generate any unacceptable economic distortions[89].

4.2.4 Distributional complications

Any choice of both charge base and revenue allocation has distributional consequences. Two distributional issues can be distinguished: a) among the participating countries and b) between the aviation industry and the public sector, or tax-payers.

One option is for the revenues to be allocated directly to the participating countries. In this case the choice of charge base at the same time determines the international distribution. An emission charge is attractive for countries with intensive routes through their airspace. A fuel charge will be favoured by countries with substantial bunkers. And countries with airports attracting passengers from neighbouring countries might profit from a movement charge.
The (political) question is: what is to be considered fair?

A second option is for revenues to be allocated at the European level. In this case it seems most acceptable to redistribute the revenues to the participating countries, by means of an allocation rule. Such an allocation rule may be incorporated in the international treaty regulating implementation of the charge. It is evident that the allocation rule is subject to conflicting financial interests.

Thirdly, the revenues can be allocated to the airline companies paying the charge (revenue-neutral emission charge). In this variant, airlines pay a

---

[89] Norway has implemented this type of charge on a national scale and with a level of around 20 US$ for international departures.

charge on all their emissions in European airspace and the revenues are fully refunded to the same carriers in proportion to their production of passenger- and tonne-kilometres in European airspace[90]. This generates an incentive for all airlines to improve their environmental performance and at the same time stimulates a shift to relatively clean carriers.
This option has the advantage that it does not impose any additional financial burden on the aviation sector, nor is there any need to regulate allocation and use of the revenues. However, in this case the distributional issue is whether it is fair for aviation not to pay for its environmental damage, nor to pay a fuel tax like road traffic.

These distributional complications are only mentioned in this report. No judgement has been made of what would be a fair international distribution of revenues or what a fair tax and charge regime for aviation would imply, e.g. in comparison with other transport modes.
With respect to the feasibility of a European aviation charge it can be stated in general that distributional issues can be solved, provided that the political will is present among the participating European countries.

4.2.5 Legal issues

Neither an emission- nor a movement-based charge face serious legal obstacles, e.g. in connection with the Chicago Convention or other international agreements. An open question is whether charges in European airspace should be limited to national territory, including the 12-mile zone, or whether airspace above large seas and part of the ocean should also be included in the charge regime. The latter option is preferable, to avoid possible changes in routes as a consequence of an emission charge.

In the case of a fuel charge, it is expected that many bilateral Air Service Agreements (ASAs) will have to be adapted. This will not be a (political) problem for ASAs between the participating European countries. Adapting ASAs between any participating country and a non-European country might generate more difficulties, however, because non-participating countries can in fact block the required changes or demand a price for allowing a fuel charge. For this reason, an emission and movement charge have advantages over a fuel charge.

A fuel charge limited to intra-European flights only might face fewer legal obstacles. However, its environmental effectiveness will be reduced by about one-quarter and supplying both charged and uncharged fuel at European airports might be sensitive to fraud. Furthermore, such a limited fuel charge probably faces different and possibly larger economic distor-

---

90 Differentiated landing charges related to air pollution per engine/airframe combination - as introduced at Zurich airport - can be regarded as a revenue-neutral charge on LTO emissions.

tions than a charge on fuel bunkers for all departures from European airports.

4.3 Conclusions and recommendations

This project can be characterized as a broad feasibility study, considering all the most relevant options for a European aviation charge. The different charge options may differ widely in terms of both environmental effectiveness and anticipated feasibility.
This broad study hopes to narrow the 'playing field' for future policy development. Because of the broad character of this study, additional in-depth research is needed on specific issues.
The following conclusions and recommendations indicate both the most promising charge options and the remaining gaps in knowledge.

Conclusions

1 The design of a European aviation charge has a substantial or even decisive impact on both its environmental effectiveness and its feasibility. Crucial choices relate to charge base, charge level and allocation of the revenues.

2 This study reveals a positive perspective on the implementation of a European aviation charge that is both environmentally effective and feasible. A charge level equivalent to 0.20 US$/litre fuel is expected to roughly halve the projected growth in emissions from civil aviation in Europe. Introduction of an aviation charge offers opportunities to increase overall economic efficiency.

3 A charge based on calculated emissions appears to be the most attractive option and is most probably feasible. The potential economic distortions[91] are smaller than those associated with other charge bases. An emission charge in European airspace will not have a noticeable impact on competition between European and non-European carriers. On average, the financial gain of shifting origin or destination to an airport outside Europe is limited to around 2 US$ per ticket. This is not expected to influence travel behaviour. If needed, compensatory measures for tourist areas in Southern Europe could be considered. Furthermore, an emission charge is not in conflict with the Chicago Convention, nor with bilateral Air Service Agreements. However, it is as yet unclear whether the assumed size of European airspace is in agreement with international law.

---

91 Economic distortions are defined in this study as distortions in competition between European and non-European companies resulting from the limited geographical scale of a European aviation charge. This definition implies that changes in the competitive position of companies that would also occur as a consequence of a *global* aviation charge are not considered as economic distortions in this study.

4 A fuel charge package[92] is less attractive than an emission charge. A fuel charge is substantially more vulnerable to economic distortions than an emission charge. On an intercontinental flight of 6000 km, for example, a financial gain of, on average, 30 US$ per passenger can be achieved by shifting the airport of departure just outside Europe. Furthermore, the fuel charge faces legal obstacles, while the emission charge probably does not. The only advantage of a fuel charge over an emission charge is its easier implementation, since an emission charge requires establishment of an internationally accepted method to calculate emissions, which is not yet available for the cruise phase. However, this advantage is not crucial, because such a calculation method can be developed fairly readily and the required research is already in progress.

A fuel charge limited to intra-EEA flights might face less legal obstacles than a fuel charge on all departing flights from Europe. The consequence is, however, that the environmental effectiveness of this limited fuel charge is roughly one-quarter lower. Furthermore, economic distortions might be larger, but this is still unclear.

5 The environmental effectiveness of a movement (or ticket) charge is roughly only one-third that of the other two charge bases. Furthermore, a movement charge does not offer any substantial advantages over an emission charge. For environmental reasons, then, an emission or fuel charge is preferable to a movement charge.
However, a movement charge might be considered for reasons of fair taxation of different economic activities. One option could be to introduce a ticket charge, for example, if it appears unfeasible to introduce VAT on international transport.
Introduction of a ticket charge in Europe is feasible (and has already been implemented by Norway on a national scale).

6 An LTO emission charge is feasible. The charge per aircraft is smaller than existing differences in total airport charges among airports. The environmental effectiveness of an LTO emission charge is roughly only one-quarter that of the emission or fuel charge package, however, because only the LTO stage of a flight is affected.

7 A revenue-neutral emission charge is most probably feasible. Its potential economic distortions are probably negligible. On the other hand, its environmental effectiveness is rather high. A revenue-neutral emission charge equivalent to 0.20$/l will reduce air pollution by around 25% between 1992 and 2025 compared to current growth trends, while an emission charge will reduce air pollution by 30%. A revenue-neutral charge has hardly any impact on volume growth, in contrast to an emission charge.

92 Including, additional to the fuel charge, an LTO emission charge and standards for NO_x emissions.

One crucial difference compared with the emission charge are the distributional consequences. In the case of a revenue-neutral charge, aviation does not contribute to public finances, to compensate for its environmental damage (Polluter Pays Principle) or as a general fuel tax similar to that paid by road traffic. It lies beyond the scope of this study to judge what would be a fair treatment of aviation, compared with other modes of transport, for instance.

In order to alter the distributional consequences, it is possible to combine the revenue-neutral emission charge with other charge options. One combination is a national charge on LTO emissions with a revenue-neutral charge on emissions during flight (excluding LTO). A second combination is a revenue-neutral emission charge plus a movement charge. The movement charge not only generates public finances, but also creates an incentive to reduce volume growth, which is not affected by the revenue-neutral charge.

Recommendations

1 A detailed study should be undertaken on the design and the consequences of a European emission charge. This study should focus on the following main points:
- Develop an internationally accepted method for calculating emissions during any (standard) flight in European airspace.
- Define the borders of European airspace, where the charge is to be applied, considering international law and minimizing opportunities for avoiding European airspace.
- Investigate in detail the practical possibilities for avoiding European airspace and seek possible mitigating measures.
- Develop schemes for international distribution of charge revenues (allocation rules).
- Investigate in detail the required legal provisions.
- Investigate opportunities and procedures for a gradual extension of the number of participating countries.
- Develop an administrative system for calculating the emissions and collecting the related charges.

2 Consideration can be given to developing, parallel to the emission charge (recommendation 1), the fuel charge package in more detail. This may offer an alternative in the event of unexpected difficulties arising with introduction of an emission charge. The main areas of focus in further development of the fuel charge package are:
- to evaluate the two variants of the fuel charge package: a fuel charge for all bunkers at European airports or a limited fuel charge only for bunkers associated with intra EEA-flights;
- to investigate in detail the required legal provisions, including changes in bilateral Air Service Agreements.
- investigate in detail potential economic distortions and seek possible mitigating measures.

3 Introducing the emission charge - or the fuel charge package - will take some time and it is therefore recommended to start with introduction of an LTO emission charge if policy measures are desired in the short term. The LTO emission charge can be seen as a first step towards an emission charge in the entire European airspace.

4 To improve the public and political acceptance of environmental charges on aviation, it is recommended to design them as a shift in taxation and not as a revenue-raising charge. This means that the policy package is revenue-neutral for the state budget. This avoids any suggestion that a hidden aim of such environmental charges might be to generate public funds.

5 Although a movement or ticket charge has rather limited environmental effectiveness, introduction of such a charge can be considered for equity reasons or in the framework of fair taxation. It could, for example, serve as an alternative to introduction of VAT on international travel, which appears to be hampered by practical obstacles and/or potential economic distortions.
A ticket charge can be implemented in the short term.

6 If the political acceptability of a revenue-neutral emission charge should prove much greater than that of an emission charge, a detailed study is required on the design and consequences of a revenue-neutral emission charge. Special attention needs to be paid to registration of passenger- and tonne-kilometres produced in European airspace (see also recommendation 1). Furthermore, due attention should also be paid to distributional consequences (see conclusion 7).

7 Develop, at a European level, the main thrust of an equitable, balanced and transparent policy with respect to all (intra-European) transport modes. Such a consistent intermodal policy promotes acceptance of the required policy measures.
The main issues here are:
- infrastructure pricing;
- internalization of external costs;
- non-discriminative and transparent system of Public Service Obligations;
- interpretation of specific taxes, e.g. on fuel, registration and sales;
- implementation of VAT or similar taxes on intra-EU transport.

8 Determine the scope for national policy measures which can be taken in the short term, as first steps towards introduction of a European aviation charge. Possibilities are:
- introduction of a national charge on LTO emissions;
- introduction of a national movement charge;
- an emission charge on domestic flights, to apply to all airline companies.

5 Zusammenfassung, Schlußfolgerungen und Empfehlungen

5.1 Machbarkeitsstudie

Hintergrund und Zielsetzung

Für den Zeitraum zwischen 1990 und 2015 wird eine Verdreifachung der Luftverschmutzung durch die Zivilluftfahrt erwartet. Das prognostizierte Wachstum beim Fluggast- und Frachttransport liegt erheblich höher als die erhofften Umweltverbesserungen an den Triebwerken, an der Flugzeugkonstruktion und im Betrieb. Obwohl die von der Zivilluftfahrt verursachten CO_2- und NO_x-Emissionen zur Zeit nur 2 - 3 % der weltweiten Emissionen ausmachen, wird sich dieser Anteil in den kommenden Jahren erhöhen. Vor diesem Hintergrund wurden verschiedene politische Initiativen ergriffen oder werden erwogen, deren Ziel eine Minderung der zunehmenden Luftverschmutzung durch die Zivilluftfahrt ist.

Eine der diskutierten Lenkungsoptionen ist eine Treibstoff- oder Umweltabgabe für die Luftfahrt. Bei weltweiter Einführung solcher Abgaben sind die umweltrelevant größten Vorteile zu erzielen. Gleichzeitig vermeidet eine weltweite Abgabe mögliche Wettbewerbsverzerrungen, die aus der Einführung einer Abgabe in einem geographisch begrenztem Gebiet, etwa in Europa, entstehen könnten. Obwohl die Vorteile einer weltweiten Abgabe offenkundig sind, muß davon ausgegangen werden, daß solche internationalen Entscheidungen nur langsam getroffen werden und Anreize aus regionalen Initiativen notwendig sein könnten. Aus diesem Grund untersucht die vorliegende Studie die Realisierbarkeit einer europaweiten[93] Abgabe, die auf eine Verringerung der Luftverschmutzung durch die Zivilluftfahrt abzielt. Die Studie will Antworten auf die folgenden wichtigsten Fragen geben: Ist die Einführung einer Umweltabgabe für die Zivilluftfahrt ausschließlich in Europa möglich? Und: Worin liegen die wichtigsten Vor- und Nachteile unterschiedlicher Abgabenmodelle?

Projektorganisation

Dieses Forschungsprojekt wurde gemeinsam von der Europäischen Kommission und fünf nationalen Staaten finanziert, nämlich Österreich, Dänemark, Deutschland, den Niederlanden und Norwegen. Vertreter der entsprechenden Behörden nahmen am Projektausschuß teil, der diese Studie leitete.

---

[93] Die 15 Mitgliedstaaten der EU sowie Island, Norwegen und die Schweiz. Diese werden hier gemeinsam mit "Europa" und "EEA" (European Economic Area, Europäischer Wirtschaftsraum) bezeichnet.

Die niederländische Stiftung für Natur und Umwelt (Stichting Natuur en Milieu, SNM) war Initiator der Studie und schloß einen Vertrag mit dem Zentrum für Energieeinsparung und Umwelttechnologie (Centrum voor energiebesparing en schone technologie, CE) in Delft (Niederlande), als Hauptauftragsnehmer. Spezielle Beiträge leisteten das Internationale Institut für Luft- und Raumfahrtrecht in Leiden (Niederlande), Economics-Plus in London sowie das Niederländische Forschungsinstitut für Erholung und Tourismus in Breda.

Die Studie wurde wie folgt strukturiert. Zunächst wurden drei Hintergrundstudien zu folgenden Themen durchgeführt:
- die Wirksamkeit von Umweltabgaben hinsichtlich der Minderung der Luftfahrtemissionen[94];
- mögliche Wettbewerbsverzerrungen aufgrund einer europäischen Umweltabgabe für die Luftfahrt[95];
- rechtliche Fragen, beispielsweise bezüglich des Chicagoer Abkommens oder bilateraler Luftfahrtabkommen (Air Service Agreements, ASAs)[96].

Auf der Grundlage dieser und anderer Informationsquellen wird das Design einer europäischen Luftfahrtabgabe diskutiert (Abschnitt 2). Bei der Auswahl der Form der Abgabe spielen sowohl die Umwelteffekte als auch die Machbarkeit vor dem Hintergrund von Wettbewerbsverzerrungen und juristischen Implikationen die entscheidende Rolle.
Als nächstes wird die Realisierbarkeit fünf spezifischer Abgabenoptionen untersucht (Abschnitt 3). Die fünf wurden so gewählt, daß sie das gesamte Spektrum der Möglichkeiten abdecken und die vielversprechendsten davon beinhalten.
Abschließend werden die Schlußfolgerungen und Empfehlungen der gesamten Studie formuliert (Abschnitt 5.3).

Hauptkriterien
Die Attraktivität einer europäischen Luftfahrtemissionsabgabe wird sowohl von der Umweltwirksamkeit bestimmt - die das Ziel der in dieser Studie betrachteten Abgaben ist -, als auch von der Machbarkeit oder möglichen negativen Nebeneffekten. Die Machbarkeit wiederum wird von verschiedenen Faktoren beeinflußt, zu deren wichtigsten Wettbewerbsverzerrungen, Verteilungsprobleme und Konflikte mit bestehender Gesetzgebung zählen.
Die wichtigsten Ergebnisse dieser Studie werden um die folgenden vier Themen gegliedert:
- Auswirkungen auf die Umwelt (Abschnitt 5.2.2);

---

94 Zusammengefaßt in Anlage B dieses Berichts und separat veröffentlicht als: European aviation emissions: trends and attainable reduction (Dings et al., 1997).

95 Zusammengefaßt in Anlage C dieses Berichts und separat veröffentlicht als: Potential economic distortions of a European environmental aviation charge (Wit und Bleijenberg, 1997).

96 Anlage D zu diesem Bericht und früher veröffentlicht im vorläufigen Bericht dieser Studie (Bleijenberg et al., 1996).

- Mögliche Wettbewerbsverzerrungen (Abschnitt 5.2.3);
- Komplikationen bei der Verteilung (Abschnitt 5.2.4);
- Juristische Fragen (Abschnitt 5.2.5).

Vor einer Diskussion dieser Themen ist zu betonen, daß die Ausgestaltung einer europäischen Luftfahrtabgabe große Auswirkungen sowohl auf die umweltmäßige Wirksamkeit als auch die Machbarkeit hat. Überlegungen bezüglich der Ausgestaltung einer solchen Abgabe werden also als erste in Abschnitt 5.2.1 präsentiert.

5.2 Hauptergebnisse

5.2.1 Abgabenform

Bezüglich der Form einer Luftverkehrsabgabe mit dem Ziel der Reduzierung der Luftverschmutzung lassen sich drei wichtige Entscheidungskriterien unterscheiden. Als erstes ist die Bemessungsgrundlage zu bestimmen. Die Studie konzentriert sich auf drei verschiedene Bemessungsgrundlagen:
- Abgabe auf die berechneten Emissionen eines Fluges im europäischen Luftraum;
- Abgabe auf den Treibstoff, der auf europäischen Flughäfen getankt wird;
- Abgabe pro Fluggastbzw. Fracht von europäischen Flughäfen (sog. Fluggastbewegungs- oder Flugticketabgaben).

Das zweite Entscheidungskriterium bezieht sich auf die Höhe der Abgabe. Verschiedene Argumente für einen bestimmten Abgabensatz werden diskutiert, die letztendliche Entscheidung ist jedoch Aufgabe der Politik. Die Stabilisierung der durch die europäische Luftfahrt verursachten CO_2-Emissionen könnte eine Abgabe in der Größenordnung von US $ 0,80 - 1,30 pro Liter Treibstoff erforderlich machen[97]. Auf der Grundlage der Internalisierung externer Kosten müßten die Treibstoffpreise um etwa US $ 0,14 - 0,20 pro Liter ansteigen. Und eine Kerosinbesteuerung in Höhe des harmonisierten Mindestsatzes bei Dieselkraftstoff für Straßenfahrzeuge in der EU entspräche einem Betrag von US $ 0,20 pro Liter Kerosin.Diese Studie erwägt Abgabensätze im Bereich von US $ 0,10 - 0,40 pro Liter Treibstoff, und zwar im Vergleich zu den derzeitigen Treibstoffpreisen von ca. US $ 0,16 pro Liter. Der anfängliche Preisanstieg für Flugtickets beträgt ca. US $ 2 - 9 für Kurzstreckenflüge (500 km, nur Hinflug) bzw. US $ 6 - 25 für innereuropäische Langstreckenflüge (2 000 km, nur Hinflug). Tabelle 5.2 gibt Schätzungwerte der resultierenden Preisänderungen nach Einführung der damit induzierten Effizienzverbesserungen wieder.

---

97 Angenommener jährlicher Wachstumstrend bei CO_2-Emissionen von 3 % und einer Preiselastizität bei Treibstoff von -0,4 - -0,5.

Das dritte Entscheidungskriterium bezüglich der Gestaltung einer Luftverkehrsabgabe bezieht sich auf die Verteilung des Abgabenaufkommens. Es werden drei Hauptoptionen betrachtet:

- an die Nationalstaaten;
- auf eine europäischer Ebene;
- an die Fluggesellschaften, die die Abgabe zahlen (aufkommensneutrale Abgabe).

Jede Wahl bezüglich der Verwendung des Aufkommens hat selbstverständlich große Verteilungswirkungen. Das Gesamtaufkommen aus den Abgaben wird auf ca. US $ 5 - 6 Mrd. geschätzt, ausgehend von einem Abgabensatz entsprechend US $ 0,20 pro Liter.

Mit dem in den Hintergrundstudien gesammelten Wissen wurden fünf Abgabenmodelle für weitere Analysen ausgewählt (Abschnitt 3). Tabelle 5.1 vermittelt eine Übersicht dieser fünf Optionen, die den Gesamtbereich der Möglichkeiten jeweils in der vielversprechendsten Variante abdecken.

Tabelle 5.1 Fünf Abgabenmodelle

Option	Bemessungsgrundlage	Abgabensatz[a]	Verwendung der Einkünfte
1 Emissionsabgabe	Berechnete Emissionen	US $ 0.03-0.12 /kg CO_2 US $ 3.10-12.40 /kg NO_x (niedrig) US $ 2.60-10.40 /kg NO_x (-hoch) US $ 2.40-9.80 /kg SO_2 US $ 3.10-12.40 /kg VOC	Europäische Ebene; Umlegung an Nationalstaaten nach Zuteilungsregeln
2 Aufkommensneutrale Emissionsabgabe	Berechnete Emissionen	Siehe Option 1	Fluggesellschaften; proportional zu deren Verkehrsleistung im EEA-Luftraum
3 Start- und Lande-bezogene Abgabe(	Berechnete LTO-Emissionen	Siehe Option 1	Nationalstaaten
4 Treibstoffabgaben-Paket[b]	Getankte Treibstoffmasse	US $ 0.10-0.40 /l	Nationalstaaten
5 Flugticketabgabe	Fluggastbewegungen	US $ 2.00-9.00 pro Fluggast für EEA-Abflüge US $ 4.00-18.00 pro Fluggast für Nicht-EEA-Abflüge	Nationalstaaten

[a] Arbeitsannahme entsprechend US $ 0,10 - 0,40 pro Liter Treibstoff

[b] Das Paket beinhaltet Abgaben für LTO-Emissionen sowie Emissionsstandard. Diese zusätzlichen Instrumente sind erforderlich, um zu vermeiden, daß eine höhere Treibstoffeffizienz auf Kosten höherer NO_x-und VOC-Emissionen erreicht wird.

5.2.2 Auswirkungen auf die Umwelt

Sowohl von einer Emissionsabgabe als auch von einem Treibstoffabgaben-Paket wird erwartet, daß sie die Luftfahrtemissionen reduzieren (Abgabenoptionen 1 und 4). Auf der Grundlage einer Sichtung der verfügbaren Forschungsdaten wird geschätzt, daß ein allmählicher Anstieg des Treibstoffpreises um US $ 0,20 pro Liter oder eine entsprechende Emissionsabgabe die Luftverschmutzung im Vergleich zu den derzeitigen Wachstumsprognosen bis 2025 langfristig um etwa 30 % senken wird. Eine solche Abgabe könnte das erwartete Emissionswachstum in etwa auf die Hälfte reduzieren. Die positive Auswirkung auf die Umwelt durch diese beiden Abgabenformen ist so groß, weil solche Abgaben Anreize zur ökologischen Optimierung schaffen. Die Anreize wirken auf die Flugzeugtechnologie, optimierte Flugzeugkonstruktionen, die Größe der Flugzeuge, die Sitzplatzauslastung und das Volumenwachstum. Relativ bescheidene Verbesserungen bei jedem Glied in der Kette resultieren gemeinsam in einer substantiellen Verringerung der Luftverschmutzung (verglichen mit heutigen Prognosen).

Die Auswirkung der aufkommensneutralen Emissionsabgabe (Option 2) auf die Umwelt ist etwas niedriger, weil in dieser Option das Volumenwachstum im Gegensatz zu den Emissions- und Treibstoffabgaben kaum reduziert wird. Angenommen wird, daß diese Abgabenoption die Emissionen gegenüber dem derzeitigen Wachstum um etwa 25 % senken wird (wobei der Abgabensatz US $ 0,20 pro Liter entspricht).

Die LTO-Emissionsabgabe (Option 3) wirkt sich nur auf etwa ein Viertel der gesamten Flugverkehrsemissionen im europäischen Luftraum aus. Die Umweltwirksamkeit ist somit in etwa proportional niedriger als bei einer Emissionsabgabe.

Eine Besteuerung von Fluggastbewegungen oder Flugtickets hat eine relativ niedrige Auswirkung auf die Umwelt: etwa ein Drittel im Vergleich zu Emissions- oder Treibstoffabgaben. Die Ursache hierfür liegt darin, daß eine auf Fluggastbewegungen beruhende Abgabe nur einen Anreiz für ein reduziertes Volumenwachstum darstellt, ohne daß hingegen Anreize zur Verbesserung Umwelteffizienz der Zivilluftfahrt zu schaffen, wodurch die größten Verbesserungen erwartet werden.

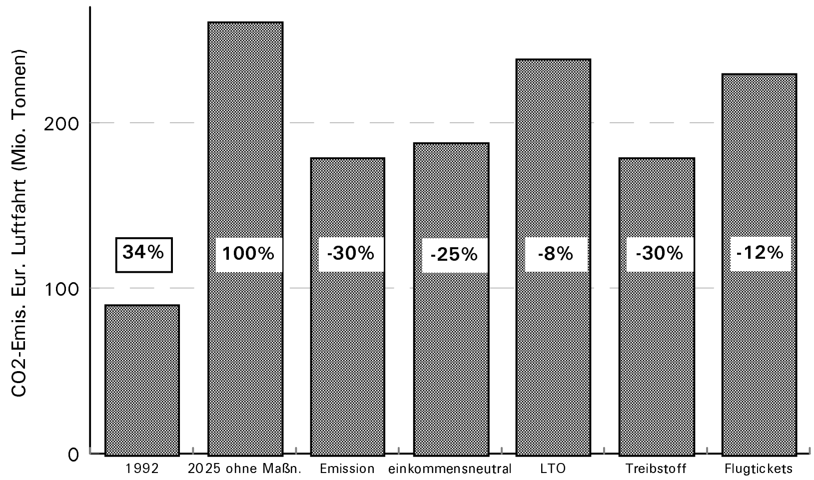


Abb. 5.1 vermittelt eine Übersicht der geschätzten Minderungen der CO_2-Emissionen der fünf Besteuerungsoptionen (entsprechend US $ 0,20 pro Liter Treibstoff) zwischen 1992 und 2025 im Vergleich zu einer "Business as usual"-Entwicklung

5.2.3 Mögliche Wettbewerbsverzerrungen

Wenn eine europäische Luftfahrtemissionsabgabesubstantielle wirtschaftliche Ungleichheiten zur Folge hat, wird die Realisierbarkeit einer solchen Abgabe schwieriger. In dieser Studie wurden somit erhebliche Anstrengungen unternommen, mögliche Wettbewerbsverzerrungen zu untersuchen. Wettbewerbsverzerrungen werden hier als Verzerrungen des Wettbewerbs zwischen europäischen und außereuropäischen Fluggesellschaften aufgrund des begrenzten geographischen Bereichs einer europäischen Luftfahrtabgabe definiert. Diese Definition impliziert, daß Änderungen in der Wettbewerbsposition von Fluggesellschaften, welche auch als Folge einer globalen Luftfahrtabgabe eintreten würden, in dieser Studie nicht als Wettbewerbsverzerrungen betrachtet wurden. Eine Änderung in der Wettbewerbsposition von relativ "sauberen" Fluggesellschaften im Vergleich zu "schmutzigen" Unternehmen wird also nicht als eine Wettbewerbsverzerrungangesehen, sondern eher als eine Effizienzverbesserung. Diesbezügliche politische Entscheidungen sollten den Gesellschaften genügend Zeit geben, sich an die geänderten Verhältnisse anzupassen.
Diese Studie konzentriert sich auf mögliche Schieflagen im Wettbewerb zwischen Fluggesellschaften untereinander, zwischen Flughäfen und zwischen Touristengebieten. Angenommen wird, daß diese wirtschaftlichen Aktivitäten am stärksten von den durch eine europäische Luftfahrtabgabe verursachten Verzerrungen betroffen seien.
Die Analyse in diesem Teil der Studie basiert hauptsächlich auf Interviews und Diskussionen mit Wirtschaftsfachleuten aus der Luftfahrt- und Touristmusindustrie. Ferner wurden auch die (spärliche) internationale Literatur zu diesem Thema sowie einige statistische Daten verwendet.

In einem ersten Schritt wird der Preisanstieg näher untersucht. Eine Besteuerung entsprechend US $ 0,10 - 0,40 pro Liter Treibstoff wird langfristig, nach umweltrelevanten Verbesserungen, zu einem Anstieg der gesamten Betriebskosten führen. Dieser Kostenanstieg läßt sich als ein Anstieg beim Flugticketpreis aUS $rücken und ist vergleichbar mit den bestehenden Flughafengebühren (siehe Tabelle 5.2).

Tabelle 5.2 Erwarteter langfristiger Preisanstieg aufgrund einer Luftfahrtemissionsabgabeentsprechend US $ 0,10 - 0,40 pro Liter Treibstoff

Preisanstieg	Flug 500 km	Flug 2 000 km
pro Flugticket (nur Hinflug)ausgedrückt als Prozentsatz der gesamten derzeitigen Flughafengebühren[a]	US $ 1.50 - 6.50 4 - 20 %	US $ 4.50 - 19.00 10 - 45%

[a] Durchschnitt der wichtigsten europäischen Flughäfen

Tabelle 5.2 zeigt, daß von einer im beabsichtigten Bereich eingeführten Abgabe bescheidene Preisanstiege zu erwarten sind. Der Preisanstieg pro Flugticket wird durch erwartete Preissenkungen mehr als ausgeglichen, die aus den laufenden Verbesserungen der Effizienz entstehen. Ferner ist der Preisanstieg als Prozentsatz der gesamten Flughafenge-bühren kleiner als die bestehenden Unterschiede zwischen einzelnen Flughäfen.

Als nächstes ist wichtig zu betonen, daß die Abgabe nicht diskriminierend ist. Sowohl europäische als auch außereuropäische Fluggesellschaften werden derselben Besteuerung für dieselben erbrachten Dienstleistungen unterworfen. Ein Unterschied liegt allerdings darin, daß einige Fluggesellschaften einen größeren Anteil ihrer Produktion in Europa als außerhalb Europas erwirtschaften. Somit ist wichtig zu wissen, ob Fluggesellschaften diesen Kostenanstieg aufgrund der Besteuerung in einen Preisanstieg umsetzen oder andernfalls zu einer Senkung ihrer Gewinnspannen gezwungen sein werden. Diese Studie hat keine überzeugenden Argumente dafür finden können, daß die Flugpreise nicht steigen werden. In einer ersten Annäherung wird somit keine Wettbewerbsverzerrung zwischen Fluggesellschaften erwartet.

Eine sekundäre Auswirkung liegt darin, daß erhöhte Flugpreise das Wachstum des europäischen Luftverkehrsmarktes etwas bremsen könnten, was in einem kleineren Heimatmarkt für europäische Fluggesellschaften im Vergleich zu außereuropäischen resultieren könnte. Diese Tatsache könnte die Wettbewerbsposition europäischer Fluggesellschaften schwächen. Es wird erwartet, daß der europäische Markt verglichen mit den gegenwärtigen Wachstumsprognosen langfristig um etwa 9 % kleiner sein wird, sobald eine Emissions- oder Treibstoffabgabe in Höhe von US $ 0,20 pro Liter eingeführt wird. Dies impliziert, daß das durchschnittliche jährliche Wachstum über einen Zeitraum von 30 Jahren von 4 % in einer Situation ohne

Besteuerung auf 3,7 % nach der schrittweisen Einführung von Abgaben sinken wird. Dieser etwas kleinere Heimatmarkt könnte zu Nachteilen im bezug auf die economies of scale von europäischen im Vergleich zu außereuropäischen Fluggesellschaften führen. Dies ist jedoch vor dem Hintergrund internationaler Entwicklungen in der Luftfahrt zu sehen.

Zunächst einmal befindet sich der europäische Luftfahrtsektor in einer Konsolidierungsphase, um economies of scale zu erzielen. Eine einzige zusätzliche Fusion im Vergleich zum Trend könnte ausreichen, die Nachteile des kleineren Heimatmarktes auszugleichen und dieselben economies of scale zu erzielen. Das muß nicht heißen, daß die Effizienz europäische Fluggesellschaften abnimmt, sondern daß die Anzahl unabhängiger Gesellschaften infolge der Einführung einer europäischen Luftfahrtabgabe zurückgehen wird.
Der zweite internationale Trend geht in Richtung globaler Allianzen. Weil alle globalen Allianzen auf dem europäischen Markt anwesend sein müssen, wird unter ihnen keine Wettbewerbsverzerrung eintreten.

Insgesamt ist es entsprechend dieser Studie unwahrscheinlich, daß infolge der Einführung einer europäischen Umweltabgabe in der beabsichtigten Größenordnung für die Luftfahrt erhebliche Wettbewerbsverzerrungen unter den Fluggesellschaften eintreten werden. Es wurden keine überzeugenden Argumente gefunden, nach denen erhebliche Wettbewerbsverzerrungen zwischen europäischen und außereuropäischen Fluggesellschaften zu erwarten sind.

Mögliche Wettbewerbsverzerrungen zwischen Flughäfen und Tourismusgebieten werden durch die Wahl der Bemessungsgrundlage beeinflußt. Eine Emissionsabgabe im europäischen Luftraum ist für solche wirtschaftlichen Verzerrungen am wenigsten anfällig und wird nicht zu erheblichen wirtschaftlichen Ungleichheiten führen. In den meisten Fällen ist der finanzielle Gewinn der Verschiebung des Abflug- oder Zielortes einer Reise auf einen außereuropäischen Flughafen auf etwa US $ 2 pro Fluggast begrenzt (bei einem Steuersatz entsprechend US $ 0,20 pro Liter). Ein solch kleiner finanzieller Vorteil reicht nicht aus, den Abflug von einem außereuropäischen Flughafen und damit eine größere Entfernung und Reisezeit zu rechtfertigen. Auf dem sehr umkämpften Tourismusmarkt in Südeuropa - "Reisen in die Sonne" - könnten kleine Preisänderungen die Wahl des Zielortes beeinflussen, beispielsweise von Griechenland und Spanien in Richtung Türkei und Tunesien. Der finanzielle Vorteil einer solchen Verschiebung beträgt jedoch im allgemeinen 0,3 - 0,6 % des Gesamtpreises einer durchschnittlichen Urlaubsreise. Somit erscheint unwahrscheinlich, daß eine Besteuerung in Höhe von US $ 0,20 pro Liter irgendwelche substanziellen Verschiebungen in Richtung außereuropäischer Touristengebiete verursachen wird. Ferner könnten im Falle erheblicher Wettbewerbsverzerrungen flankierende Maßnahmen für bestimmte Touristengebiete in Erwägung gezogen werden.

Eine Treibstoffabgabe ist etwa 2 - 6 mal empfindlicher gegen Wett-bewerbsverzerrungen zwischen Flughäfen und Tourismusgebieten als eine Emissionsabgabe (ausgehend von einer Flugdistanz von 500 bzw. 2 000 km). Auf Interkontinentalflügen ist diese Empfindlichkeit gegen mögliche wirtschaftliche Verzerrungen sogar noch größer. Bei einem 6 000-km-Flug wird der mögliche Vorteil der Verschiebung des Abflugs- oder Zielortes auf einen gerade außerhalb Europas gelegenen Flughafen auf etwa US $ 30 geschätzt. Es läßt sich schwierig voraussagen, ob ein solcher Preisvorteil das Reiseverhalten wesentlich beeinflussen wird.

Eine Treibstoffabgabe ist gegenüber solchen wirtschaftlichen Verzer-rungen empfindlicher als eine Emissionsabgabe, weil die Wahl des Abflugs- oder Zielflughafens außerhalb Europas bedeutet, daß die Zahlung der beim Tanken erhobenen Abgabe für den gesamten Flug vermieden wird. Im Falle einer Abgabe auf die Emissionen wird das Fliegen im europäischen Luft-raum immer besteuert, also unabhängig vom Abflugs- oder Zielort des Fluges.
Auf der Grundlage dieser Studie läßt sich die Machbarkeit einer Treib-stoffabgabe nicht in bezug auf mögliche wirtschaftliche Verzerrungen beurteilen.

Die möglichen Wettbewerbsverzerrungen einer auf Fluggastbewegungen beruhenden Abgabe liegen etwa in der Mitte zwischen denen einer Emissions- und Treibstoffabgabe. Das Zahlen einer Fluggastbewegungs-abgabe läßt sich nur dann vermeiden, wenn sowohl der Abflug- als auch der Zielflughafen außerhalb Europas befinden. Solches ist nur für Reisende mit einem außereuropäischen Ziel und einem Abflug nahe den europäi-schen Außengrenzen möglich, sowie für außereuropäische Reisende, die eine Ankunft in Europa vermeiden. Diese beiden Marktsegmente sind relativ klein. Überdies beträgt der finanzielle Gewinn solcher Verlagerungen nur etwa US $ 9 (bei einem Abgabensatz entsprechend US $ 0,20 pro Liter, bezogen auf eine feste Flugentfernung von 500 km).
Von einer auf Fluggastbewegungen beruhenden Abgabe werden keine unakzeptablen wirtschaftlichen Verzerrungen[98] erwartet.

---

[98] Norwegen hat eine solche Besteuerung auf nationaler Ebene und mit einem Satz von etwa USD 20 für internationale Abflüge eingeführt.

5.2.4 Probleme bei der Verteilung des Aufkommens

Die Auswahl sowohl der Bemessungsgrundlage als auch die Verwendung des Aufkommens bewirkt Verteilungseffekte. Dabei müssen zwei Fälle unterschieden werden:

a Verteilung zwischen den teilnehmenden Ländern und
b Verteilung zwischen der Luftfahrtindustrie und dem öffentlichen Sektor, oder dem Steuerzahler.

Eine Option besteht darin, die Einkünfte direkt an die Teilnehmerländer auszuschütten. In diesem Fall bestimmt die Wahl der Bemessungsgrundlage gleichzeitig die internationale Aufteilung. Eine Emissionsabgabe ist attraktiv für Länder mit intensiv beflogenen Routen durch ihren Luftraum. Länder mit großen Betankungsvolumina werden eine Treibstoffabgabe favorisieren. Länder mit Flughäfen, die Fluggäste aus Nachbarländern anziehen, können von einer Abgabe auf Fluggastbewegungen profitieren.
Die (politische) Frage lautet: Was ist als gerecht zu betrachten?

Eine zweite Option besteht darin, Einkünfte auf europäischer Ebene zu verteilen. In diesem Fall erscheint als annehmbarste Lösung, die Einkünfte an die Teilnehmerländer auf dem Wege eines Verteilungsschlüssels umzuverteilen. Ein solcher Verteilungsschlüssel kann mit dem internationalen Übereinkommen vereinbart werden, das die Einführung dieser Besteuerung regelt. Es ist offenkundig, daß der Verteilerschlüssel gegensätzlichen finanziellen Interessen ausgesetzt ist.

In einer dritten Option können die Einkünfte an die Fluggesellschaften, die die Abgabe zu zahlen haben, zugewiesen werden (aufkommensneutrale Emissionsabgabe). In dieser Variante entrichten die Fluggesellschaften eine Abgabe über alle Emissionen im europäischen Luftraum, und die Einkünfte werden an dieselben Gesellschaften nach Maßgabe ihrer Verkehrsleistung in Personen- und Tonnenkilometern im europä-ischen Luftraum[99] voll zurückerstattet. Dadurch entsteht ein Anreiz für alle Fluggesellschaften, die verkehrsleistungsspezifischen Emissionen zu verbessern und gleichzeitig eine Verschiebung zu relativ "sauberen" Fluggesellschaften zu bewirken.Diese Option hat den Vorteil, den Fluggesellschaften insgesamt keine zusätzlichen finanziellen Lasten aufzubürden, auch besteht keinerlei Notwendigkeit für die Regelung der Zuteilung und Verwendung des Aufkommens. In diesem Fall ist jedoch die Verteilungsfrage die, ob es nicht gerechter wäre, wenn die Fluggesellschaften für die von ihnen verursachten Umweltschäden aufkämen und, wie dies im Straßenverkehr üblich ist, ebenfalls Kraftstoffsteuern zahlten.

---

[99] Differenzierte Landegebühren, die sich auf die Luftverschmutzung pro Motor-Flugzeug-Kombination beziehen - wie dies am Flughafen Zürich eingeführt wurde -, läßt sich als aufkommensneutrale Abgabe über LTO-Emissionen betrachten.

Die möglichen Probleme mit der Verwendung des Aufkommenswerden in diesem Bericht nur angeschnitten. Es erfolgt keine Beurteilung dessen, was eine gerechte internationale Verteilung des Aufkommens wäre oder was ein gerechtes Besteuerungs- und Abgabensystem - beispielsweise im Vergleich zu anderen Transportmodalitäten - für die Luftfahrt implizieren würde. Bezüglich der Realisierbarkeit einer europäischen Luftfahrtabgabe kann generell festgestellt werden, daß sich Verteilungsfragen lösen lassen, sofern unter den teilnehmenden europäischen Ländern der politische Wille vorhanden ist.

5.2.5 Juristische Fragen

Weder bezüglich einer Abgabe auf Emissions- noch auf Fluggastbewegungsbasis bestehen ernsthafte juristische Bedenken, beispielsweise im Zusammenhang mit dem Chicagoer Abkommen oder anderen internationalen Übereinkommen. Eine offene Frage bleibt, ob eine Abgabe im europäischen Luftraum auf das nationale Hoheitsgebiet einschließlich der 12-Meilen-Zone beschränkt werden sollte, oder ob auch der Luftraum über großen Meeren und einem Teil des Ozeans in die Abgabe eingebunden werden sollte. Die letztgenannte Option ist vorzuziehen, um möglichen Routenänderungen zur Vermeidung einer Emissionsabgabe vorzubeugen.

Im Falle einer Treibstoffabgabe wird erwartet, daß zahlreiche bilaterale Luftfahrtabkommen (ASAs) einer Anpassung bedürfen. Dies wird kein (politisches) Problem für ASAs zwischen den teilnehmenden europä-ischen Ländern sein. Eine Anpassung von ASAs zwischen einem teil-nehmenden Land und einem außereuropäischen Land kann jedoch zu mehr Schwierigkeiten führen, weil nicht-teilnehmende Länder de facto die verlangten Änderungen blockieren oder einen Preis für die Gestattung einer Treibstoffabgabe verlangen könnten. Aus diesem Grund weisen Emissions- und Fluggastbewegungsabgaben Vorteile gegenüber einer Treibstoffabgabe auf.

Eine auf innereuropäische Flüge begrenzte Treibstoffabgabe dürfte demgegenüber geringere juristische Probleme aufwerfen. Die umweltmäßige Wirksamkeit wird jedoch um etwa ein Viertel reduziert, und der Verkauf von mit einer Abgabe beraufschlagten neben abgabenfreiem Treibstoff auf europäischen Flughäfen könnte Betrügereien zur Folge haben. Überdies bewirkt eine solche begrenzte Treibstoffabgabe wahrscheinlich unterschiedliche und möglicherweise größere wirtschaftliche Verzerrungen als eine Abgabe von Betankungen für alle Abflüge von europäischen Flughäfen.

5.3 Schlußfolgerungen und Empfehlungen

Dieses Projekt läßt sich als eine erste Machbarkeitsstudie charakterisieren, wobei alle wichtigen Optionen für eine europäische Luftfahrtabgabe in

Erwägung gezogen wurden. Die verschiedenen Abgabenoptionen können bezüglich der umweltmäßigen Wirksamkeit und der erwarteten Machbarkeit stark differieren.
Diese Studie hofft, den Spielraum für zukünftige politische Entwick-lungen einzuengen. Aufgrund des noch allgemein angelegten Charakters der Studie sind zusätzliche und eingehendere Forschungen zu spezifischen Fragen erforderlich.
Die folgenden Schlußfolgerungen und Empfehlungen benennen sowohl die vielversprechendsten Abgabenoptionen als auch die noch offenen Fragen.

Schlußfolgerungen

1 Die Ausgestaltung einer europäischen Luftfahrtabgabe hat einen wesentlichen oder sogar entscheidenden Einfluß auf die umweltmäßige Wirksamkeit und die Realisierbarkeit. Maßgebliche Entscheidungen müssen hinsichtlich der Bemessungsgrundlage, dem Abgabensatz und der Verwendung des Aufkommens getroffen werden.

2 Diese Studie zeigt eine positive Perspektive bezüglich der Implementierung einer europäischen Luftfahrtabgabe auf, die sowohl umweltmäßig wirksam als auch realistisch ist. Ein Steuersatz, der etwa US $ 0,20 pro Liter Treibstoff entspricht wird vermutlich die erwarteten Zunahmen bei den Emissionen aus der Zivilluftfahrt in Europa halbieren. Die Einführung einer Luftfahrtabgabe bietet Möglichkeiten zur Verbesserung der allgemeinen Wirtschaftlichkeit.

3 Eine auf den berechneten Emissionen beruhende Abgabe erscheint als die attraktivste und wahrscheinlich auch am leichtesten realisierbare Option. Die möglichen Wettbewerbsverzerrungen[100] sind geringer als jene, die mit anderen Bemessungsgrundlagen einhergehen. Eine Emissionsabgabe im europäischen Luftraum wird sich kaum merkbar auf den Wettbewerb zwischen europäischen und außereuropäischen Fluggesellschaften auswirken. Im Durchschnitt ist der finanzielle Vorteil der Verlagerung des Abflug- oder Zielortes auf einen außereuropäischen Flughafen auf etwa US $ 2 pro Flugticket begrenzt. Eine Beeinflussung des Reiseverhaltens wird hiervon nicht erwartet. Erforderlichenfalls ließen sich kompensierende Maßnahmen für südeuropäische Tourismusgebiete in Erwägung ziehen. Überdies steht eine Emissionsabgabe nicht im Widerspruch mit dem Chicagoer Abkommen und auch nicht mit bilateralen Luftfahrtabkommen. Es ist vorläufig jedoch noch unklar, ob der angenommene Umfang des europäischen Luftraums mit der internationalern Gesetzgebung im Einklang steht.

---

[100] Wettbewerbsverzerrungen werden in dieser Studie als Verzerrungen des Wettbewerbs zwischen europäischen und außereuropäischen Gesellschaften definiert, welche sich aus dem begrenzten geographischen Bereich einer europäischen Luftfahrtabgabe ergeben. Diese Definition beinhaltet, daß Änderungen in der Wettbewerbsposition von Fluggesellschaften, welche auch infolge einer globalen Luftfahrtabgabe entstehen würden, in dieser Studie nicht als Wettbewerbsverzerrungbetrachtet werden.

4 Ein Treibstoffabgaben-Paket[101] ist weniger attraktiv als eine Emissionsabgabe. Treibstoffabgaben sind viel empfindlicher gegen wirtschaftliche Verzerrungen als Emissionsabgaben. Auf einem Interkontinentalflug von 6 000 km läßt sich beispielsweise durchschnittlich ein finanzieller Vorteil von US $ 30 pro Fluggast durch die Verlagerung des Abflughafens nach gerade außerhalb Europas erzielen. Ferner ist eine Treibstoffabgabe mit juristischen Hindernissen verbunden, was bei einer Emissionsabgabe wahrscheinlich nicht der Fall ist. Der einzige Vorteil einer Treibstoff- gegenüber einer Emissionsabgabe ist die einfachere Implementierung, weil eine Emissionsabgabe die Einrichtung einer international akzeptierten Methodik zur Berechnung der Emissionen erfordert, die zur Zeit für den Reiseflug noch nicht verfügbar ist. Dieser Nachteil ist jedoch nicht ausschlaggebend, weil sich eine solche Berechnungsmethode relativ schnell entwickeln läßt und die entsprechende Arbeiten bereits anlaufen.

Eine auf EEA-interne Flüge begrenzte Treibstoffabgabe kann weniger juristische Hindernisse aufwerfen als eine Treibstoffabgaben auf alle aus Europa startenden Flüge. Die Konsequenz ist jedoch, daß die Umweltwirksamkeit dieser begrenzten Treibstoffabgabe um etwa ein Viertel niedriger liegt. Überdies könnte die Wettbewerbsverzerrunggrößer sein, was jedoch noch nicht geklärt ist.

5 Die Umweltwirksamkeit einer Abgabe auf Fluggastbewegungen (oder Flugtickets) beträgt etwa ein Drittel der anderen beiden Bemessungsgrundlagen. Überdies bietet eine Fluggastbewegungsabgabe keine wesentlichen Vorteile gegenüber einer Emissionsabgabe. Aus Umweltgründen ist somit eine Emissions- oder eine Treibstoffabgabe einer Fluggastbewegungsabgabe vorzuziehen.
Eine Fluggastbewegungsabgabe könnte jedoch aus Gründen der gerechten Besteuerung unterschiedlicher wirtschaftlicher Aktivitäten in Erwägung gezogen werden. Eine Option könnte darin liegen, beispielsweise eine Flugticketabgabe einzuführen, wenn es sich als unmöglich erweist, die Mehrwertsteuer für internationale Verkehrsdienstleistungen einzuführen.
Die Einführung einer Flugticketabgabe in Europa ist machbar (und wurde in Norwegen bereits auf nationaler Ebene implementiert).

6 Eine LTO-Emissionsabgabe ist machbar. Die Abgabe pro Flugzeug wäre geringer als derzeitige Unterschiede bei der Gesamtheit der Flughafengebühren zwischen den einzelnen Flughäfen. Die Umweltwirksamkeit einer LTO-Emissionsabgabe beträgt allerdings nur etwa ein Viertel im Vergleich einer Emissions- oder Treibstoffabgabe, weil nur die LTO-Phasen eines Fluges betroffen sind.

7 Eine aufkommensneutrale Emissionsabgabe ist höchstwahrscheinlich machbar. Die möglichen Wettbewerbsverzerrungen sind wahrscheinlich

---

[101] Einschließlich, zusätzlich zur Treibstoffabgabe, eine LTO-Emissionsabgabe sowie Standards für NO_x-Emissionen.

vernachlässigbar. Andererseits ist die Umweltwirksamkeit relativ hoch. Eine aufkommensneutrale Emissionsabgabe in Höhe von US $ 0,20 pro Liter wird die Luftverschmutzung zwischen 1992 und 2025 im Vergleich zu den derzeitigen Wachstumsprognosen um etwa 25 % reduzieren, während sie durch nicht-aufkommensneutrale Emissionsabgabe um 30 % zurückgehen. Eine aufkommensneutrale Abgabe wirkt sich kaum auf das Volumenwachstum aus, dies im Gegensatz zu einer Emissionsabgabe.

Ein ausschlaggebender Unterschied im Vergleich zur nicht-aufkommensneutralen Emissionsabgabe sind die Verteilungseffekte. Im Falle einer aufkommensneutralen Abgabe trägt die Luftfahrt nicht zu den öffentlichen Finanzen bei, um für die verursachten Umweltschäden aufzukommen (Verursacherprinzip) oder wirkt nicht wie die allgemeine, im Straßenverkehr übliche Treibstoffsteuer. Die Frage, was eine gerechte Behandlung der Luftfahrt im Vergleich zu anderen Transportträgern ist, sprengt den Rahmen dieser Studie.

Um die Verteilungseffekte zu mildern, läßt sich die aufkommensneutrale Emissionsabgabe mit anderen Abgabenoptionen kombinieren. Eine Kombination wäre eine nationale Abgabe auf LTO-Emissionen mit einer aufkommensneutralen Besteuerung von Emissionen während des Reiseflugs (ohne LTO). Eine zweite Kombination wäre eine aufkommensneutrale Emissionsabgabe in Verbindung mit einer Fluggastbewegungsabgabe. Die Fluggastbewegungsabgabe generiert nicht nur öffentliche Finanzmittel, sondern schafft auch einen Anreiz zur Reduzierung des Volumenwachstums, das von einer aufkommensneutralen Besteuerung unbeeinflußt bleibt.

Empfehlungen

1 Eine detaillierte Studie sollte bezüglich der Gestaltung und der Konsequenzen einer europäischen Emissionsabgabe durchgeführt werden. Diese Studie sollte sich auf folgende Hauptpunkte richten:
  - Entwicklung eines international akzeptierten Verfahrens zur Berechnung von Emissionen während eines beliebigen (standard-isierten) Fluges im europäischen Luftraum;
  - Definition der Grenzen des europäischen Luftraums, innerhalb dessen die Abgabe anzuwenden ist, unter Berücksichtigung internationaler Gesetzgebung und unter Minimalisierung von Möglichkeiten, den europäischen Luftraum zu vermeiden;
  - ausführliche Studie zu den praktischen Möglichkeiten, den europäischen Luftraum zu vermeiden und die Suche nach möglichen mildernden Maßnahmen;
  - Entwicklung von Schemata für die internationale Verteilung des Aufkommens aus den Abgaben (Zuteilungsregeln);
  - detaillierte Studie der erforderlichen juristischen Maßnahmen;
  - Untersuchung von Möglichkeiten und Verfahren für eine allmähliche Erweiterung der Anzahl der Teilnehmerländer;
  - Entwicklung eines Verwaltungssystems zur Berechnung der Emissionen und die Erhebung der damit einhergehenden Abgaben.

2 Es sollte erwogen werden ein detailliertes Treibstoffabgaben-Paket, parallel zur Emissionsabgabe (Empfehlung 1), zu entwickeln. Dieses könnte eine Alternative für den Fall unerwarteter Schwierigkeiten bei der Einführung einer Emissionsabgabe sein. Folgende Punkte sollten bei der weiteren Entwicklung des Treibstoffabgaben-Pakets verfolgt werden:
- Bewertung der beiden Varianten eines Treibstoffabgaben-Pakets: eine Treibstoffabgabe für alle Betankungen auf europäischen flughäfen oder eine begrenzte Treibstoffabgabe nur von Betankungen mit EEA-interne Flügen;
- ausführliche Studie bezüglich der erforderlichen juristischen Maßnahmen, einschließlich Änderungen in bilateralen Luftfahrtabkommen;
- ausführliche Untersuchung potentieller Wettbewerbsverzerrungen und Suche nach möglichen mildernden Maßnahmen.

3 Die Einführung einer Emissionsabgabe - oder des Treibstoffabgaben-Paket - wird einige Zeit in Anspruch nehmen; es wird also empfohlen, mit der Einführung einer LTO-Emissionsabgabe zu beginnen, wenn kurzfristig Lenkungsmaßnahmen erwünscht sind. Die LTO-Emissionsabgabe läßt sich als erster Schritt in Richtung einer Emissionsabgabe im gesamten europäischen Luftraum betrachten.

4 Um die öffentliche und politische Akzeptanz von Umweltabgaben in der Luftfahrt zu verbessern, wird empfohlen, sie im Rahmen einer Steuerreform einzuführen und nicht als ein Mittel zur Erhöhung der Steuereinkünfte. Dies bedeutet, daß die Gestaltung des Pakets für den Staatshaushalt aufkommensneutral ist. Dadurch wird jeder Schein vermieden, daß ein verstecktes Ziel solcher Umweltabgaben die Generierung von öffentlichen Mitteln ist.

5 Obwohl eine Fluggastbewegungs- oder Flugticketabgabe eine recht begrenzte Auswirkung auf die Umwelt hat, kann die Einführung einer solchen Abgabe aus Gleichheitsgründen oder vor dem Hintergrund einer gerechten Besteuerung erwogen werden. Sie könnte beispielsweise als Alternative zur Einführung der Mehrwertsteuer auf internationale Reisen erwogen werden, was offensichtlich durch praktische Hindernisse und/oder mögliche Wettbewerbsverzerrungen behindert wird.
Eine Besteuerung von Flugtickets läßt sich kurzfristig einführen.

6 Wenn die politische Akzeptanz einer aufkommensneutralen Emissionsabgabe größer als die einer nicht-aufkommensneutralen Emissionsabgabe sein sollte, ist eine ausführliche Studie zur Gestaltung und bezüglich der Konsequenzen einer aufkommensneutralen Emissionsabgabe erforderlich. Besondere Aufmerksamkeit ist auf die Erfassung von Personen- und Tonnenkilometern zu richten, die innerhalb des europäischen Luftraums produziert werden (siehe auch Empfehlung 1). Überdies müssen auch die Konsequenzen für die Verteilung entsprechende Aufmerksamkeit finden (siehe Schlußfolgerung 7).

7 Auf europäischer Ebene ist der zentrale Gedanke einer gerechten, ausgewogenen und transparenten Politik in bezug auf alle (innereuropäischen) Transportträger zu entwickeln. Eine solche konsistente intermodale Politik fördert die Akzeptanz der erforderlichen Lenkungsmaßnahmen.
Hier geht es um folgende wichtige Fragen:
- Preisgestaltung der Infrastruktur;
- Internalisierung externer Kosten;
- nicht-diskriminierendes und transparentes Auflagen seitens der Behörden;
- Interpretation spezieller Steuern, beispielsweise auf Treibstoff, Zulassung und Verkäufe;
- Einführung der Mehrwertsteuer oder ähnlicher Steuern auf EU-interne Beförderung.

8 Die Zielrichtung nationaler, kurzfristig zu ergreifender Lenkungsmaßnahmen ist zu festzulegen, und zwar als erste Schritte in Richtung einer Einführung einer europäischen Luftfahrtabgabe. Möglichkeiten hierzu sind:
- Einführung einer nationalen Abgabe auf LTO-Emissionen;
- Einführung einer nationalen Fluggastbewegungsabgabe;
- eine Emissionsabgabe auf Inlandsflüge, anwendbar auf alle Fluggesellschaften.

6 Résumé, conclusions and recommandations

6.1 Etude de faisabilité

Contexte et objectif

On prévoit que la pollution de l'air due à l'aviation civile va tripler au cours de la période 1990-2015. La croissance estimée du transport de passagers et de fret est notablement plus forte que les améliorations environnementales escomptées sur les moteurs, la conception des avions et les opérations. Bien qu'à l'heure actuelle les émissions de CO_2 et de NO_x en provenance de l'aviation civile ne comptent que pour 2 à 3% des émissions mondiales, cette proportion est destinée à augmenter dans les années qui viennent. Dans ce contexte, plusieurs initiatives ont été prises ou sont à l'étude quant à une politique visant à réduire la croissance de la pollution de l'air due à l'aviation civile.

L'une des options envisagées est celle d'une taxe sur le carburant ou d'une écotaxe sur l'aviation. Les avantages sur l'environnement seront d'autant plus grands si de telles taxes sont introduites à l'échelle du globe. En même temps, une taxe mondiale évite les distorsions économiques potentielles que pourrait entraîner l'introduction d'une taxe dans une zone géographique limitée, par exemple l'Europe. Bien que les avantages d'une taxe mondiale soient évidents, on s'attend à ce que le processus décisionnel soit lent, et doive nécessiter l'impulsion d'initiatives régionales. C'est pourquoi cette étude a examiné la faisabilité d'une taxe européenne[102] visant à réduire la pollution provoquée par l'aviation civile. Les questions principales auxquelles cette étude tente de répondre sont : l'introduction d'une écotaxe sur l'aviation pour la seule Europe est-elle faisable? Et : Quels sont les principaux avantages et inconvénients de différentes options pour une taxe?

Organisation du projet

Ces recherches ont été financées conjointement par la Commission Européenne et par cinq Etats : Allemagne, Autriche, Danemark, Norvège et Pays-Bas. Des représentants de ces autorités ont participé au Comité de Projet qui a guidé cette étude.

La Société Néerlandaise pour la Nature et l'Environnement (SNM) a initié cette étude et passé contrat avec le Centre pour Economies d'Energie (CE) de Delft, Pays-Bas, en tant que principal consultant. Des contributions spécifiques ont été apportées par l'Institut International de Législa-tion Aérienne et Spatiale de Leiden, Pays-Bas, par Economics-Plus de Londres

---

[102] Les 15 Etats Membres de l'UE et l'Islande, la Norvège et la Suisse. On s'y réfèrera par les termes Europe ou EEA (European Economic Area).

et par l'Institut de Recherche Néerlandais pour la Récréation et le Tourisme de Bréda.

L'étude a été structurée comme suit. Dans un premier temps, trois études de base ont été menées sur les sujets suivants:
- efficacité d'écotaxes pour réduire la pollution de l'air par l'aviation[103];
- distorsion économique potentielle d'une écotaxe européenne sur l'aviation[104] ;
- problèmes juridiques, entre autres liés à la Convention de Chicago et aux Accords Bilatéraux sur le Service Aérien[105].

Sur la base de ces sources d'information et d'autres sources, le concept d'une taxe européenne sur l'aviation est discuté (Chapitre 2). Les choix quant à la forme à donner à cette taxe auront une grande influence dans la détermination de l'avantage environnemental et de la faisabilité, en termes de distorsions économiques et de complications juridiques.
Dans un second temps, la faisabilité de cinq options de taxes spécifiques a été étudiée (Chapitre 3). Ces cinq options ont été sélectionnées pour représenter la gamme complète des possibilités et illustrent chaque fois la variante la plus intéressante.
Enfin, des conclusions et recommandations sont formulées pour l'ensemble de l'étude (Section 6.3).

Principaux critères
L'attrait d'une écotaxe européenne sur l'aviation est déterminé à la fois par son efficacité sur l'environnement, ce qui est l'objectif des taxes considérées dans cette étude, et par sa faisabilité ou ses effets secondaires négatifs possibles. La faisabilité est a son tour influencée par plusieurs facteurs différents, dont les plus importants sont : les distorsions économiques, les complications de répartition et les conflits avec la législation existante. Les principaux résultats de cette étude seront structurés autour de ces quatre thèmes :
- Efficacité sur l'environnement (Section 6.2.2);
- Distorsions économiques potentielles (Section 6.2.3);
- Complications de répartition (Section 6.2.4);
- Problèmes juridiques (Section 6.2.5).

Avant d'aborder la discussion de ces questions, il faut souligner que la forme arrêtée pour une écotaxe européenne sur l'aviation présente un impact majeur à la fois sur son efficacité sur l'environnement et sur sa

---

103 Résumée en Annex B de ce rapport et publiée séparément sous le titre *European aviation emissions: trends and attainable reduction* (Dings et al., 1997).

104 Résumée en Annexe C de ce rapport et publiée séparément sous le titre *Potential economic distortions of a European environmental aviation charge* (Wit and Bleijenberg, 1997).

105 Annexe D de ce rapport et publié auparavant dans le Rapport Préliminaire de cette étude (Bleijenberg et al., 1996).

faisabilité. Aussi présentera-t-on d'abord des considérations liées à la conception d'une telle taxe, dans la Section 6.2.1.

6.2 Principaux résultats

6.2.1 Conception de la taxe

En ce qui concerne la forme à donner à une taxe sur l'aviation visant à réduire la pollution de l'air, on peut distinguer trois choix importants. D'abord, la base de la taxe doit être définie. Cette étude se concentre sur trois bases possibles pour cette taxe :
- taxe sur les émissions calculées pour un vol dans l'espace aérien européen;
- taxe sur le carburant mis en soute sur des aéroports européens;
- taxe sur les passagers et le fret partant d'aéroports européens (taxe sur le déplacement ou le billet).

Le second choix concerne le niveau de la taxe. Différents arguments pour un certain niveau sont discutés, mais le choix final est de nature politique. Parvenir à une stabilisation des émissions de CO_2 dues à l'aviation européenne pourrait requérir une taxe de l'ordre de 0,80 à 1,30 $/l de carburant[106]. En outre, on prévoit que la prise en compte des frais externes entraînera une hausse du prix de carburant d'en gros 0,14 à 0,20 $/l. En fin de compte, taxer le carburant pour avions selon le niveau minimum convenu pour le diesel routier dans l'UE correspond à 0,29 $/l de kérosène. Cette étude envisage des niveaux de taxe allant de 0,10 à 0,40 US$ par litre de carburant, pour des prix actuels de carburant de l'ordre de 0,16 $/l. L'augmentation du prix initial du billet est en gros de 2 à 9 US$ pour des vols courts (500 km aller) et de 6 à 25 $ pour de longs trajet en Europe (2000 km, aller). Le Tableau 4.2 présente une estimation des modifications de prix résultantes après réalisation de l'amélioration d'efficacité induite par la mesure.
Le troisième choix concernant la conception d'une taxe sur l'aviation est lié à l'allocation des revenus de cette taxe. Trois options principales sont examinées :
- allocation au niveau national (Etats);
- au niveau européen;
- aux compagnies aériennes payant la taxe (taxe à revenu-neutre).

Il est évident que tout choix concernant l'allocation des revenus a des conséquences majeures sur leur répartition. Ils sont estimés au total à 5 à 6 milliards de US$, pour un niveau de taxe équivalent à 0,20 US$/l.

Avec les connaissances acquises dans les études de base, cinq options d'écotaxe ont été sélectionnées pour des analyses plus poussées (Chapitre

---

[106] Hypothèse d'une tendance de croissance annuelle des émissions de CO_2 de 3% et d'une flexibilité du prix de carburant de -0.4 à -0.5.

3). Le Tableau 6.1 résume ces cinq options qui couvrent la gamme complète des possibilités, chacune dans la variante la plus intéressante.

Tabl. 6.1 Cinq options de taxe

Option	Base de la taxe	Niveau de taxe[a]	Allocation des revenus
1 Taxe sur émissions	Emissions calculées	0.03-0.12 \$/kg CO_2 3.10-12.40 \$/kg NO_x (bas) 2.60-10.40 \$/kg NO_x (haut) 2.40-9.80 \$/kg SO_2 3.10-12.40 \$/kg VOC	Au niveau Européen. Redistribués aux Etats via réglementation d'allocation.
2 Taxe sur émissions à revenu-neutre	Emissions calculées	Voir option 1	Aux companies aériennes. Au prorata de leur "production" dans l'espace aérien EEA.
3 Taxe sur émissions LTO*	Emissions calculées durant LTO*	Voir option 1	Aux Etats
4 Taxe combinée sur carburant[b]	Citernes de carburant	0.10-0.40 \$/l	Aux Etats
5 Taxe sur ticket	Déplacements	2.00-9.00 \$/passager pour départs EEA 4.00-18.00 \$/passager pour départs non-EEA	Aux Etats

*Landing/Take Off(atterrissage/décollage)

[a] Hypothèse de travail équivalente à 0,10-0,40 US\$ par l. de carburant.

[b] Taxe combinée comprenant, outre la taxe sur le carburant, une taxe sur émissions LTO et sur standards d'émissions. Ces instruments additionnels sont nécessaires pour éviter l'obtention d'une efficacité accrue du carburant au prix d'émissions plus fortes de NO_x and COV.

6.2.2 Efficacité sur l'environnement

Nous estimons que la taxe sur les émissions et la taxe combinée sur le carburant seront efficaces pour réduire la pollution de l'air due au trafic aérien (options de taxe 1 et 4). Sur la base de recherches disponibles, on estime qu'une augmentation graduelle du prix du carburant de 0.20 \$/l, ou une taxe équivalente sur les émissions, réduira la pollution de l'air d'environ 30% à long terme, par rapport aux émissions selon les tendances actuelles de croissance jusqu'à 2025. Une telle taxe pourrait en gros diminuer de moitié l'augmentation prévue pour les émissions. L'impact environnemental positif de ces deux taxes est élevé, parce que ces deux types de taxe sont des stimulants pour la plupart des formules d'améliorations environnementales. On pense ici à la technologie des avions, la conception optimisée des appareils, la dimension des appareils, le facteur de charge et la croissance en volume. Des améliorations relativement modestes dans chaque maillon de la chaîne se traduisent ensemble par une réduction substantielle de la pollution de l'air (par rapport aux tendances actuelles).

L'efficacité sur l'environnement de la taxe de revenu-neutre sur les émissions (option 2) est un peu plus faible, parce que cette option réduit à peine la croissance en volume, au contraire des taxes sur les émissions et le carburant. On estime que cette option réduira les émissions d'environ 25% par rapport à la croissance actuelle (niveau de taxe équivalent à 0,20 $/l).
La taxe sur les émissions LTO (option 3) ne porte que sur environ le quart de la pollution totale due à l'aviation dans l'espace aérien européen, et son efficacité environnementale est donc en proportion plus faible que celle d'une taxe sur les émissions en général.

La taxe sur le déplacement ou le ticket est d'une efficacité relativement faible : en gros le tiers de celle d'une taxe sur les émissions ou le carburant. Ceci parce qu'une taxe basée sur le déplacement stimule seulement une réduction de la croissance en volume, sans inciter à augmenter l'efficacité environnementale de l'aviation civile, alors que c'est là qu'on prévoit les profits les plus importants.

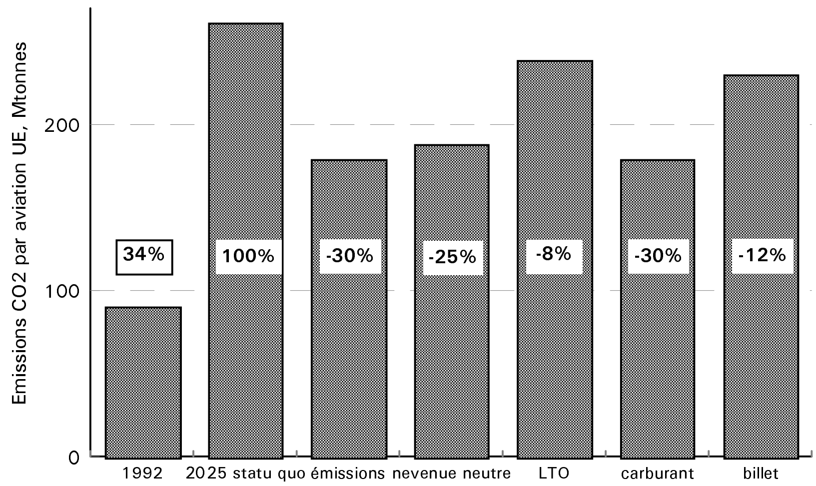


Figure 6.1 La Figure 6.1 donne un aperçu des réductions estimées pour les émissions de CO_2 entre 1992 et 2025 selon les cinq options de taxe (équivalentes à 0,20 $/litre de carburant), par rapport à une situation inchangée

6.2.3 Distorsions économiques potentielles

Si une écotaxe européenne sur le trafic aérien entraîne des distorsions économiques importantes, sa faisabilité sera réduite. Cette étude a par conséquent consacré des efforts considérables à l'investigation de distorsions économiques potentielles. Par distorsions économiques, on entend

des distorsions touchant la concurrence entre compagnies européennes et non-européennes résultant de l'échelle géographique limitée d'une taxe européenne sur l'aviation. Cette définition implique que, dans cette étude, on ne considérera pas comme distorsions économiques des modifications dans la position concurrentielle des compagnies résultant d'une taxe *mondiale* sur l'aviation. Un changement dans la position concurrentielle de compagnies aériennes relativement propres par rapport à de gros pollueurs n'est pas considéré par conséquent comme une distorsion économique, mais plutôt comme une amélioration de l'efficacité. Des modifications dans les politiques devraient laisser aux compagnies le temps nécessaire pour s'adapter aux nouvelles circonstances.
Cette étude se focalise sur des distorsions potentielles dans la concurrence entre compagnies aériennes, aéroports et zones touristiques. On présume que ces activités économiques sont les plus vulnérables aux distorsions causées par une taxe européenne sur l'aviation.
L'analyse dans cette partie de l'étude se fonde surtout sur des interviews et des discussions avec des experts économiques de l'aviation et des industries touristiques. De plus, le peu de littérature internationale sur ce sujet ainsi que quelques données statistiques ont également été utilisées.

Dans un premier temps, la hausse de prix est examinée plus attentivement. Une taxe correspondant à 0,10 à 0,40 US$ par litre de carburant entraînera à la longue, après des améliorations touchant l'environnement, une hausse du coût opérationnel total. Cette hausse de coût peut s'exprimer comme une hausse du prix du billet et peut se comparer avec les taxes d'aéroport existantes (voir Tableau 6.2).

Tabl. 6.2 Estimation de la hausse du prix à long terme, due à une écotaxe sur l'aviation équivalente à 0,10-0,40 US$ par litre de carburant

Hausse de prix	Vol 500 km	Vol 2000 km
Par ticket (aller)	1.50 - 6.50 $	4.50 - 19.00 $
Exprimée en pourcentage des taxes totales actuelles d'aéroport[a]	4 - 20 %	10-45%

[a] Grands ou moyens aéroports européens.

Le Tableau 6.2 indique qu'on peut prévoir qu'une taxe de l'ordre considéré aura pour résultat des hausses de prix modiques. La hausse de prix par ticket sera plus que compensée par les économies de prix qu'on prévoit par suite des constantes améliorations de l'efficacité de marché. En outre, la hausse du prix en tant que pourcentage de la totalité des taxes d'aéroport est inférieure aux différences existant entre aéroports.

Ensuite, il est important de souligner que la taxe est non-discriminatoire. Les transporteurs européens et non-européens sont confrontés à la même taxe pour le même service fourni. Une différence est cependant que la part de production réalisée en Europe est pour certaines compagnies aériennes plus grande que pour d'autres. Aussi est-il important de savoir si les transporteurs répercuteront sur leurs prix la hausse du coût due à la taxe ou si, au contraire, ils se verront contraints de réduire leur marge de profit. Cette étude n'a identifié aucun argument convaincant contre une hausse des tarifs. Par conséquent, en première approximation, on ne prévoit pas de distorsion dans la concurrence des compagnies aériennes.

Un effet d'ordre secondaire est que des tarifs plus élevés de transport aérien peuvent ralentir quelque peu la croissance du marché du transport aérien européen, avec pour résultat un marché interne plus petit pour les transporteurs européens par rapport aux transporteurs non-européens. Ceci pourrait affaiblir la position concurrentielle des compagnies aériennes européennes. On estime que le marché européen sera à long terme environ 9% moins important, par rapport à la tendance de croissance actuelle, après introduction d'une taxe sur les émissions ou sur le carburant équivalente à 0,20 US$ par litre. Ceci implique que la croissance annuelle moyenne passera de 4% sans taxe à 3,7% sur une période de 30 ans, par suite de l'introduction par étapes d'une telle taxe sur l'aviation. Ce marché interne quelque peu réduit pourrait conduire à des économies d'échelle réduites pour les compagnies aériennes européennes, en comparaison avec les non-européennes. Ceci doit cependant être considéré sous l'angle des développements internationaux de l'aviation.
Premièrement, le secteur de l'aviation européenne se trouve dans un processus de consolidation, pour réaliser des économies d'échelle. Une fusion supplémentaire par rapport au statu quo pourrait être suffisante pour contrebalancer la réduction du marché intérieur et obtenir la même efficacité d'échelle. Ceci ne veut pas dire que l'efficacité des transporteurs européens sera réduite, mais que le nombre de transporteurs européens sera moindre par suite de l'introduction d'une taxe européenne sur l'aviation.
Une seconde tendance internationale se dessine, celle d'alliances à l'échelle du globe. Etant donné que toutes ces alliances doivent être présentes sur le marché européen, aucune distorsion concurrentielle ne devrait naître entre elles de ce fait.

Selon cette étude, il est improbable que des distorsions économiques significatives entre compagnies aériennes apparaissent par suite d'une écotaxe européenne sur l'aviation de l'ordre de grandeur considéré. Aucun argument convaincant n'a été avancé incitant à prévoir des distorsions concurrentielles significatives entre transporteurs européens et non-européens.

Des distorsions économiques possibles entre aéroports et zones touristiques sont influencées par la base choisie pour la taxe. Une taxe sur les émissions dans l'espace aérien européen est moins sensible à ces distorsions économiques et n'entraînera pas de distorsions économiques significatives. Dans la plupart des cas, le gain financier obtenu en déplaçant le point de départ ou d'arrivée d'un vol vers un aéroport hors d'Europe est limité en moyenne à environ 2 US$ par passager (niveau de taxe équivalent à 0,20 $/l). Un gain financier aussi faible est insuffisant pour justifier un départ à partir d'un aéroport hors d'Europe, c'est-à-dire une plus longue distance et un temps plus long. Sur le marché touristique fortement concurrentiel du Sud de l'Europe - "voyages soleil" - de petites modifications de prix pourraient influencer le choix de la destination, par exemple Turquie ou Tunisie au lieu de Grèce ou Espagne. Toutefois, le gain financier de ce choix est, en général, de 0,3 à 0,6% du prix moyen total du forfait vacances. Il semble par conséquent improbable qu'un niveau de taxe équivalent à 0,20 $/l entraîne un déplacement important vers des zones touristiques hors d'Europe. De plus, on pourrait envisager l'application de mesures compensatoires pour certaines zones touristiques dans le cas de distorsions significatives.

Une taxe sur le carburant est en gros 2 à 6 fois plus sensible aux distorsions économiques entre aéroports et zones touristiques qu'une taxe sur les émissions (correspondant à une distance de vol de respectivement 500 et 2000 km). Pour les vols intercontinentaux, la sensibilité à ce genre de distorsions économiques potentielles est même plus grande. Pour un vol de 6000 km, on estime à quelque 30 US$ le gain potentiel résultant du transfert du point de départ ou d'arrivée vers un aéroport situé juste hors d'Europe. Il est difficile de dire si un tel gain aurait un impact substantiel sur le comportement au voyage.

Une taxe sur le carburant est plus sensible à de telles distorsions économiques qu'une taxe sur les émissions, du fait que choisir l'aéroport de départ ou d'arrivée hors d'Europe revient à éviter de payer la taxe sur le carburant mis en soute pour un vol entier. Dans le cas d'une taxe basée sur les émissions, le fait de voler dans l'espace aérien européen est toujours taxé, indépendamment du point de départ ou d'arrivée du vol.
Sur la base de cette étude, il est impossible d'indiquer la faisabilité d'une taxe sur le carburant pour ce qui concerne les distorsions économiques potentielles.

Les distorsions économiques potentielles d'une taxe basée sur le déplacement sont à peu près intermédiaires entre celles dues respectivement à une taxe sur les émissions et une taxe sur le carburant. On ne peut éviter de payer la taxe sur le déplacement que si les aéroports de départ et d'arrivée sont tous deux situés hors d'Europe. Ceci n'est possible que pour des voyageurs européens avec une destination hors d'Europe et partant d'un aéroport proche de la frontière européenne, ou pour des voyageurs non-européens évitant d'arriver en Europe. Ces deux segments de marché sont relativement réduits. De plus, le gain financier de tels transferts n'est que d'environ 9 US$ (niveau de taxe équivalent à 0,20 $/l en relation avec une distance donnée de vol de 500 km).
On ne prévoit pas qu'une taxe basée sur le déplacement soit à l'origine de distorsions économiques inacceptables[107].

---

[107] La Norvège a introduit ce genre de taxe à l'échelle nationale au niveau d'environ 20 US$ pour les départs internationaux.

6.2.4 Complications au niveau de la répartition des revenus

Tout choix en matière de base de taxe ainsi que d'allocation des revenus a des conséquences sur la répartition de ces revenus. On peut distinguer deux formules de répartition : a) parmi les pays participants et b) entre l'industrie aéronautique et le secteur public, ou les contribuables.

Une option consiste à allouer les revenus directement aux pays participants. En ce cas, le choix de la base de la taxe détermine aussi la répartition internationale. Une taxe sur les émissions est attractive pour des pays dont l'espace aérien est très fréquenté. Une taxe sur le carburant aura la préférence de pays possédant un parc important de citernes de stockage. Et les pays dont les aéroports attirent des passagers des pays voisins pourraient tirer profit d'une taxe sur le déplacement.
La question (politique) est : que doit-on considérer comme équitable ?

Une seconde option consiste à allouer les revenus au niveau européen. En ce cas, le plus acceptable semble de redistribuer les revenus aux pays participants, selon une réglementation d'allocation. Une telle réglementation pourrait être incorporée au traité international réglant l'implémentation de la taxe. Il est évident que la réglementation d'allocation est sujette à des conflits d'intérêts financiers.

En troisième lieu, les revenus peuvent être alloués aux compagnies aériennes payant la taxe (charge de revenu-neutre sur émissions). Dans cette variante, les compagnies payent une taxe sur toutes leurs émissions dans l'espace aérien européen et les revenus sont entièrement reversés à ces mêmes transporteurs au prorata de leur production, exprimée en passagers/km et tonnes/km dans l'espace aérien européen[108]. Ceci crée une incitation pour toute les compagnies aériennes à améliorer leur performance environnementale et stimule en même temps une conversion vers des appareils relativement propres.
Cette option a l'avantage de n'imposer aucune charge financière additionnelle au secteur aéronautique et de ne pas nécessiter un règlement de l'allocation et de l'utilisation des revenus. En ce cas cependant, le problème en fait de répartition est de savoir s'il est juste que l'aviation ne soit pas pénalisée pour les dommages environnementaux dont elle est la source et ne paye pas de taxe sur le carburant, comme c'est le cas pour le trafic routier.
On se borne ici à mentionner ces complications de répartition. Aucun jugement est émis sur ce que serait une répartition internationale équitable des revenus, ni sur ce qu'un régime équitable d'impôt et de taxe impliquerait pour l'aviation, par exemple en comparaison avec d'autres modes de transport.

[108] Des taxes d'atterrissage différenciées liées à la pollution de l'air par combinaison moteur/fuselage - telle celle introduite à l'aéroport de Zurich - peuvent être considérées comme une taxe à revenu-neutre sur des émissions LTO.

En ce qui concerne la faisabilité d'une taxe européenne sur l'aviation, on peut dire en général que les problèmes de répartition peuvent être résolus, pourvu qu'il en existe la volonté politique parmi les pays participants européens.

6.2.5 Problèmes juridiques

Ni une taxe sur les émissions, ni une taxe sur les déplacements, ne rencontre de sérieux problèmes juridiques, par exemple avec la Convention de Chicago ou d'autres accords internationaux. Reste de la question de savoir s'il faut limiter les taxes portant sur l'espace aérien européen aux territoires nationaux, y compris la zone de 12 miles, ou si l'espace au-dessus de mers importantes et une partie de l'océan dout être également inclus dans le régime de taxe. Cette dernière option est préférable, pour éviter de possibles changements de routes par suite d'une taxe sur les émissions.

Dans le cas d'une taxe sur le carburant, on prévoit qu'il faudra adapter de nombreux accords bilatéraux aériens (Air Service Agreements). Ce ne sera pas un problème (politique) pour ceux passés entre des pays européens participants. L'adaptation d'accords passés entre tout pays participant et un pays non-participant peut cependant entraîner plus de difficultés, parce que les pays non-participants peuvent en fait bloquer les changements requis ou faire payer leur autorisation de taxer le carburant. Pour cette raison, une taxe sur les émissions ou sur le déplacement présente des avantages sur une taxe sur le carburant.

Une taxe sur le carburant limitée aux seuls vols intérieurs européens pourrait rencontrer moins d'obstacles juridiques. Cependant, son efficacité environnementale sera réduite du quart environ, et le fait de fournir sur des aéroports européens les deux types de carburant, taxé et non-taxé, pourrait faciliter la fraude. En outre, une taxe sur le carburant ainsi limitée offre probablement des distorsions économiques différentes et peut-être plus importantes qu'une taxe sur les citernes de carburant appliquée pour tous les départs à partir des aéroports européens.

6.3 Conclusions and recommandations

Ce projet peut être caractérisé comme une étude générale de faisabilité, envisageant toutes les options les plus significatives pour une taxe européenne sur l'aviation. Les différentes options pour cette taxe peuvent être très différentes en termes d'efficacité sur l'environnement et de faisabilité anticipée.
On espère, avec cette étude, avoir contribué à rétrécir le "terrain de jeu" pour le développement futur d'une politique. Etant donné le caractère général de cette étude, des recherches additionnelles en profondeur sont nécessaires sur certaines questions spécifiques.

Les conclusions et recommandations suivantes indiquent les options les plus encourageantes et les lacunes qui restent encore dans les connaiss-ances sur le sujet.

Conclusions

1 La forme à donner à une taxe européenne sur l'aviation a un impact important ou même décisif sur son efficacité environnementale et sur sa faisabilité. Les choix cruciaux concernent la base de la taxe, le niveau de la taxe et l'allocation des revenus.

2 Cette étude révèle une perspective positive pour l'introduction d'une taxe européenne sur l'aviation qui soit à la fois efficace pour l'environnement et faisable. On prévoit qu'un niveau de taxe équivalent à 0,20 US$/litre de carburant diminuerait approximativement de moitié l'augmentation prévue des émissions dues à l'aviation civile en Europe. L'introduction d'une taxe sur l'aviation offre des opportunités pour accroître l'efficacité économique totale.

3 Une taxe basée sur des émissions calculées se révèle être l'option la plus attractive avec une faisabilité très probable. Les distorsions économiques potentielles[109] sont moindres que celles associées aux autres bases de taxe. Une taxe sur les émissions dans l'espace aérien européen n'aura pas d'impact notable sur la concurrence entre les transporteurs européens et non-européens. En moyenne, le gain financier procuré par un transfert du point de départ ou d'arrivée vers un aéroport hors d'Europe est limité à environ 2 US$ par billet. On ne prévoit pas que cela influencera le comportement au voyage. Si nécessaire, des mesures compensatoires pourraient être envisagées pour les zones touristiques du Sud de l'Europe. En outre, une taxe sur les émissions n'est pas incompatible avec la Convention de Chicago, ni avec les Accords Bilatéraux sur le Service Aérien (Air Service Agreements). Cependant, il n'est jusqu'ici pas très clair si l'étendue présumée pour l'espace aérien européen est en accord avec la législation internationale.

---

[109] Dans cette étude, on définit comme distorsions économiques, des distorsions dans la concurrence entre compagnies européennes et non-européennes résultant de l'échelle géographique limitée d'une taxe européenne sur l'aviation. Cette définition implique que des modifications dans la position concurrentielle de compagnies qui interviendraient aussi du fait d'une taxe sur l'aviation à l'échelle du *globe* ne sont pas considérées comme des distorsions économiques dans cette étude.

4 Une taxe combinée sur le carburant[110] est moins attractive qu'une taxe sur les émissions. Une taxe sur le carburant est considérablement plus sensible aux distorsions économiques qu'une taxe sur les émissions. Sur un vol intercontinental de 6000 km, par exemple, on peut en moyenne réaliser un gain financier de 30 US$ par passager en transférant le point de départ vers un aéroport situé juste hors d'Europe. En outre, la taxe sur le carburant se heurte à des obstacles juridiques, ce qui n'est probablement pas le cas pour la taxe sur les émissions. Le seul avantage d'une taxe sur le carburant par rapport à une taxe sur les émissions est qu'elle est plus facile à mettre en place, puisqu'une taxe sur les émissions requiert de mettre au point une méthode internationalement acceptée de calcul des émissions, qui n'est pas encore disponible pour la phase de croisière. Cependant, cet avantage n'est pas crucial, étant donné qu'une telle méthode de calcul peut être développée assez vite et que les recherches requises à cet effet sont déjà en cours.

Une taxe sur le carburant limitée aux vols intra-EEA pourrait se heurter à moins d'obstacles juridiques qu'une taxe sur le carburant pour tous les vols au départ de l'Europe. La conséquence est cependant que l'efficacité environnementale de cette taxe limitée sur le carburant est en gros réduite d'un quart. En outre, les distorsions économiques pourraient être plus fortes, mais ceci est encore confus.

5 L'efficacité environnementale d'une taxe sur le déplacement (ou le billet) n'est approximativement que le tiers de celles des deux autres bases de taxe. En outre, une taxe sur le déplacement ne présente aucun avantage substantiel sur une taxe sur les émissions. Pour des raisons de protection de l'environnement, une taxe sur les émissions ou sur le carburant est par conséquent préférable à une taxe sur le déplacement.
Cependant, une taxe sur le déplacement pourrait être prise en considération pour des raisons de taxation équitable de différentes activités économiques. Une option pourrait être d'introduire une taxe sur le billet, par exemple, si l'application d'une TVA sur le transport international se révélait impraticable.
L'introduction en Europe d'une taxe sur le billet est réalisable (et a déjà été mise en place par la Norvège à l'échelle nationale).

6 Une taxe sur les émissions LTO est réalisable. La taxe par appareil est inférieure aux différences existant d'un aéroport à l'autre entre les taxes totales d'aéroport. Cependant, l'efficacité environnementale d'une taxe sur les émissions LTO n'est approximativement que le quart de celle d'une taxe sur les émissions ou sur le carburant, étant donné que seule l'étape atterrissage/décollage d'un vol est taxée.

7 Une taxe de revenu-neutre (sur les émissions) est très probablement réalisable. Ses distorsions économiques potentielles sont probablement

[110] Comprenant, outre la taxe sur le carburant, une taxe sur émissions LTO et des standards pour émissions de NO_x.

négligeables. Par ailleurs, son efficacité environnementale est assez élevée. Une taxe de revenu-neutre équivalente à 0,20 $/l réduirait la pollution de l'air d'environ 25% entre 1992 et 2025, par rapport aux tendances actuelles de croissance, tandis qu'une taxe sur les émissions réduirait cette pollution de 30%. Une taxe de revenu-neutre n'a pratiquement aucun impact sur la croissance en volume, au contraire d'une taxe sur les émissions.

Une différence cruciale, par rapport à la taxe sur les émissions, concerne les conséquences en matière de répartition. Dans le cas d'une taxe à revenu-neutre, l'aviation ne contribue pas aux finances publiques, pour compenser les dommages qu'elle cause à l'environnement (Principe du Pollueur Payeur) ou au titre d'une taxe générale sur le carburant similaire à celle payée par le trafic routier. Il n'entre pas dans le cadre de cette étude de porter un jugement sur ce que serait un régime équitable pour l'aviation, en comparaison avec les autres modes de transport, par exemple.

Afin d'atténuer les conséquences en matière de répartition, il est possible de combiner la taxe de revenu-neutre sur les émissions avec d'autres options de taxe. L'une des combinaisons possibles est une taxe nationale sur les émissions LTO avec une taxe de revenu-neutre sur les émissions en cours de vol (LTO exclu). Une autre combinaison associe une taxe de revenu-neutre sur les émissions à une taxe sur le déplacement. La taxe sur le déplacement génère non seulement des finances publiques, elle incite en outre à réduire la croissance en volume, qui n'est pas affectée par la taxe de revenu-neutre.

Recommandations

1 Une étude détaillée devrait être entreprise sur la conception et les conséquences d'une taxe européenne sur les émissions dues à l'aviation. Cette étude devrait se focaliser sur les points principaux suivants:
- Développer une méthode internationalement acceptée pour calculer les émissions au cours de tout vol (standard) dans l'espace aérien européen.
- Définir les frontières de l'espace aérien européen, où la taxe devrait s'appliquer, en tenant compte de la législation internationale et en réduisant au minimum les possibilités d'éviter l'espace aérien européen.
- Etudier en détail les possibilités pratiques d'éviter l'espace aérien européen et rechercher des mesures compensatoires.
- Développer des formules pour la répartition internationale des revenus de la taxe (réglementation d'allocation).
- Etudier en détail les dispositions juridiques requises.
- Etudier les possibilités et procédures pour l'extension graduelle du nombre de pays participants.
- Développer un système administratif pour le calcul des émissions et la collecte des taxes correspondantes.

2 On peut envisager de développer de façon plus détaillée, parallèlement à la taxe sur les émissions (recommandation 1), la taxe combinée sur le carburant. Ceci peut offrir une alternative dans le cas de difficultés

imprévues liées à l'introduction d'une taxe sur les émissions. Les principaux points d'attention pour le développement plus détaillé de la taxe combinée sur le carburant sont :
- évaluer les deux variantes de la taxe combinée sur le carburant : soit une taxe s'appliquant à l'ensemble du parc de citernes de carburant en Europe; soit une taxe sur le carburant limitée, ne portant que sur les citernes associées à des vols intra-EEA;
- étudier en détail les dispositions juridiques requises, y compris des modifications dans les Accords Bilatéraux sur le Service Aérien;
- étudier en détail les distorsions économiques potentielles et rechercher des mesures compensatoires possibles.

3 L'introduction de la taxe sur les émissions - ou de la taxe combinée sur le carburant - exigera quelque temps, et il est par conséquent recommandé de débuter par l'introduction d'une taxe sur les émissions LTO, au cas où des mesures politiques sont souhaitables à court terme. La taxe sur les émissions LTO peut être considérée comme un premier pas vers une taxe sur les émissions dans l'ensemble de l'espace aérien européen.

4 Pour renforcer l'acceptabilité publique et politique d'écotaxes sur l'aviation, on recommande de leur donner la forme d'une réorientation d'imposition et non d'une taxe dont le premier but est de rapporter des revenus. Ceci veut dire que la formule politique est de revenu-neutre pour le budget de l'Etat. Ceci écarte toute suggestion qu'un objectif caché de ce type d'écotaxes serait de générer des fonds publics.

5 Bien qu'une taxe sur le déplacement ou le billet n'ait qu'une efficacité environnementale assez réduite, son introduction peut être envisagée pour des raisons d'équité, ou dans le cadre d'une taxation juste. Elle pourrait servir, par exemple, d'alternative à l'introduction de la TVA sur les voyages internationaux, dont on constate qu'elle est entravée par des obstacles pratiques et/ou des distorsions économiques potentielles.
Une taxe sur le billet peut être mise en place à court terme.

6 Si l'acceptabilité politique d'une taxe de revenu-neutre sur les émissions se révélait beaucoup plus importante qu'une taxe sur les émissions, une étude détaillée serait requise sur la conception et les conséquences d'une taxe de revenu-neutre sur les émissions. Il faut consacrer une attention spéciale à l'enregistrement des passagers-kilomètres et tonnes-kilomètres produits dans l'espace aérien européen (voir aussi recommandation 1). En outre, toute l'attention nécessaire doit aussi être accordée aux conséquences en matière de répartition (voir conclusion 7).

7 Développer au niveau européen l'impulsion majeure d'une politique équitable, équilibrée et transparente en rapport avec tous les modes de transport (intra-européens). Une telle politique intermodale conséquente stimule l'acceptation des mesures politiques requises.
Les questions principales sont ici :
- le prix de l'infrastructure (si fournie au public);

- prise en compte des coûts externes;
- système non-discriminatoire et transparent des obligations des services publics (OSP);
- interprétation d'impôts spécifiques, par ex. sur carburant, enregistrement et ventes;
- mise en place d'une TVA ou d'impôts similaires sur le transport intra-UE.

8 Déterminer la portée des mesures politiques nationales qu'on peut prendre à court terme, comme premières étapes vers l'introduction d'une taxe européenne sur l'aviation. Des possibilité sont :
  - l'introduction d'une taxe nationale sur les émissions LTO;
  - l'introduction d'une taxe nationale sur le déplacement;
  - une taxe sur les émissions sur les vols intérieurs, imposable à toutes les compagnies aériennes.

References

Alamdari, F.E. and D. Brewer (1994)
Taxation policy for aircraft emissions
Transport Policy, Vol. 1 (3) page 149-159.

Bleijenberg, A.N., W.J. van der Berg and G. de Wit (1994)
The social costs of traffic
CE, Delft, 1994.

Bleijenberg, A.N. and M.D. Davidson (1996)
The price of pollution
CE, Delft, November 1996.

Bleijenberg, A.N., R.C.N. Wit, P.M.J. Mendes de Leon, S.A. Mirmina and D.N.M. Starkie (1996)
A European aviation charge: Preliminary study
CE, Delft, The Netherlands.

Cranfield University (1997)
Airport Development Economics
An evaluation of the consequences to airports of withdrawing EU duty and tax free concessions.
European Travel Research Foundation, July 1997.

Dings, J.M.W., M.D. Davidson and G. de Wit (1997)
Optimizing fuel mix in road transport.
CE, Delft, May 1997.

Dings, J.M.W. and A.N. Bleijenberg (1996)
Prices of motor fuels in the European Union.
CE, Delft, January 1996.

Dings, J.M.W., W.J. Dijkstra and R.C.N. Wit (1997)
European aviation emissions: trends and attainable reductions
CE, Delft, December 1997.

Doganis, R. (1991)
Flying of course, the economics of international airlines
London, 1991.

ECMT (1997)
Draft report of the Task Force on the Social Costs of Transport
Paris, February 1997.

European Commission (1995)
Towards fair and efficient pricing in transport
Green Paper
Brussels, COM (95) 691 final, December 1995.

European Commission (1996)
Effects of the third package of measures to liberalize the air transport market
COM(96)514def., 22.10.1996, Brussels.

Fransen, W. and J. Peper, 1994
Atmospheric effects of aircraft emissions.
KNMI & NLR, the Netherlands, June 1994.

ICAO (1993)
Annex 16 to the Convention on Civil Aviation, Volume II, Aircraft Engine Emissions, Second Edition
ICAO, Montreal, July 1993.

ICAO (1995)
Outlook for Air Transport to the Year 2003
Montreal, 1995.

ICAO (1995b)
Civil Aviation Statistics of the World 1994
ICAO, Montreal, September 1995.

ICAO (1996)
Environmental Charges and Taxes on International Civil Aviation, Paper presented by the Secretariat to the 14th Session of the Council, AT-WP/1794, Montreal October 1996.

IPCC (1994)
Radiative forcing of climate change. The 1994 report of the Scientific Assessment Working Group of IPCC
UNEP/WMO.

IWW/Infras (1994)
External Effects of Transport.
Karlsruhe/Zürich, November 1994.

Kågeson, P. (1993)
Getting the Prices Right
T&E, Brussels, May 1993.

Luftfartverket (1997)
Action Programme against the Emissions of Air Pollutants from Civil Air Traffic in Sweden.
Environment and Planning Secretariat, February 1997.

Meurs, H. and R. Köhler (1995)
Tax harmonisation in the EU: consequences for mobility and profitability of Transport Firms
MuConsult, Utrecht and Dutch Ministry of Transport, The Hague, 1995.

Michaelis, L. (1997)
Policies and Measures for Common Action: Special Issues in Carbon/Energy Taxation: Carbon Charges on Aviation Fuels, Working paper 12, OECD, March 1997.

Norwegian Green Tax Commission (1996)
Policies for a better environment and high employment
Ministry of Finance and Customs, Oslo, September 1996.

OECD (1996)
Integrating environment and economy
OECD, Paris, 1996.

Olivier, J.G.J. (1995)
Scenarios for global emissions from air traffic
RIVM report 773, Dutch National Institute of Public Health and Environmental Protection
RIVM, Bilthoven, 1995.

Oum, T.H., W.G. Waters and J.S. Yong (1992)
Concepts of price elasticities of transport demand and recent empirical estimates: an interpretative survey
Journal of Transport Economics and Policy, 26(2), 139-154.

Roos, J., Bleijenberg, A.N. and W. Dijkstra (1997)
Energy and emission profiles of aircraft and other modes of passenger transport over European distances.
CE, Delft, 1997.

SH&E International Air Transport Consultancy (1997)
Assessment of the impact of the abolition of intra-EU duty & tax free allowances on charter airline economics.
SH&E, London, 1997.

Snape, T. (1998)
A European environmental aviation charge, Workshop report
Brussels, 1998.

Swedish Environmental Protection Agency (1996)
Towards an Environmentally Sustainable Transport System
Report 4682, Stockholm, October 1996.

Symonds Travers Morgan (1997)
Assessment of the impact of the abolition of intra-EU duty & tax free allowances on low-cost scheduled airlines.
London, June 1997.

UN (1995)
Energy Statistics Yearbook 1993
United Nations, New York, 1995.

Vedantham, A. and M. Oppenheimer (1994)
Aircraft emissions and the global atmosphere, Long term scenarios
Environmental Defense Fund, New York, 1994.

Wit, de G. (1994)
The effects on employment of a shift in taxation from labour to the environment
CE, Delft, 1994.

Wit, R.C.N. (1996)
How to control greenhouse gas emissions from international aviation? Options for allocation
CE, Delft, June 1996.

Wit, R.C.N. and A.N. Bleijenberg (1997)
Potential economic distortions of a European environmental aviation charge
CE, Delft, December 1997.

World Resources 1996-1997
A guide to the global environment: the urban environment
UNEP/UNDP/Worldbank, New York, 1997.

Abbreviations

AERO	= Aviation Emissions and Evaluation of Reduction Options
ASA	= Air Services Agreement
ATC	= Air Traffic Control
ATK	= Available Tonne Kilometre
CAEP	= Committee on Aviation Environmental Protection
CARFM	= Conference on Airport and Route Facility Management
EASG	= Economic Analysis Sub-Group of CAEP
EC	= European Commission
ECAC	= European Civil Aviation Conference
EEA	= European Economic Area
EU	= European Union
FCCC	= Framework Convention on Climate Change
IATA	= International Transport Association
ICAO	= International Civil Aviation Organisation
IEA	= International Energy Agency
IPCC	= Intergovernmental Panel on Climate Change
Jet A1	= aircraft fuel
LTO	= Landing and Take-Off
MTOW	= Maximum Take-Off Weight
NLR	= National Aerospace Laboratory
OECD	= Organization for Economic Cooperation and Development
RLD	= Dutch Civil Aviation Authority
VAT	= Value Added Tax

CE
Centre for
Energy Conservation
and Environmental
Technology
Oude Delft 180
2611 HH Delft
The Netherlands
Telephone: +31 15 2 150 150
Telefax: +31 15 2 150 151
E-mail: ce@antenna.nl
URL: http://antenna.nl/ce

A European environmental aviation charge

Feasibility study

Annexes

A Environmental impact

A.1 General

This chapter provides a summary of the *White Paper of the Netherlands on Air Pollution and Aviation* [VROM, 1995]. This summary has been especially drafted for inclusion in the final report of the European Environmental Aviation Charge project.

Modern aviation fuels are obtained from the refining of crude oil and consist mainly of hydrocarbons. When complete, the combustion of aviation fuels gives rise to emissions of carbon dioxide (CO_2), water (vapour) (H_2O) and sulphur dioxide (SO_2). Although the combustion efficiency of jet engines is generally very high, in practice combustion is incomplete and a number of other combustion products are also generated, particularly carbon monoxide (CO), volatile organic compounds (VOC) and 'particles' (this term refers to substances of diverse composition). In addition to incomplete combustion products, oxides of nitrogen (NO_x) are also formed owing to the high temperatures in the combustion chamber. Aircraft engines also emit nitrous oxide (N_2O) and methane (CH_4). The emissions of these two substances are extremely low and they are therefore not further considered here.

Aircraft emissions contribute to climate change (depletion of the ozone layer and the greenhouse effect), acidification and nuisance (local air pollution and odours).

Scientific understanding of the impact of aircraft emissions on the environment is still rather inadequate. These gaps in our understanding relate particularly to climate change. The first gap concerns the possible role played by NO_x emissions from aircraft in the stratosphere[111]. The second relates to particle formation, heterogeneous chemistry, the additional formation of cirrus clouds and chemical processes in clouds, including their influence on cloud optical properties. The first issue has received a great deal of attention from the international scientific community in recent years. The second issue has only recently become an area of interest for scientists. A good overview of current scientific understanding of the contribution of aircraft emissions to climate change is presented in a report by the European Commission entitled *European Scientific Assessment of the Atmospheric Effects of Aircraft Emissions* [EC, 1997]. In a forthcoming Special Report of the IPCC on Aviation and the Climate (publication sched-

---

[111] Gaps in our understanding also relate to the role of NO_x in the upper troposphere. However, these gaps are considered smaller than those relating to NO_x and the stratosphere.

uled in early 1999) further consideration will be given to these scientific questions.

One of the reasons for the current focus on the effects of NO_x emissions on the atmosphere is what is called the 'fuel-NO_x trade-off'. Historically, the fuel efficiency of jet engines has risen steadily. A higher efficiency will, as a rule, reduce the unit emissions of CO_2, H_2O, CO, VOC and SO_2. With increasing efficiency, however, temperature and pressure in the combustion chamber rise, whereby NO_x emissions will as a rule increase. This effect can be compensated through improvements in the combustion process in the combustion chamber. Examples are lean-burn and staged combustion techniques or revolutionary new combustion chamber concepts. See for further reading [CAEP, 1997] and other related CAEP-documents.

A.2 Composition of the atmosphere

The atmosphere, the ring of gases which girds our planet, can be divided into a number of layers, characterized by their temperature profile. The lowest layer of the atmosphere is the troposphere. In the troposphere the temperature falls with increasing altitude. The troposphere is turbulent and the substances present in it undergo vertical mixing within a few days. Above the troposphere is the stratosphere. In this layer temperature first remains constant and then rises with increasing altitude. At the global level this makes the stratosphere much more stable than the troposphere. On smaller scales there is an exchange between the two layers. The upper boundary of the troposphere is called the tropopause. The exact position of the tropopause depends on latitude and season, and is also influenced by weather systems; it fluctuates strongly and on a day-to-day basis. Near the poles the tropopause occurs at an average altitude of 6-8 km and near the equator at an average altitude of 16-18 km.
It is exactly in this very complex region of the atmosphere where aircraft fly: both in the troposphere and in the stratosphere. The different characteristics of these two layers mean that the substances emitted by aircraft have different respective effects on them. In addition, recent investigations indicate that the exchange between the two layers is stronger than previously believed. It is therefore no simple matter to answer the question 'What are the atmospheric effects of aviation?'.

A.3 The impact of aircraft emissions

The aircraft pollutant that probably plays the most important role in depleting the ozone layer is NO_x. However, model calculations indicate that this contribution is expected to be small in quantitative terms. Scientific understanding of the indirect effects of SO_2, soot and water vapour emissions by aviation is still incomplete, and the possibility of these effects proving important, e.g. more important than NOx, cannot be excluded. There are major concerns regarding the possible impact on ozone depletion of a new generation of supersonic airliners. All things considered, the knowledge concerning ozone depletion by aviation is still very incomplete.

Aircraft emissions contribute to the greenhouse effect. The climate effects of aircraft CO_2 emissions are no different from those of other CO_2 emissions, and are relatively clear. The role of aircraft emissions of NO_x has become better understood in recent years. Changes in ozone concentrations due to aircraft NO_x emissions disturb or influence the radiative field of the earth. Quantitatively speaking the effects depend on location and season, and are therefore difficult to compare with the global effects of persistent greenhouse gases such as CO_2. The international scientific community gathered together in the International Panel on Climate Change (IPCC) at present estimates that the indirect effect on the enhanced greenhouse effect of aircraft NO_x emissions, as a result of ozone formation, is of the same or a smaller order of magnitude as the direct effect of aircraft CO_2 emissions [IPCC, 1994 and WMO, 1994].

There is still a great deal of uncertainty about the effects of water vapour, SO_2 and soot particles. These pollutants emitted by aircraft could make an important contribution to the greenhouse effect, because of their influence on the formation of clouds and aerosols. The radiative effect of aerosols and their ability to modify cloud properties are strongly influenced by their atmospheric concentrations, which exhibit very major local variations in magnitude and composition. Overall, an increase in cloud cover and optical properties probably result in a net warming effect and the radiative effect of aerosols in a net cooling. At present our knowledge does not allow us to quantify these climatic effects properly. It is assumed, however, that the indirect effects of H_2O, SO_2 and particulate emissions from aircraft are not greater in quantitative terms than the effects of aircraft emissions of CO_2 and NO_x.

The contribution of aircraft emissions to acidification can, in principle, be readily quantified. Of greatest importance are the NO_x emissions, with the SO_2 emissions less important in this respect. On a global level, the aviation sector contributes about 0.7% to acidifying emissions of NO_x and SO_2, expressed in terms of acid equivalents [VROM, 1995].

The fourth environmental problem related to aviation emissions is the contribution to local and regional air quality problems in the residential areas around airports. For some airports this contribution is low, while for others it is high and may cause severe problems. The emission products of potential importance are VOC, CO, SO_2, NO_x, particulates and odours.

Table A.1 presents a systematic overview of the above findings.

Table A.1 The importance of controlling emissions of the various aircraft pollutants for each of the relevant environmental problems [VROM, 1995]

Environmental problems	Control important	Control unimportant	Importance uncertain
Ozone depletion	NO_x	CO_2, VOC, CO	SO_2, H_2O, particulates
Greenhouse effect	CO_2, NO_x	VOC, CO	SO_2, H_2O, particulates
Acidification	NO_x	CO_2, SO_2[1], H_2O, VOC, CO, particulates	-
Local air quality[2]	VOC, CO, SO_2, NO_x, particulates, odours	CO_2, H_2O	

1 SO_2 is an important acidifying agent. The contribution made by aircraft is small compared with that from other sources, however.

2 The impact of the various pollutants depends on local circumstances.

A.4 Future emission trends

At present, CO_2 and NO_x can be regarded as being the most important aircraft pollutants. In both cases, aircraft emissions accounted for between 2 and 3% of total world emissions from the combustion of fossil fuels in 1990, as is shown in Table A.2.

Table A.2 Aircraft emissions and their share of total emissions due to combustion of fossil fuels (coal, petroleum and gas) in 1990 [RIVM, 1995]

	CO_2 (Mt)	NO_x (kt)	VOC (kt)	CO (kt)	SO_2 (kt)
Aircraft	498	1,786	406	679	156
All sources (world total)	22,000	82,000	27,000	303,000	130,000
Percentage attributable to aircraft	2.3	2.2	1.5	0.2	0.1

Civil aviation is a growth market. It is expected to grow faster in future years than the economy as a whole. This means that in the years to come the economic importance of air traffic will increase relative to other sectors. Over the last two decades, air travel was the fastest growing mode of transport, and this trend is expected to continue. There will be a corresponding rise in the pollution caused by this sector, both in absolute and relative terms. That much is clear from calculations carried out for the *White Paper of the Netherlands on Air Pollution and Aviation*. These model calculations indicate that with current emission trends (including current international regulatory action) and without further policy measures, global aviation emissions in 2015 will be approximately three times those in 1990. Table A.3 provides detailed information. Other forecasts support these growth figures. According to a forecast by the Environmental Defense Fund, aviation may be responsible for as much as 10 per cent of worldwide CO_2 emissions by 2050, depending on many factors associated with economic growth [EDF, 1994].

Table A.3 Developments in world aviation emissions of CO_2 and NO_x for the period 1990 - 2015 for three economic scenarios [RIVM, 1995]

	CO_2		NO_x	
	Mtonne	Index (1990 = 1)	Mtonne	Index (1990 = 1)
Emissions 1990	498	1.0	1,786	1.0
Global Shift 2015	1,760	3.5	5,204	2.9
European Renaissance 2015	1,409	2.8	4,166	2.3
Balanced Growth 2015	1,678	3.4	4,964	2.8

In Western Europe the CO_2 growth figures associated with aviation will create an unbalanced situation, since, under the influence of policy measures driven by the Framework Convention on Climate Change, CO_2 emissions in other sectors are set to stabilize or decrease.

At the national level, emissions attributable to flights related to the Netherlands will increase by a factor of between 2 and 2.5. Allowing for the effect that environmental policy will have on other national emission sources, under an unchanged policy regime aircraft emissions will become more significant. In 2010 it is estimated that emissions from flights related to the Netherlands will account for 6% of national CO_2 emissions and 16% of national NO_x emissions. For other European countries and for the European Union as a whole, similar numbers apply. From an environmental policy point of view it is clear that these numbers cannot be neglected.

A.5 References

CAEP, 1997. Wesoky, H.L. *CO_2, NO_x and Related Topics*. Presentation to the Emissions Working Group (WG3) of the Committee on Aviation Environmental Protection, Seville, Spain, January 1997.

EC, 1997. *European Scientific Assessment of the Atmospheric Effects of Aircraft Emissions*. Report by the European Commission.

EDF, 1994. Vedantham, A and Oppenheimer, M. *Aircraft Emissions and the Global Atmosphere: Long-term Scenarios*. Environmental Defense Fund, 1994.

IPCC, 1994. *Radiative forcing of climate change. The 1994 report of the Scientific Assessment Working Group of IPCC; summary for policy makers*. UNEP/WMO.

RIVM, 1995. Olivier, J.G.J., *Scenarios for global emissions from air traffic*. RIVM report 773 002 003, March 1995. National Institute for Public Health and Environmental Protection, Bilthoven.

VROM, 1995. *Government policy of The Netherlands on air pollution and aviation*. Ministry of Housing, Spatial Planning and the Environment, Ministry of Transport, Public Works and Water Management and Ministry of Defence.

WMO, 1994. *Scientific assessment of ozone depletion: 1994 - Chapter 11 Subsonic and supersonic aircraft emissions*, World Meteorological Organization.

B Summary of the background study European aviation emissions: trends and attainable reduction

Introduction

This annex presents a summary of a background[112] study which focuses on the following three questions:

1 What trends in European aviation emissions can be expected in a 'Business as Usual' scenario, in which the current environmental policy remains basically unchanged?
2 What trends can be expected if all technical and operational options to reduce emissions were to be implemented? In other words: what is the technically feasible emission reduction potential (apart from volume effects)?
3 What fraction of this emission reduction potential is likely to be achieved under certain possible charging schemes?

With the results of this background study, the environmental effectiveness of several charging options has been assessed. Environmental effectiveness is obviously a very important criterion in evaluating charges designed to reduce the environmental impact of aviation.

The background study focuses on emissions of CO_2 and NO_x and takes the year 2025 as its time horizon. It is important to consider such a long period because some charging options will have an effect on the development of new aircraft and will thus only reach their full effect in the longer term.
The 'Business as Usual' fuel price is assumed to be $ 0.60 per gallon, or $ 0.16 per litre, of Jet A aviation fuel.

The effects of the following four charging options have been considered:
1 A fuel charge of $ 0.20 per litre[113].
2 A charge on calculated (CO_2) emissions, equivalent to $ 0.20 per litre.
3 A 'revenue-neutral' charge on (CO_2) emissions, equivalent to $ 0.20 per litre. The charge is assumed to be paid back to the airlines proportionally to their transport performance in revenue-tonne-kilometre (RTK).
4 A ticket charge.

---

[112] *European aviation emission: trends and attainable reduction* (Dings et al., 1997).

[113] This implies a fuel price rise of about 125%, or an increase in the share of fuel costs from about 12% to about 25%.

Literature review

An extensive literature review has been carried out in order to gather the data on emission reduction options and their potentials. All in all, over 50 literature sources have been studied.

From these sources, six different approaches to reducing aviation emissions were identified. The first five focus on a reduction of emissions per passenger-kilometre (pax.km) or RTK performed; the sixth is, obviously, a reduction of the number of pax.km or RTK: a volume effect.

1 Technological improvement, broken down into engine improvements, weight reductions and a reduction of the drag-to-lift ratio.
2 New optimization of aircraft design. The design of aircraft is highly optimized towards minimum Direct Operating Costs (DOC). A substantial change in the composition of these costs, for example via the aforementioned rise in fuel price, will push the 'optimum' design towards a concept that consumes less fuel and probably has a lower flight speed.
3 Increase of aircraft size and flight distance. Generally, fuel consumption per pax.km or RTK will decrease with increasing flight distance and increasing aircraft size.
4 Increase of the load factor.
5 Improvement of flight operations. By flying shorter routes, minimizing congestion and improving flight handling procedures, emissions can be reduced.
6 A reduction of the number of pax.km or RTK to be flown.

Alternative fuels are not considered, as they are not expected, in the short or medium term, to play a substantial role in reducing aviation emissions.

'Business as Usual' scenario

In the 'Business as Usual' scenario, the number of pax.km flown will rise by a factor 4 to 5 between 1992 and 2025. The energy required (and CO_2 emitted) per pax.km will fall by 35 to 40%. This implies that in this case CO_2 emissions from EU aviation will approximately triple during this period.

Moreover, it seems likely that NO_x emissions will rise even faster. Analysis of trends in engine sales and type-approval NO_x emissions suggests that there is an upward rather than downward trend in NO_x emission per unit of fuel burnt, despite the promising laboratory results reported in the literature.

A possible Business as Usual trend in CO_2 emissions is given in Table B.1. The trend is presented graphically in Figure B.1.

Table B.1 CE data[a] for CO_2 emissions from EU aviation

		1992	2005	2015	2025[b]
pax.km	billions	386	715	1,209	1,789
	index	100	185	313	463
annual growth, %			4.9%	5.4%	4.0%
fuel consumption, Mtonnes		28.5	40.7	59.4	82.2
CO_2 emissions total	Mtonnes	89.8	126	187	261
	index	100	141	208	290
CO_2 emissions per pax.km	grammes	232	177	155	146
	index	100	76	67	63

a The data are based on AERO model data. They are calculated by adding 'Intra EU' data and 50% of 'EU-other' data.

b The data for the year 2025 are CE estimates.

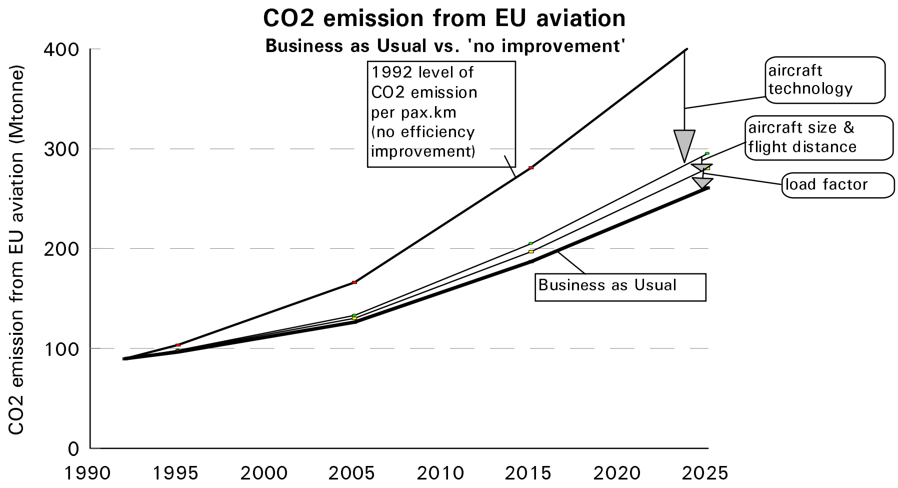


Figure B.1 Illustration of emission trends in Business as Usual scenario

'Technically Feasible' (TF) scenario

In this variant all the technical and non-technical options found in the literature have been commercialized to their maximum in 2025. The following data was found:

- The extra technological potential to reduce the energy intensity of new aircraft, on top of the BaU trend, is quite high and probably exceeds 20%. This improvement consists mainly in advanced engine technologies, plus a rapid introduction of these technologies in the fleet due to rapid fleet turnover.
- Aircraft design optimization appears to offer major potential for emission reduction. Aircraft could be designed with larger wingspans, lower optimum speeds and higher bypass ratios. The potential is estimated preliminarily at 20%. This aspect definitely requires further study.

- The emission reduction feasible by further increases in load factor is deemed only moderate, as the load factor is currently already quite high. We consider a doubling of the load factor improvement from 7% to 15% (from 67% to 77% of maximum payload) to be feasible, leading to an additional reduction of 6-7% in energy intensity.
- The environmental effect of cutting back the share of short flights with small aircraft is likely to be moderate, too. We assume an extra 5% reduction in energy intensity to be feasible.
- The extra reduction potential of operational changes is likely to be quite small: probably in the order of about 3%. On individual flights, higher reductions are feasible.
- For clarity's sake, we opted *not* to include a volume effect in this variant.

Together, all the available technical and non-technical options lead to 46% reduction in energy intensity compared to BaU. The situation is presented graphically in Figure B.2.

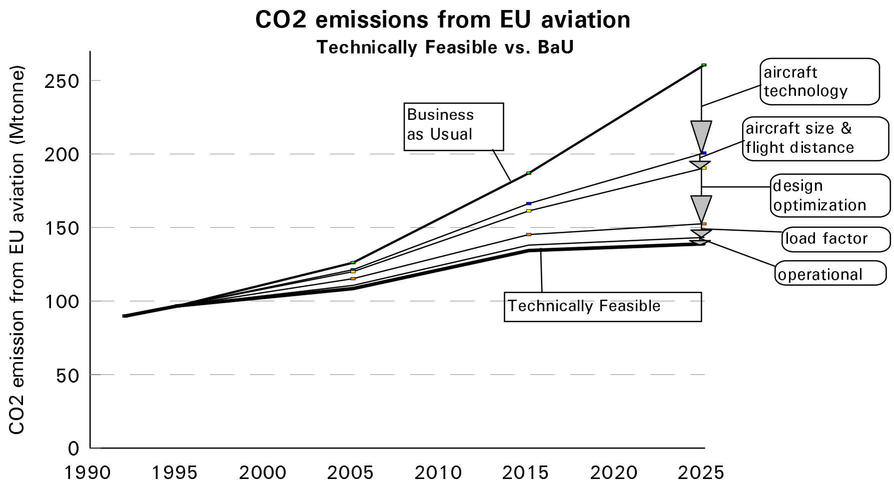


Figure B.2 Illustration of trend in 'Technically Feasible' variant

Possible reactions to emission charges

It proved very difficult to attribute accurate environmental effects, broken down into the six aspects mentioned, to the four charging options considered. There is major uncertainty associated with quantifying the effects. We therefore first completed a table describing the environmental effects of the various charging schemes in a qualitative manner.

Table B.2 Qualitative indication of possible effects of an emission charge of $ 0.20 per litre

aspect	reduction potential 1992-2025[a]	Effect of charge on CO_2 emission[b]			
		fuel charge	calculated emission charge	revenue-neutral charge[c]	ticket charge
volume	high	+	+	0	+ +
technology	high	+ +	+ +	+ +	0
size/distance	moderate	0/+?	0/+?-	+	0
optimized design	high ?	+ +	+ +	+ +	0
load factor	moderate	+	+	+ +	0
operational	low	+	0	0/+	0

a This column indicates emission reduction potentials.
Low 5% or less
Moderate 5-10%
Medium 10-20%
High 20% or more

b These columns indicate the effectiveness of the various charge types with respect to the aspects mentioned.
+ + large effect
+ moderate effect
0 no effect
- adverse effect

c This is a calculated emission charge paid back to the airlines proportionally to the number of pax.km performed.

In this table we see the following:

- A fuel charge has exactly the same effects as a calculated (CO_2) emission charge of equal level, except for the operational aspects. However, the operational aspects offer only minor potential for emission reduction. This implies that a fuel charge will be only marginally more effective than a calculated (CO_2) emission charge.
- There is a substantial difference between the calculated emission charge and the *revenue-neutral* calculated emission charge (assumed to be refunded to the airlines proportionally to the RTK performed). The first charge will reduce volume, while the second will not. However, the second charge will provide an extra incentive for 'clean' performance by acting to raise the load factor and by reduce the number of short-haul flights by small aircraft. However, the overall emission reduction resulting from the revenue-neutral charge is certainly less than that resulting from the calculated emission charge.
- A ticket charge has an effect on volume only. As it does not provide any incentives to improve the environmental efficiency of air transport, it is not considered further in the rest of this summary.

Figure B.3 and Figure B.4 give graphical indications of possible effects of the fuel/CO_2 emission charge and the revenue-neutral CO_2 charge.

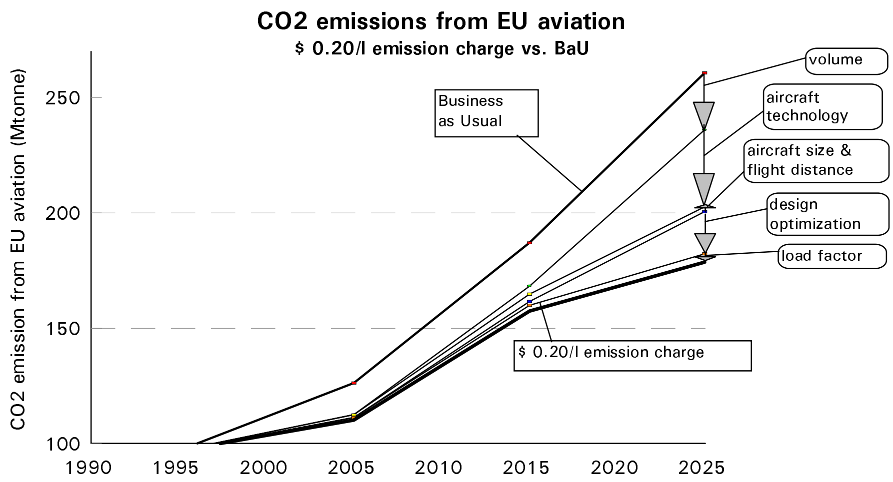


Figure B.3 Indication of possible effects of a calculated CO_2 emission charge of $ 0.20 per litre

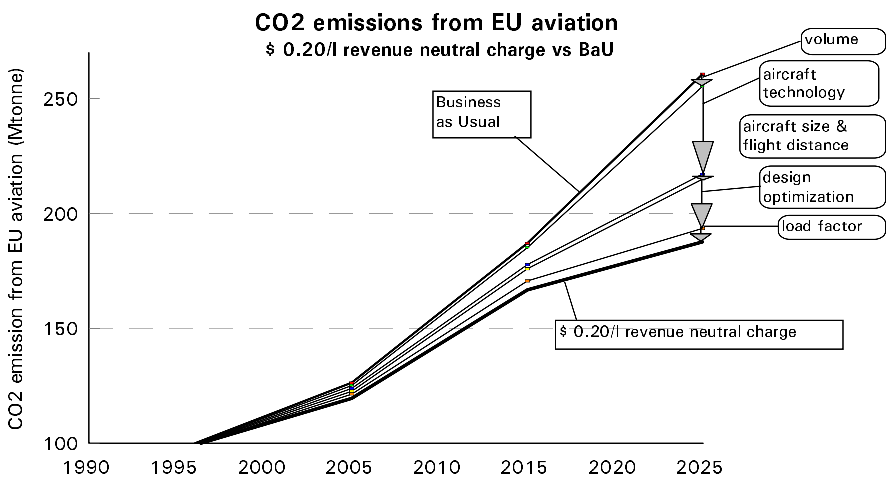


Figure B.4 Indication of possible effects of a calculated revenue-neutral CO_2 emission charge of $ 0.20 per litre

Overall conclusions

1 Data on specific fuel consumption (per pax.km) in the base year differ widely. Model calculations for civil aircraft lead to 20 to 30% lower fuel consumption than that reflected in actual total jet fuel consumption figures. This is probably due to fuel consumption in activities other than registered civil flying and to differences in attributing fuel to freight transport.
2 Data on NO_x emission indices also differ widely (by about 30%), mainly because of different calculation methodologies.
3 In a Business as Usual (BaU) scenario the NO_x emission index (in g per kg of fuel burnt) is likely to increase rather than decrease. This is due to

an increase in the average pressure ratio and size of aircraft engines and legislation permitting higher NO_x emissions for these engines.

4 In a BaU scenario average fuel consumption and CO_2 emission per pax.km will fall by 35-40% in 2025 relative to 1992. Because of volume growth, total CO_2 emissions will almost triple. As a consequence of the previous conclusion, NO_x emissions will rise by even more.

5 In considering possible emission reductions it is very important to take a long-term perspective. Technological developments (especially engines) and an optimized 'low emissions' aircraft design are very important factors contributing to emission reduction. Both factors have a very long lead time, however.

6 In 2025 a reduction of CO_2 emissions by almost 50% relative to BaU seems technically feasible, mainly by developing more efficient engines, by optimizing new aircraft for lower fuel consumption (lower speed, larger wingspans) and by raising the load factor.

7 A ticket charge has an effect on volume only; it does not improve the environmental efficiency of air transport. Consequently, it is not considered to be an attractive charging option.

8 In the long term a $ 0.20 per litre CO_2 emission charge (equivalent to a 125% increase in fuel price) could lead to a very substantial CO_2 emission reduction (probably in the order of 30%, relative to BaU). Aircraft technology (especially engines), optimized aircraft design and a volume effect are the main contributors to this reduction.

9 A revenue-neutral CO_2 charge (refunded to airlines proportionally to their transport performance in RTK) of $ 0.20 per litre seems quite effective as well, with a CO_2 emission reduction that could exceed 25% in 2025, relative to BaU. The differences of the effects of the revenue-neutral charge compared to the 'normal' emission charge lie in the volume effect (which is very small: probably about 1-2%), the load factor (which is probably higher), the average flight distance and average aircraft size (longer and larger, respectively).

10 Charges based on calculated emissions have no effect on flight operations and the emission reductions associated with these operations, while a real fuel charge will have an effect in this respect. However, as the reduction potential of operational measures is rather low, the fact that the charge has been priory calculated does not seriously reduce the effectiveness of the charge, compared with the fuel charge.

Recommendations

We give the following recommendations for further study:

1 Closer study of NO_x emissions from recent engine models compared with older ones, in order to gain a better idea of the trend in NO_x emission per kg of fuel burnt.

2 Extensive study of long-term effects of fuel/emission charges on technological development of new aircraft, new aircraft design optimization and renewal of the existing fleet.

C Summary of the background study on potential economic distortions

This annex summarizes the results of a background study[114] on economic distortions that might result from introduction of a European aviation charge. This background study is part of the main study on the feasibility of a European aviation charge.

A crucial issue with respect to the feasibility of a European aviation charge is whether it will give rise to economic distortions. A charge will be less feasible if it creates a competitive disadvantage for European relative to non-European companies. In this context, the aim of this background study is to evaluate competitive distortions between the European and non-European aviation industry and tourist industry that might be caused by imposition of a European aviation charge. To this end, three potential forms of distortion are discussed:
1 competitive distortions between European and non-European airlines;
2 competitive distortions between European and non-European airports;
3 competitive distortions between the European and non-European tourist industry, in so far as aviation constitutes the dominant transport mode.
These potential forms of distortion are analyzed separately.

Economic distortions are defined in this study as distortions in competition between European and non-European companies, caused by the limited geographical scale of a European aviation charge. This definition implies that changes in the competitive position of companies that would also occur as a consequence of a *global* aviation charge are not considered to be economic distortions in this study. Thus, a change in the competitive position of relatively clean airline companies compared with to highly polluting ones is not considered to be an economic distortion. This is, rather, an efficiency improvement, which might, however, require a transitional period of time to allow companies enough time to adapt to the new circumstances.

Features of the charge analyzed
There are various ways to shape a European aviation charge. In this background study we take as the starting point of our analysis a charge of the following form.
- The countries participating in the aviation charge are all the countries of the European Economic Area (EEA). Besides the countries of the European Union these include Norway, Switzerland, and Iceland.

---

[114] *Potential economic distortions of a European aviation charge* (Wit and Bleijenberg, 1997).

- A non-discriminative charge is considered, in the sense that all airlines - including airlines from non-EEA countries - are charged in the same way.
- The charge is based on the emissions caused by aircraft during their flight through EEA airspace.
- The charge is levied as a *route* charge in EEA airspace. As a result, the charge is effective *irrespective* of whether or not an aircraft lands in an EEA country. Only the distance travelled in EEA airspace and the emissions per kilometre matter.
- The charge levels considered correspond to between 0.10 and 0.40 $/l. For comparison: the current fuel price is 0.16 $/l. Table C.1 shows the long-term cost increase resulting from such a charge following improvements of energy and environmental efficiency.

Table C.1 Estimated long-term impact of a charge of 0.10 - 0.40 $/l on ticket price and costs

	Total flight, 500 km	One-way flight, 2000 km	LTO only
Total per-flight charge	+220$ to +890$	+630 to +2514$	+330-1320
Percentage increase of current airport charges	+4% to 38%	+4% to 80%+	+1 to 18%
Long-term ticket price change	+1 to +6$	+4 to +19$	+1 to +4$

Results for a Boeing 737-400.

Table C.1 indicates that modest price increases can be expected as a consequence of a charge in the range considered. The price increase per ticket will be more than outweighed by anticipated price cuts originating from efficiency improvements. Furthermore, the price increase as a percentage of total airport charges is smaller than existing differences among airports.

Our main analysis focuses on a charge of the above form. At the end of the analysis an indication is given of how results would differ from other charge options - in particular a fuel charge or a ticket charge.

Competitive distortions among airlines
In general, there are two conceivable reactions to imposition of the assumed charge. First, airlines can absorb the cost increase, lower their profit margins and accelerate (environmental) efficiency improvements. This implies a decrease in the average total operating margins of European airlines compared with non-European airlines, because the EEA airlines have a relatively high market share in the EEA. Consequently, the competitive position of European airlines would deteriorate compared with non-European airlines.

The second possible reaction, which seems more likely, is for all airlines to pass on a major part of the charge to customers, with, in the long run, part of the charge being absorbed by environmental efficiency improvements.

It should be stressed that all carriers, both European and non-European, are assumed to be subject to exactly the same charge. Because our study considers only non-discriminative charges, all carriers providing a given service are charged in the same way. This implies that both European and non-European carriers would face the same cost increase on the same flight stage[115]. In fully liberalized international markets for air transport, and with keen competition, both European and non-European carriers will then pass on the whole charge to their customers. The first-order effect would then be for the European environmental aviation charge to not have any different direct effect on the per-unit operating costs of European and non-European carriers.

At the moment, however, there is no fully liberalized market in many markets and regions of the international air transport market. In order to assess whether European and non-European airline companies could pass on the charge to their customers, it is therefore necessary to take the specific market situation of different type of carriers into account.

From literature and interviews it was found that charter carriers and low-cost carriers are likely to pass on the entire cost increase due to the charge to customers. The main reason is that these markets are highly competitive with, as a consequence, very small profit margins that do not permit higher costs. Furthermore, on the basis of an analysis of possible price adjustment behaviour we conclude that both European and non-European scheduled carriers will also pass on the whole of the charge to the customers.
Below, we discuss whether competitive disadvantages for the different types of European carriers are to be expected, assuming full fare adjustment.

Charters and low-cost carriers
A second-order effect is that the higher air fares might slow down the growth of the European air transport market somewhat, resulting in a smaller home market for European compared with non-European carriers. In theory, this may weaken the competitive position of European carriers, because of the lower economies of scale that can be achieved, with resultant higher production costs for those companies operating mainly in the European market. Charters and low-cost carriers, however, operate direct flights on origin/destination markets. Doganis (1991) indicates that airlines

---

115 In practice, there will be winners and losers because airline companies with relatively old and inefficient aircraft would have to pay higher total charges per flight. This effect is not an economic distortion between European and non-European carriers, however, but the intended aim of the charge: to provide an incentive to increase environmental efficiency. It should be stressed that this change of the relative competitive position of airlines in favour of those operating more efficient aircraft would also occur if a global environmental aviation charge were to be applied.

that operate direct flights on origin/destination markets are hardly able to achieve economies of scale or economies of density. This implies that reduced growth of the European market would not result in lower per-unit operating profits on an isolated flight for European charters and low-cost carriers compared with those from non-European countries.
A probably even more convincing argument for not expecting competitive disadvantages for European charters following introduction of a European aviation charge is that non-European carriers hardly compete with European charters.
On the basis of both arguments above, we conclude that a European environmental aviation charge would not create potential competitive disadvantages for European charters and low-cost carriers.

Scheduled carriers
As already mentioned, a smaller home market might result indirectly in reduced economies of scale and thus in higher production costs for those companies operating mainly on the European market. This might, indirectly, affect the operating margin of European scheduled carriers and thus the competitive position of those carriers. It is estimated that average annual growth in the European market will decrease from 4.0% to 3.7% between 1992 and 2025 following gradual introduction of a charge corresponding to 0.20 $/l.
In contrast to charters, which operate origin/destination services, scheduled carriers can often be regarded as multi-product firms, because they offer both direct and indirect destinations, implying that they operate on both origin/destination markets and transfer markets. Multi-product firms can achieve economies of scope and economies of information. A smaller European home market due to the charge would then reduce these scale advantages for European scheduled carriers to a relatively greater extent. This reduced growth in demand might reduce the increase in economies of scale somewhat for carriers operating largely in the European market. This should, however, be seen in the light of international developments in aviation.
Firstly, the European aviation sector is in the process of consolidation, to achieve economies of scale. One extra merger compared to Business-as-Usual might be sufficient to counterbalance the smaller home market and achieve the same scale efficiency. This does not mean that the efficiency of European carriers will be lowered, but that the number of independent carriers will decrease as a consequence of a European aviation charge.
The second international trend is towards global alliances. Because all global alliances have to be present in the European market, no distortion in competition will arise among them.

According to this study it is unlikely that relevant economic distortions among airline companies will arise as a consequence of a European aviation charge in the considered range. No convincing arguments have been found for expecting relevant distortions in competition between European and non-European carriers.

Competitive distortions among airports

A potential distortion that may arise is that *origin/destination (O/D)* passengers from or to the EEA may shift their origin or destination airport just outside the EEA. Obviously, such adaptive behaviour is relevant only for passengers originating from along the border of the EEA. Moreover, as reasonable alternative airports are only available on the Eastern border, this so-called `border effect' is likely to be relevant only for this border.

How much of the charge can be avoided by such adaptive behaviour? As we are considering an emission charge levied en route, this question boils down to the question of what decline in emissions in EEA air space will occur because of such adaptive behaviour.

Obviously, the *distance* travelled through EEA air space remains essentially unchanged after shifting to an airport just outside the EEA. Thus, emissions will hardly be lower because of fewer miles being travelled in EEA air space. Nevertheless, emissions in EEA air space will be somewhat lower, because the landing and take-off cycle (LTO cycle) - which causes relatively high emissions - will take place outside the EEA air space as a result of such adaptive behaviour.

Thus, as Table C.1 shows, changing to an airport just outside the EEA generates a financial gain of approximately 2-9% on airport costs, which is roughly 2$ on a two-way ticket (assuming an emission charge equivalent to 0.20 $/l fuel).

Having established this, we do not expect the considered charge to lead to any significant shift of origin/destination services towards airports outside the EEA, for the following reasons.

1 The relative increase in EEA airport costs is much smaller than current differences in airport charges among the major European airports and the most important airports just outside the EEA. The latter generally charge over 50% less, which does not apparently result in any major shift of traffic. This indicates that travellers are not willing to travel a long distance to their airport of departure and prefer a nearby airport, even if this is more expensive.

2 Time-related variables (`access time' and 'frequency') appear to be dominant in the airport choice behaviour of business travellers.

   To facilitate interpretation of the importance of the variable 'access time to an airport', in the background study on economic distortions[116] this variable was expressed in terms of value of time in dollars per hour. It was concluded that business travellers would accept an additional access time of one hour to a non-EEA airport if the level of the aviation charge was $ 77 or more, while non-business travellers would accept one hour of extra travel to an alternative airport if the aviation charge was over $ 23. As avoiding the emission charge by using non-EEA airports generates a financial benefit in the order of $ 2 per ticket, travellers would only accept an extra travel time of between 2 and 6

---

116 *Potential economic distortions of a European environmental aviation charge* (Wit and Bleijenberg, 1997).

minutes to an airport just outside the EEA. This indicates that the travel time to the nearest principal airports in countries bordering the EEA is probably too long and the financial benefit per ticket of avoiding the charge too small.

Another potential distortion that may arise between EEA and non-EEA airports is that *transfer* passengers might shift to airlines that can offer cheaper ticket prices because they have flight connections with a transfer outside EEA air space. Consequently, in the long run, airline companies might choose to locate their hub outside the EEA instead of inside.
The possibility of transfer passengers shifting to connections with hubs outside the EEA depends very much on the geographical situation. Hubs outside the EEA are probably not a suitable alternative for hubs oriented towards the Atlantic route, because airlines still have to fly through EEA air space. A large detour around EEA air space is probably too costly. Hubs oriented towards the Asian route, however, do have potential locations outside the EEA, mainly in Central Europe and Turkey.
The incentive for airlines to choose a hub outside the EEA is probably counterbalanced by the economies of scale achieved at the airports within the EEA, because of their much further developed home market. In addition, locations in Eastern Europe might not be very suitable for use as a hub airport, because their location is not central for many routes, which means that the overall journey time of transfer flights would be excessively high.

Competitive distortions in international tourism
Any aviation charge, European or worldwide, will favour nearby over long-distance tourism. Thus, the considered charge will slow down the current trend of tourist destinations being chosen further and further away. This effect will increase environmental efficiency and is therefore *not* a competitive distortion. On the contrary, it leads the economy as a whole towards more efficient allocation.
However, the brake on the growth of long-distance tourism will have some impact on the spatial distribution of tourist activities. Clearly, there will be countries that gain and countries that lose. The appropriate policy response to this may be to provide transitional support for the losers to allow them a period of time, following introduction of an aviation charge, to improve their environmental efficiency.

However, if tourist destinations inside the EEA were to become more costly than destinations outside the EEA solely because of the charge being levied only on emissions in EEA airspace, this would certainly constitute a competitive distortion. Below, we therefore investigate the extent to which this effect occurs.

The majority of intra-EEA charter passengers originate in Northern Europe and travel to Mediterranean holiday destinations. This charter flow from Northern Europe represents over 80% of the total EU charter market. These travellers go to Spain and Greece mainly for the sun and beaches, which are not available in their home countries. Their first reaction might therefore

be to shift to destinations outside the EEA instead of travelling to destinations closer to home: from Greece to Turkey, for instance, or from Spain to Tunisia.
Such behaviour might be induced if the aviation charge makes European destinations more costly compared to non-European tourist areas. However, to what extent is this the case? At first sight, one would not expect European destinations to become more costly than non-European destinations, because the distance travelled through EEA airspace for European destinations will, on average, not be systematically greater than for alternative destinations outside the EEA. Nevertheless, European destinations are expected to become systematically somewhat more costly, because for such destinations one LTO cycle more is taking place in EEA airspace compared to non-European destinations. Thus, tickets to European destinations are expected to become 1-4$ more costly than those to non-European destinations (see Table C.1).
We have found no conclusive evidence that such a price differential would lead to amy substantial shift in tourist destinations.
If such evidence emerges, however, one might consider compensating certain sensitive tourist destinations in Europe for their financial losses using part of the charge revenues.

A competitive distortion of a European aviation charge might also arise if tourists from outside the EEA change their destination from a European to a non-European country or region. It can be argued, however, that such a distortion is likely to be small, because many people tend to go to Europe to visit a capital city such as London, Paris or Rome. In this case, obviously, it is difficult to find an alternative outside Europe.

Other charge bases
Above, the possible economic distortions of an emission charge levied en route in EEA airspace have been discussed. Other charge bases - in particular a fuel or a ticket charge - are likely to generate greater competitive distortions.
A fuel charge will cause larger distortions for both airports and tourist destinations, because roughly half the charge on a two-way trip can be avoided by shifting origin or destination to outside the EEA. This generates a much larger financial benefit than in the case of an emission charge levied en route. On a flight of 6000 km, for example, the potential gain of shifting origin or destination to an airport just across the Eastern border of the EEA is estimated at 30 US$ or more (compared with about 2$ for the emission charge), assuming introduction of a fuel charge of 0.20 $/l. It is hard to judge whether such a gain will have any substantial impact on travel behaviour. A fuel charge is more vulnerable to such economic distortions than an emission charge, because by choosing the airport of origin or destination outside Europe bunker charge payment on the whole flight can be avoided.
The economic distortions of a ticket charge depend on the structure of the charge. The most acceptable structure of the ticket charge seems to be a specific tariff for each departure for an intra-European flight and a double

tariff for each departure with a destination outside the EEA. In this case a financial gain can be achieved for travellers and freight with an origin or destination outside Europe if they shift their airport of arrival or departure to just outside the EEA. The resulting distortions might be somewhat larger than in the case of an emission charge levied en route but are certainly smaller than those of a fuel charge.

A word of caution

Finally, it is important to stress that current knowledge of the impact of environmental charges on competition between the European and non-European aviation and tourist industries is limited. We are embarking on a new and complex field of research with many uncertainties. The results of this background study should therefore be seen as a first step in understanding the potential competitive distortions that might arise as a result of a European aviation charge.

D Legal issues

D.1 Introduction

This legal analysis[117] addresses the regulations relevant to implementing a tax or charge on aviation activities to protect the environment. It focuses on the relevant national and international provisions, including the Chicago Convention, bilateral Air Services Agreements (ASAs), the GATT/GATS and European Union legislation. Specifically, the Centre for Energy Conservation and Environmental Technology (CE), of Delft, the Netherlands, has submitted four suggestions for a charge: on fuel, on emissions, on tickets and on air traffic control. These options are examined in this chapter.

The paper does not focus on political or economic issues relating to applying fiscal measures to aviation. Nor does it address the practical questions related to what body will collect such a tax or how the collected funds should be apportioned.

The analysis is structured as follows: Section D.3 analyses the relevant provisions of the Chicago Convention and Section D.4 looks at bilateral ASAs and how they apply to taxes and charges on aviation. In addition, information is given on ICAO initiatives and opinions related to aviation charges (Section D.5). Section D.6 examines relevant European Union law. Section D.7 looks at how the present questions relate to the General Agreement on Tariffs and Trade. It then provides information on comparable measures from the viewpoint of international organizations. The last part of this annex (Section D.8) examines each of the four suggestions put forward by the CE (a charge on fuel, on emissions, on tickets, and on air traffic control) in the light of the legal regulations presented in Sections D.3 to D.7. Instead of a conclusion, the chapter rests on the Executive Summary, which follows (Section D.2). This also offers a very brief review of the material to be found in this annex, so that the reader can examine the appropriate section of the chapter for detailed information.

One point should be noted from the outset: although the current legal regulatory structure is outlined below, it is stressed that, before any particular fiscal measure is implemented, the precise factual legal situation must be investigated. In other words, this paper does not provide legal advice on a measure about which all details are not currently known.

---

[117] This legal analysis has been carried out by the International Institute of Air and Space Law of Leiden, the Netherlands. This analysis is the former Chapter 5 of the preliminary study (Bleijenberg et al., 1996) for this project.

D.2 Executive summary

Although Article 15 of the Chicago Convention Article 15 forbids a charge on transit fuel, it does not prevent a state from levying a charge on the fuel bunkered on its territory. Nor does it prevent a levy being raised on fuel emissions. There is also no prohibition against levying a fee on tickets or air traffic control. Moreover, the international system of bilateral Air Services Agreements (ASAs) also prevents charges on fuel in transit and usually restricts fuel taken on board an aircraft at an airport from being taxed, although each specific bilateral situation must be investigated individually.

The European Union's Third Package of Aviation Liberalization Measures has made the territories of the EU member states into one Community aviation market. The bilateral ASAs between the member states still regulate the international aviation situation where there are no Community measures taken, such as the Third Package. With regard to fiscal matters, member states are sovereign where no Community measures are taken. In the present situation, it should be noted that all measures must comply with specific Community measures and some fundamental principles of Community law, such as the prohibition of national discrimination, distortions of competition, unfair state aids, infringements on free movement of persons, goods and services, and the objective of harmonization.

The GATT (General Agreement on Tariffs and Trade) and GATS (General Agreement on Trade in Services) are not of direct relevance to fuel taxes and charges on air transport. Currently air transport services are only affected sectorally by the GATS, so for the purposes of this study GATS does not apply.

With regard to the proposed taxes and charges on fuel, on emissions, on tickets and on air traffic control, which are examined in detail in this chapter, there may be legal regulations which could hinder their implementation, but assuming the proper procedures and precautions are followed, there remain several options. However, it should be noted that before any measure is adopted, the precise legal and factual situation must be verified under existing international and national law.

D.3 Chicago Convention

The International Civil Aviation Organization (ICAO) is a specialized agency of the United Nations and was formed in 1947. It has a Legal Committee which prepares and drafts international treaties and conventions on air law, and later submits them for approval to diplomatic conferences. It was created under the *Convention on International Civil Aviation* (the Chicago Convention). The Chicago Convention[118] is the fundamental treaty governing international civil aviation. It currently has 183 parties, and can be

[118] Chicago, 7 December 1944, ICAO Doc. 2187.

considered to have global application. With particular regard to *charges*, the Convention states in Article 15 that they must be applied in a non-discriminatory fashion.

One can generally divide aeronautical charges into two groups: those for the airport (comprising landing, passenger check-in, security, ramp services, etc) and those for air navigation services (such as meteorology, air traffic control, etc). Details of these services are provided in the Convention's 18 annexes, containing what are called Standards and Recommended Practices (SARPS). The SARPS are a set of minimum *standards* which ICAO insists that states maintain for their aviation industry in addition to *recommendations* which ICAO urges states to adopt. Only the Standards are mandatory (unless states find it impractical to comply with any standard), while the Recommended Practices are simply that - recommended. Annex 16 Volume II contains the provisions with regard to aircraft emissions, certification of engines and similar related details.

Article 15, which forbids discrimination, is relevant to environmental taxes and charges. The right to use the facilities (aerodromes and related facilities) of a state must be subject to uniform conditions for the aircraft of the states party to Chicago. What must be highlighted here is the last sentence of Article 15: '*No fees, dues or other charges shall be imposed by any contracting state in respect solely of the rights of transit over or entry into or exit from its territory of any aircraft of a contracting state of persons or property thereon'.*

The word '*solely*' in the preceding sentence may have legal relevance. If one would say that the environmental 'fee' is not *solely* for transit over or entry into or exit from a state, then environmental charges/taxes should be permissible. But the problem then is stating what purpose the 'fee' is for, if not for permission to use the airspace for travel? If it is for environmental reasons, it would be permissible.

The following would appear to be an example of a non-discriminatory provision: if the Netherlands wanted to tax fuel bunkered within its territory, it would have to tax all fuel bunkered by all airlines. Thus, it could not tax only 'richer' countries such as Japan (Japan Air Lines) or America (American Airlines), and then give favourable treatment to 'poorer' countries, such as Zimbabwe (Air Zimbabwe). All airlines of all countries would have to be taxed equally.

In addition to Article 15, there is Article 38 which concerns 'departures from international standards and procedures'. This article requires a state to report its charges to ICAO regarding how its practice differs form the international standard. ICAO thus reviews any charges imposed to monitor uniformity and legality. The concern of the ICAO Council is that charges on air traffic will proliferate and they could lead to retaliatory effects[119].

Article 24, which grants tax-exempt status and exemptions from charges to fuel and aircraft stores that are used *in transit*, is also worthy of note, and is discussed in Section D.4, below.

Thus, the Chicago Convention and the ICAO Council's administration of it show that *fiscal measures could be implemented*, provided they are narrowly tailored, non-discriminatory, and have a specific purpose other than passage through a state's airspace[120].

D.4 Bilateral Air Services Agreements

As stated in the previous chapter, the Chicago Convention provides the framework for international civil aviation. However, this relationship is further regulated under treaties between individual states called 'bilateral air services agreements' (or ASAs). These ASAs permit the states to provide for all issues between themselves governing matters in the field of the operation of air services.

Legally, these ASAs are between states, and the airlines are not parties to them. Thus, they can be viewed as contracts between the governments and only binding on the states themselves, and therefore an airline generally cannot claim that a provision was violated by the opposing state, as the airline is not a party to the ASA.

However, the vast majority of bilateral ASAs contain language which forbids taxes on fuel, lubricants, spare parts and the like which are not unloaded from an aircraft but are then re-exported to another territory. Thus, the proposal to charge or tax fuel which is kept on board an aeroplane and not consumed by airlines of any state other than the state which imposes the tax would be contrary not only to Article 24 of the Chicago Convention but also to many bilateral agreements[121].

---

119 See, Heilbronn and Bonsall, *Aeronautical Charges: the need for a more specific legislative context* (on file at Institute) on pp. 4-5, citing the ICAO Council's *Statements by the Council to Contracting States on Charges for Airports and Air Navigation Services*, (ICAO Doc. 9082/4, 4 ed. 1992) 3 (airport charges) and 10 (air navigation service charges), which states that States should:

> (i) impose charges only for services and functions which are required for international civil aviation; and
> (ii) refrain from imposing charges which discriminate against international civil aviation in relation to other modes of international transport.

120 There are other conventions as well that partially regulate fuel or lubricants, but the Chicago Convention is the most relevant. For example, there is the *Convention Concerning Exemption from Taxation for Liquid Fuel and Lubricants in Air Traffic*, London, 1939, but only Denmark has adhered to it, and it is consequently not in force.

121 "It can be seen that any imposition of (tax) on the fuel, lubricants, spare parts and aircraft stores used by airlines in international air transport, including intra-EC air transport, would be contrary to the bilateral air transport services agreement under which these airlines

The question then focuses on fuel bunkered in the country. If fuel in transit is, in principle, not taxable, then what about fuel taken on the aircraft? In most cases, fuel introduced into an aircraft on foreign territory is also exempted from charges and taxation under exemption clauses in ASAs[122]. Such practice is based on ICAO Recommendations in this respect[123].

In practice, there are countries imposing taxes on fuel bunkered and consumed on domestic services within their territories. Some of these are examined further in Chapter 2 of the preliminary study. In the United States, individual states can tax fuel consumed even on international flights[124].

The question as to whether or not this is allowed under the relevant bilateral ASAs cannot be answered without examining both the national legislation and the applicable bilateral ASAs[125]. The national law of a certain country may permit charging or taxing fuel bunkered in that country. However, if a bilateral ASA provides for exemption from such charging or taxation, the

---

operate." *International Air Transport Position Paper on the Application of European Community Value Added Tax on International Air Transport*, Document 6, (1990), at p. 72. As to the applicable exemption clause, see the next footnote.

122 Thus, 'Standard Customs Clauses' exist in bilateral agreements. Not only "use" in the territory is covered (preventing taxing fuel *used* during the journey, which was brought in by the aircraft), but also the fuel bunkered on foreign territory. It states: "There shall also be exemption from all customs duties, inspection fees and other charges or taxes for the hereafter mentioned items, even when these items are to be used on the parts of the journey over the territory of either Contracting Party:... (c) supplies of fuels and lubricants *introduced into* the territory of one Contracting Party or *taken on board* the aircraft operated by such designated airline and intended solely for use on board outbound aircraft in the operating of international services" *(Italics added)*. The point can not be stressed heavily enough that every bilateral situation is different, and the specific treaty must be read before a definite legal answer can be given.

123 See ICAO's *Policies in the Field of International Air Transport*, ICAO Doc 8632-c/968, November 1966, Section IV, at p. 14.

124 See, *Wardair Canada, Inc. v. Florida Department of Revenue*, 106 S.Ct. 2369 (1986). This case is from the U.S. Supreme Court, the highest court in the country. See also Subsection 2.3, above.

125 There are very few examples of air services agreements which provide for an explicit exception to the general rule that fuel taken on board aircraft in foreign territory is exempted from taxation. See, however, Article 6(2)(c) of the Model multilateral air transport agreement between a group of states and another group of states, designed by the African Civil Aviation Conference (AFCAC), stating: "There shall also be an exemption from the same duties, fees and charges with the exception of charges corresponding to the service performed:

> (c) fuels and lubricants supplied to aircraft of the designated airline of a contracting party engaged in an International air service even in the case where such supplies shall be used in the journey performed over the territory of the contracting party where they were loaded." (Quotation taken from *Instituut voor Onderzoek van Overheidsuitgaven, Luchtvaart en Milieu: Instrumenten voor Overheidsbeleid* 44 (1994). It could be defended that an implicit exception to that general rule may be found in, for instance, the bilateral ASA France - US of 1946, as amended in 1950, 1951, 1959, 1960 and 1969, which only exempts fuel in transit and fuel consumed in foreign territory, but not fuel bunkered in that foreign territory (see Article III(c)).

bilateral ASA supersedes the application of national law[126]. Another complicating factor may arise in the situation of federal states.
If the government of a federal state, for instance the USA or Canada, concludes a bilateral ASA with a foreign country, that ASA may provide for an exemption from charging or taxation of fuel taken on board the aircraft registered in or operated by the designated airlines of the two countries party to the ASA. Such an exemption clause does not prevent non-federal governmental entities, for instance the state of Florida or the state of British Columbia, from charging or taxing fuel taken on board by foreign aircraft in their territory.

It can be noted that the introduction of new taxes on aviation would contradict some recently published policy studies, ranging from the US National Commission's *To Ensure a Strong Competitive Airline Industry* to the European Union's *Committee of Wise Men* on Air Transport report, both of which have urged governments to provide tax relief to the airline industry[127]. However, it can also be pointed out that researchers have yet to find a major global industry as large as international aviation that has favoured the introduction of new taxes.

In conclusion, the picture as regards bunkering of fuel is very complicated. There is no other general conclusion than that each situation must be looked at on a case-by-case basis. The only general rule is that fuel in transit is not taxable, and that in most cases fuel bunkered on foreign territory is exempt from charges and taxation.

D.5 ICAO position

During the Worldwide Air Transport Conference (23 November - 6 December 1994) on ICAO's 50th Anniversary, there were expressions of hope that the Committee on Aviation Environmental Protection (CAEP) would complete its study of emissions-related charges. Furthermore it was recommended that "ICAO should continue to attach high priority to addressing environmental issues related to civil aviation"[128]. The Worldwide Air Transport Conference elicited many statements from many delegations over a two-week period. In order to be perfectly accurate, here are several of the conclusions reached at the conference.

---

[126] Of course, within Europe, the bilateral ASAs have been superseded by measures taken at the community level, in so far as the Community level provides for regulation of the issues covered by the bilateral ASAs. This is not the case for the taxation duties and charges clauses of the bilateral ASAs. However, at this point, and as a general principle of international law, individual States may not take measures contrary to international treaties to which they are a party. See, generally, Brownlie, *Principles of Public International Law*, at pp. 12-13 (1979).

[127] See, Working Paper presented by the International Air Transport Association, entitled *"Taxation"*, at the Worldwide Air Transport Conference, 23 November - 6 December 1994, AT Conf/4, WP/21, 20/7/94, at par 2.3.

[128] Working Paper presented by Sweden, *Using Charges to Achieve Reductions in Aircraft Emissions*, A31-WP/70, EX/25, 7/8/95, at par. 2.4.

Regarding taxes, the conference concluded that "the imposition of taxes on the sale or use of international air transport was an impediment to the sound economical and orderly development of international air transport operations". Furthermore, "taxes and user charges constitute an ever growing burden on airlines and consumers and have a negative impact on the development of the air transport industry"[129]. It is very clear therefore where ICAO stands.

Regarding environmental laws, ICAO was also very clear. ICAO is not in favour of additional taxes and charges. More constructively, and arguably better for the environment, ICAO proposes *stricter and harmonized regulations regarding environmental standards*. It asserts that considering that the environmental problems of civil aviation are of a global nature, their solutions must be addressed in a coordinated manner. There should thus be uniform rules on aircraft noise, engine emissions, etc., and the work should primarily be done through CAEP (the
Committee on Aviation Environmental Protection).

Finally, with regard to environmental concerns and charges, ICAO gave its full support to integrated regulatory practices. This meant efforts to reduce environmental burdens associated with civil aviation by consolidating approaches to airport capacity development, reductions of aircraft emissions and noise at-source, careful land-use planning around airports, and other complementary operational and intermodal measures. In other words, there was support for increasing harmonized technical standards in respect of environmental regulation of air transport, such as international noise and emission standards for aircraft certification through Annex 16 of the Chicago Convention.

The conclusion of the conference was therefore that stricter environmental regulation would be welcomed, provided it be accomplished through stricter regulatory measures rather than fiscal ones.

D.6 European Community

The European Community's Third Package of Aviation Liberalization Measures has opened up the territory of the European Union into one Community aviation market. The bilateral ASAs between member states only regulate the international aviation situation where no Community measures apply. In this context, regard must be given to Directive 92/81/-EEC (discussed below under Harmonization). All member states are sovereign in regard to domestic fiscal matters. In the current situation, it should be noted that all measures must comply with some fundamental principles of Community law, such as the prohibition of national discrimination, unfair state aids, and infringements of the free

[129] Report of the Worldwide Air Transport Conference, 23 November - 6 December 1994, Doc. 9644, AT Conf/4, at page 36, par. 2.6.15.1.

movement of persons, goods, and services.

Fiscal neutrality of proposed tax measures
The starting point is unambiguous: each member state of the EC is sovereign in fiscal matters. Subject to certain restrictions which will be discussed in the following paragraphs, each state is free to set up its own tax system, and to determine the level of these taxes, up to the moment at which harmonization is realized.

The main restriction to be taken into account in the present context is the non-discrimination principle, which is also embodied in international air law. Taxes on imported products may not exceed taxes on the same or similar products. Taxes include environmental charges. In other words, domestic goods and services may not enjoy a preferential treatment as a consequence of fiscal privileges.

Prohibition of infringement of free movement of goods and services, and prohibition of state aid
One of the basic objectives of the EC is to ensure the free movement of goods and services. Another objective is the adoption of a common policy in the field of air transport. Since the EC is based on a customs union, customs duties on imports and exports are prohibited, as are all charges having a similar effect.

Moreover, the revenues from the charge may not result in state aid, which is forbidden under EC law. That means that the revenues produced by the charge may not be used for the financing of national activities which distort intra-EC competition. Under EC law, unanimity is required for tax/fiscal measures at Community level.

The environmental justification
Since 1993, the EC is working to develop an environmental policy which is based on Title VII of the Treaty on European Union. Its objectives are:
- to preserve, protect and improve the quality of the environment;
- to contribute towards protecting human health;
- to ensure a rational utilization of natural resources.

As pointed out earlier, there is a growing tendency to permit environmental concerns to prevail over free trade interests. It very much depends on the nature, purpose, and side-effects of the proposed measure whether or not such a justification will be considered valid. Here as elsewhere, jurisprudence and decisions of the EC Commission must give an answer. This is, again, not quite predictable in the light of uncertainty over the precise nature and purposes of the charge, and on the outcome of legal proceedings.

Harmonization
EC member states have committed themselves to the harmonization of national legislation concerning turnover taxes, excise duties and other forms of indirect taxation to the extent that such harmonization is necessary to

ensure the establishment and the functioning of the internal market. In view of the impact of air services on the completion of the internal market, it would appear that the latter condition has been fulfilled. The results of intra-EC tax harmonization have, however, so far been rather modest. However, it is worth taking note of Directive 92/81/EEC, which exempts air carriers from payment of fuel taxes within Europe. As this directive is set to expire in 1997[130], some governments are re-evaluating its value, such as Germany.

External Relations
Until now, each member state of the Community has been responsible for the conduct of its external relations with non-EC countries. At present, discussions are occurring between the EC Council of Ministers and the Commission about transferring certain competencies in the field of external aviation relations from the member states to the Commission. The most obvious instances in which this might occur are relations between the EC and the USA, and between the EC and Switzerland, followed by countries in Central and Eastern Europe.

If consensus regarding the introduction of a tax or a charge on air transport services or products has been reached by the EC Council of Ministers, the Council could be advised, *inter alia* on the basis of the results of this study, to take these results into account when mandating the EC Commission to formulate the external aviation policy of the Community. In other words, the EC, as represented by the Commission, could submit that it is no longer prepared to maintain the clause which exempts air carriers from taxation and duties which apply in the present bilateral context.

This would be tantamount to modifying the existing laws as they relate to aviation policy. Thus, what remains to be respected are, of course, the principles of the Chicago Convention and ICAO Resolutions, as all EC Member States are members of ICAO. References to the Convention and ICAO are discussed elsewhere in the report.

Conclusions
Each member state is, in principle, free to set up its own domestic taxation system, subject to:

- the non-discrimination principle, implying fiscal neutrality between domestic products on the one hand and products imported from other EC states on the other;
- the objective of elimination of intra-EC trade barriers;
- the prohibition of state aid;
- achievement of the environmental objectives;
- the objective of fiscal harmonization.

In short, the EC context is very complex. It very much depends on the circumstances of the case - that is the nature, purposes and side- effects of

---

[130] See Article 8(1)(b) of said directive.

the proposed measures - as to whether or not the above requirements are fulfilled. Consequently, this study strongly recommends at least an EC based-solution, as opposed to a national measure, taking into account the existence of Directive 92/81/EEC.

D.7 Trade and the environment

GATT and the World Trade Organisation (WTO) are committed to the minimization of government actions which inhibit or limit global trade. GATT maintains global coverage.

Several provisions must ensure this commitment. Reference is made to the Most Favoured Nation clause, Article III of the GATT, which states that a privilege granted to one contracting party must be awarded to all contracting parties, and the national treatment principle in the field of taxation, including the provision that imported goods must be given treatment no less favourable than domestic goods. The General Agreement on Trade in Services (GATS) applies only marginally to trade in air services, and is not of relevance to the environmental fiscal measures proposed here.

Exceptions to the global free trade rule are in some cases of an environmental nature, namely the protection of the life and health of humans, animals and plants, and the conservation of exhaustible natural resources. The GATT panel decides whether or not these exceptions can be deemed to apply.

In recent years, several cases have been brought to the attention of the panel, which has tended to interpret the environmental exceptions rather broadly. This attitude is also influenced by the coming into being of environmental conventions and commitments, such as the Climate Change Convention and the 1992 Rio Declaration on Environment and Development.

Conclusions
- The GATS does not apply to the current proposals;
- Global free trade and the environment may have conflicting interests, which have not yet been resolved by a treaty which combines and balances both interests;
- To judge which interest should prevail very much depends on the particulars of each case, including the question of whether or not the state or group of states proposing the environmental charge is party to a convention which has been drawn up to protect the environment from damaging acts for which the polluter should be charged.

D.8 Conclusions

The picture regarding aviation law can be summarized as follows. The Chicago Convention is the fundamental treaty on international civil aviation.

Most nations of the world, including the 15 EU member states, are parties to this treaty. Its provisions form binding international law, superseding bilateral ASAs and national air codes. Bilateral ASAs regulate the operation of air services between pairs of countries. They supersede national regulations. EC aviation law replaces the bilateral ASAs between the EC member states, if EC aviation law covers matters dealt with by these ASAs. It follows from this that EC aviation law does not replace, or supersede, the provisions of the Chicago Convention. EU member states are committed to respecting these provisions. EC aviation law applies only to the relations between the member states of the European Union. Each EU member is still responsible for the conduct of its own aviation relations with non-EU members. Therefore, these relations continue to be governed by bilateral ASAs concluded between an EU member and a non-EU member, so long as the superseding competence of the EU in the field of external relations does not apply[131].

There are three basic options proposed by the Centre for Energy Conservation and Environmental Technology (CE) for instituting a charge on aviation to further environmental protection: an emissions charge, a fuel charge and a surcharge placed on passenger movements. These options are investigated respectively below. However, it should be pointed out that the details of these various charges have not yet been formulated, and there may be differences based on various factors, such as between scheduled and charter flights. Moreover, there may be variations in respect to flights (departing or arriving), whether or not the flights are intercontinental, and whether they are domestic or international.

Emission Charge

Placing a charge on the emissions actually emanating from an aircraft does not face too many obstacles, that is from the point of view of an international aviation law. As stated above, airlines acknowledge that they should be responsible for any environmental damage they cause. Not only would airlines be encouraged to find more environmentally beneficial technology, but also, if it were possible, they might fly at altitudes which would more readily absorb their harmful emissions[132]. Again, however, the precise details of a legal measure would need to be

---

[131] Confusion may arise as to the references to both EC and EU. Since aviation is considered as an economic activity, it falls under the scope of the Treaty Establishing the European Community (EC), which is the follow-up of the Treaty Establishing the European Economic Community (EEC), having as its objective the creation of a common market and an economic union. The scope of the Treaty on European Union (EU Treaty) is broader, as it encompasses not only the EC Treaty, but also provisions on foreign policy and external relations. That is why both abbreviations are used.

[132] Not a lot is known about the effect of aviation emissions on the three basic layers of the atmosphere: the boundary layer, the upper stratosphere and the lower troposphere. The boundary layer is closest to the ground, and is affected not only by aircraft, but also by cars, factories and daily human life. The report *Aircraft Emissions and the Global Environment* of the Environmental Defense Fund (1994) details aviation's effects on each layer, at pp. 7-12.

worked out in order to determine its compliance with both national and international law. In this context, it should be added that the above conclusion is based on a literal interpretation of the applicable provisions of the Chicago Convention and the bilateral ASAs. A broader interpretation could lead to the assumption that emissions fall under the heading of fuel, which would mean they would be exempted in the same circumstances. It is not relevant from the point of view of international aviation whether the emissions charge is levied as a landing charge, an *en route* charge, a charge per carrier, or a passenger airport charge. It has been explained that, pursuant to Article 15 of the Chicago Convention, the non-discrimination principle also applies, but that provision does not explicitly mention emissions charges. Article 15 merely refers to "charges that may be imposed ... for the use of ... airports and air navigation facilities". Again, the same conclusion as stated above regarding the interpretation of bilateral clauses applies here: if one can adopt a broad interpretation, emissions charges could fall under the scope of Article 15, and hence the non-discrimination principle, whereas a strict interpretation excludes emissions charges from the reach of Article 15.

Eurocontrol could be asked to play a role in the collection of emissions charges. In Europe, the essential tasks of Eurocontrol are to coordinate the planning of air traffic for the relevant airspace, to collect *en route* charges on behalf of member states, and to harmonize air traffic control systems in Europe. Under certain conditions, charges relating to the use of air navigation services are to be paid by the operator of the aircraft to the organization. States party to Eurocontrol have agreed to adopt a common policy with respect to the establishment and collection of these *en route* charges. Most EU countries are members. Since Eurocontrol works on the basis of a common policy of its member states, nothing would prevent them from raising the proposed charges for environmental purposes. If such a measure is to be attained, there are internal Eurocontrol procedures that would have to be followed. In short, the establishment of charges is a matter of national competence. Here again, the non-discrimination principle of Article 15 of the Chicago Convention must be respected.

Fuel Charge
A charge based on bunkering of fuel would provide a direct incentive to improve the efficiency of an aircraft engine. An engine that uses less fuel would save an airline money it would otherwise have to pay in taxes. The exact details of the charge are yet to be worked out, such as the collecting authority or the amount of the actual tariff.

The taxing or charging of fuel in *transit* violates the Chicago Convention and could violate existing bilateral ASAs. One option is that the states could agree to amend the Chicago Convention, or their bilateral ASAs, or at least draft another international accord. This, however, is currently unrealistic. Although there are at times restrictions on taxing fuel bunkered within a state's territory, it is possible that measures could be taken which comply with the established legal rules.

Although the Chicago Convention regulates this matter, the bilateral ASAs go further, as stated above, most even going so far as to regulate the fuel consumed and even taken on board in foreign territory. Thus, although the general guidelines have been provided here, for any particular proposal a precise legal investigation must be undertaken, accounting for the peculiarities of each case.

Charge on passenger movements

Placing a surcharge on passenger tickets levied at airports in Europe is another option to assist environmental protection from aviation[133]. The charge would be easy to collect, as it could be built right into the price of the ticket, or added on separately as airport taxes sometimes are. IATA has passed a resolution on this, which can be noted by the reader[134]. Norway has introduced such a charge and had hoped that the introduction of a tax on flying would encourage passengers to use the train instead. Those anxious to tax aviation propose a 'seat charge', which collects more revenue than a ticket charge, as the airline must then pay for seats it cannot fill; hence it may encourage efficient use of capacity.

NOTA BENE: Although the detailed regulatory structure has been provided in this analysis, the precise wording and formulation of each measure must be examined to verify its compliance with national and international law and inter-state relations. This examination has focused on international aviation law, but the circumstances of each case will differ. Other legal agreements may be affected, such as, for example, the EU guarantees of free movement of persons, services and goods, or treaties on a particular point which has not been investigated in this analysis. Proper legal advice cannot be provided in the absence of full details of any particular measure.

---

133 In regard to passengers, tickets may be subject to an environmental charge. However, in regard to cargo, a formula can be devised relating to the weight of the item to be shipped, or in reference to the air waybill, for example. Again, the actual details could be worked out, should this idea be implemented.

134 See IATA resolution 785.

E Selection of charge options for further research in this study

E.1 Introduction

In Chapter 3 of this report five options for a European aviation charge are evaluated. These five charge options are the result of a selection from a longer list of options for a European aviation charge. This annex describes the selection process (Section E.3) followed to limit the number of charge options to be evaluated in Chapter 3. First, in Section E.2, an overview of possible options is presented.

Based on the different combinations of characteristics (charge base, levy point, allocation and use of the revenues) for the design of a charge, a huge number of different options for an aviation charge could be distinguished[135]. A detailed evaluation of all possible options leads to an unreadable book and is not effective in this context. Instead, a pre-assessment has been carried out in order to select charge options for further research. It should be stressed that the only reason for this pre-assessment is to limit the number of options for a European aviation charge to be evaluated in detail. For this reason, the selection of the options is based on research criteria (representativeness, perspective on feasibility, and consistency) and not on the criteria used for the evaluation of the charge options.

E.2 Overview of options for an aviation charge

This section presents an overview of possible types of aviation charges.
As shown in Chapter 2 of this report, the following characteristics are important for designing a charge option:

1 charge base:
  - emissions
  - fuel
  - movements

2 levy points:
  - landing
  - route charge
  - carrier
  - bunkering fuel
  - measured fuel consumption
  - airport

[135] See also Barret, M. (1994) for an overview of environmental charges for controlling greenhouse gas emissions from civil aviation.

- ticket

3 options for allocation of the charge revenues:
  - to national states
  - to the European level, e.g. to a body or international treaty
  - to the airline companies paying the charge

4 options for use of the revenues:
  - to finance environmental policy measures for the aviation industry, such as R&D and subsidies for cleaner aircraft
  - to compensate economic sectors hurt by the charge
  - to reduce general tax levels, especially labour and company taxes.

Combining with one or more option(s) for each characteristic would lead to an enumeration of specific options for a European aviation charge, thus yielding a huge number of possible charge options. Figure E.1 shows the different possibilities for a charge based on different combinations of characteristics. An example of a charge option is an emission-based landing charge of the level that is required to achieve environmental targets, with the revenues being collected by a European authority in order to compensate for negative economic effects and to start an R&D fund for energy-efficient, low-emission aircraft.

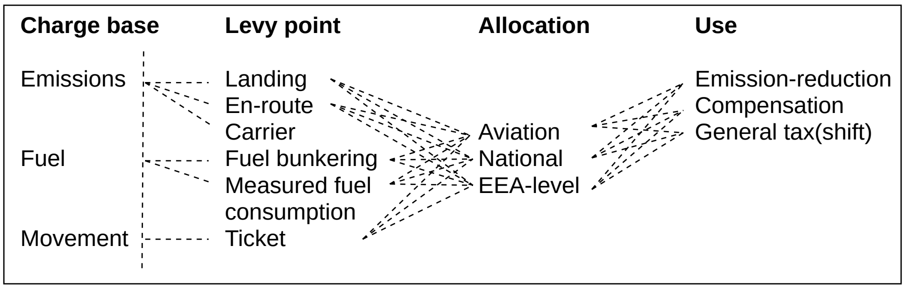


Figure E.1 Overview of possible charge options

Obviously, the level of a charge also constitutes a characteristic for defining a charge option. For the charge options to be selected, a working range for the charge level has been considered corresponding with 0.10 to 0.40 $ per litre fuel. In the remainder of this annex the charge level will therefore not be discussed further.

Below, different options for an aviation charge are described. The starting point of the overview presented is the levy point. For each charge, as relevant, the tariff structure (percentage, absolute, etc.) of the charge is discussed.

Landing charge

An emission-based landing charge could be applied to aircraft visiting an airport. This charge is easy to apply because it can be included in existing landing fees. The following sub-options can be distinguished:

- to charge each kg pollutant emitted during landing and take-off (LTO)
- to charge each kg pollutant emitted during the incoming flight
- to charge each kg pollutant emitted during the incoming *and* outgoing flight.

It seems logical for the revenues of the first sub-option (LTO emissions) to be allocated to the country where the airport is located. Revenues of the second and third suboption could be allocated to the European level or (based on an allocation rule to be agreed upon) to national states.

Differentiation of landing fees
The basic idea would be to increase existing landing fees for environmentally inefficient aircraft and reduce existing landing fees for environmentally efficient aircraft. The pattern of increase and reduction would be specified with the aim of being revenue-neutral. This implies that the higher charges levied on inefficient aircraft would balance the lower charges levied on efficient aircraft. The revenue-neutral charge implies that the overall level of the charge is not high enough to internalize all the environmental costs of aviation.

En-route charge
An emission-based charge could be levied at the same time as a route air navigation services charge. The charge could be implemented according to the current procedure of Eurocontrol that charges airlines the costs of air traffic control services[136]. In this way all emissions emitted by an aircraft in European airspace will be charged.

Emission-based ticket charge
This charge would be added to the air transport fare and have a level based on 'standard' emissions for a certain engine/airframe combination between a certain city pair. As the number of passengers is uncertain in advance, the emission charge would have to be levied on each seat or on a fixed load factor.

Combination of emission-based options
Combining different levy points might be attractive. One option is to charge for the emissions during landing and take-off (LTO) as part of the landing fees, and to charge for those during the cruise phase in European airspace via a route charge. The revenues of the landing charge on LTO emissions can be allocated to the national states, while the revenues of the route charge on cruise emissions can be allocated to the European level.

---

[136] For many years now, the flight paths of aircraft are measured and registered by Eurocontrol based on the formula of the 'most flown route' of all aircraft between each city pair. If an emissions-based route charge were added in accordance with this formula it would also minimize the risk of airlines trying to avoid paying the charge (see also the background study on 'economic distortions').

Charge on fuel bunkering

A charge based on fuel bunkering, in the form of a levy per litre sold, could be implemented in a straightforward manner, without necessitating much extra administrative work. Currently, petroleum companies routinely act as tax collectors for governments, and all major international companies have the accounting infrastructure and capability to extend this function to an aviation fuel tax. The tariff structure of the fuel charge could be a proportional charge (e.g. percentage of fuel price per litre) or an absolute charge (in cents per litre).

Charge on measured fuel consumption

A charge based on the fuel consumption measured during a flight would require that airlines inform the collecting authority on the actual fuel consumption of each specific flight. An advantage of a charge on actual fuel consumption compared with a charge on each litre sold is that airlines could not avoid the fuel charge by 'tankering'[137].

Movement-based ticket charge

This charge could be levied at the time of ticket purchase and can be added to the fare. From the various passenger taxes already operated at airports throughout the world it can be concluded that charges can be organized very easily.

Different forms for the tariff structure of the ticket charge can be distinguished:

- absolute (lump-sum) charge;
- proportional (percentage) charge;
- charge per passenger-kilometre (pkm).

The first option, an absolute charge, would hit short-haul flights relatively hard. The effect of a proportional charge (second option) depends strongly on the absolute level of the air transport fare. On routes with keen competition and therefore relatively low air fares, the ticket charge would subsequently be relatively low compared with 'high-fare' routes. The same phenomenon would arise between the different market segments. A first-class passenger would pay a much higher charge than an economy-class passenger, owing to the difference in fares. This second option is comparable to a form of VAT. The third option, a charge per passenger-kilometre, is a ticket charge related to the distance of the flight.

Alternative instruments

Consideration can be given to other policy instruments aiming at the reduction of emissions. For example, regulations on aircraft emissions, energy-efficiency standards, voluntary agreements with manufacturers and airlines, tradeable emission permits, a charge on newly purchased aircraft, or government funding or other support for R&D on clean and energy efficient technology and alternative fuels.

---

[137] Tankering implies airlines carrying extra fuel on flights stopping in a country with higher fuel prices in order to avoid or diminish refuelling in that country.

One approach might be to design a package of policy instruments, with a charge as a key instrument, in order to achieve a (cost-) effective reduction of all aviation emissions.
In this study the focus is on aviation charges to reduce emissions, hence the above-mentioned alternative policy instruments are not discussed. However, this does not imply that these alternative policy instruments are to be considered less feasible.

E.3 Research criteria for selecting charge options

In the previous section an overview of options for a European charge has been presented. This section presents three criteria for selecting charges with a view to selecting and consequently discussing a limited number of charge options.
The following research criteria have been used to select the main options for a European aviation charge, which are evaluated in depth in Chapter 3 of this report:
- representativeness;
- feasibility;
- consistency.

Representativeness
The results of the study should give a comprehensive presentation of different options for a European aviation charge. This implies that the selected charges should cover a broad range of characteristics (see above) of an aviation charge. For example, all three possible charge bases (emissions, fuel and movement) should be represented by the selected charge options.

Feasibility
The options for an aviation charge should have a chance of being feasible. In general, the feasibility of a charge (or any other policy instrument) depends on the evaluation of the charge on the policy criteria described in Chapter 2. These policy criteria are:
- environmental effectiveness;
- cost-effectiveness;
- distributional equity;
- transparency;
- subsidiarily;
- side-effects (economic distortions);
- enforcement;
- legal provisions.

Before selection of the main charge options to be evaluated in Chapter 3, it is necessary to undertake a pre-assessment based on the criterion of environmental effectiveness. The argument for using only this criterion for selection is that environmental effectiveness reflects the aim of the charge, viz. to reduce aviation emissions. This implies that the selected charge should ideally provide effective incentives for technical, operational (flight), load and volume measures to reduce aviation emissions.

Consistency
The charge options should be designed consistently with respect to the different characteristics of the charge. For example, it is not consistent to design a charge based on movements with bunkering as its levy point. It also appears to be inconsistent to choose a European authority for collecting the revenues while their use is for general tax expenditures at the individual state level. Obviously, this criterion limits the number of possible charges.

E.4 Selection of charge options for further research

In the previous section the research criteria for selecting a limited set of aviation charges are discussed. This section describes the selection process and sets out the arguments for the choice of five main charge options for a European aviation charge. The selected five main options are described in the next section E.5.

The starting point of the selection is the criterion **representativeness**. Based on this criterion, it is assumed in this study that all three options for a charge base (emissions, fuel and movements) and all three options for the allocation of the revenues (national states, European level, airline companies) should be represented in at least one of the main options selected. In this way, the feasibility study provides information on the advantages and disadvantages on all of the possible charge bases and allocation options.
In order to provide sufficient information on the different options it is, however, not necessary to describe all possible combinations. Once a characteristic of a charge is presented by at least one of the main options, the reader is then in a position to design a charge with his or her own combinations.

The criterion **feasibility** also provides a guideline for selecting the main options for further research. In the context of selection, this criterion is based only on environmental effectiveness. This implies that the selected charge options should provide rather good incentives for reducing aviation emissions by all of the possible measures (technical, operational and volume). Below, the extent to which the different charges give incentives for introducing a broad range of emission reduction measures is discussed.

The emission-based charge would require some kind of classification of aircraft according to performance in standard emission tests. This implies that an emission-based charge would provide incentives for technical improvements and higher loads, but not for operational flight measures (e.g. cruising at higher altitude or to reducing speed) that may lead to emission reductions.

A fuel charge would provide an incentive for reducing emissions of CO_2, H_2O and SO_2. The advantage of a fuel charge compared to a calculated emission charge is that it may encourage operational flight measures. An important disadvantage is that a fuel charge is poorly related to the NO_x emissions of aircraft.

Finally, a movement-based ticket charge is poorly related to the pollution caused. Emissions per passenger movement may differ widely owing to differences in flight distance, type of aircraft and load factor.

Based on the above discussion on environmental effectiveness, it might be opted to select only emission- and fuel-based charges for further study. The criterion representativeness, however, requires that at least one movement-based charge added to the ticket price should be selected. A second reason for selecting a ticket charge is the similarity to a Value Added Tax (VAT) on air transport in the EU. Currently, intra-EU air transport is exempted from VAT. A third reason for selecting at least one movement-based ticket charge is that it might combine well with a revenue-neutral charge. In this combination, the incentives for technical and load measures are provided by the emission charge, while the incentive for volume measures is given by the ticket charge.

As justified above, a fuel charge should be selected because it provides very good incentives for fuel-related emission reductions. Legal constrains constitute an important reason for selecting only one fuel charge, however, as most of the Bilateral Air Services Agreements (ASAs) in force would have to be adapted in order to allow imposition of a European fuel charge. Most of the ASAs between various pairs of countries exempt from taxation fuel bunkered and consumed in the signatory countries[138]. The most commonly used clauses in ASAs do not prohibit charges on landing fees, en-route tariffs and surcharges on tickets in so many words.

Thus far, the selection process has resulted in one fuel charge, one ticket charge and one or more emission-based charges. Selection can be completed by using the criterion **consistency** with respect to the different allocation options for the charge revenues. Based on the consistency criterion, one might argue that the revenues of a charge on tickets and fuel bunkering should be collected by a national authority. This is in accordance with existing methods of tax collection: for example, the revenues of VAT on economic goods and excise duties on mineral oils are collected at the national level.

The remaining question is, then, which emission-based charges should be selected. The representativeness criterion requires that both other options for allocation of the revenues (European level and airline companies) should be represented in the selection of main charge options. This implies

138 See the preliminary study (Bleijenberg et al., 1996) for a detailed analysis of the legal implications of aviation charges.

that, besides the ticket and fuel charge in which the revenues go to the national states, two other charges should be selected: an emission-based charge in which the revenues are allocated to the airline companies and an emission-based charge in which the revenues are allocated to European level. For the sake of consistency, a third emission-based charge will be selected in which LTO emissions are charged and the revenues go to the national states.

The selection process described above leads to five main options for a European aviation charge: three emission-based charges, one fuel charge and one ticket charge. These five options for a European aviation charge are described in the next section.

E.5 Five main options for a European aviation charge

This section describes five options for a European aviation charge, which are evaluated in Chapter 3 of this report. These five charge options are the result of a selection from a longer list of options for a European aviation charge. It should be stressed that the reason for selecting only five options is a practical one: to limit the number of charge options for further research. The five selected charge options are:

1 **Calculated emission charge (revenues to the European level);**
This charge would be levied on each kg pollutant (CO_2, NO_x, etc.) caused by an aircraft in European airspace. The emission-based charge would require some kind of classification of aircraft according to performance in standard emission tests. One method could be to calculate the emissions of each engine/airframe combination on a certain route[139].
The emission-based charge leaves freedom to choose a levy point, because the calculations are not linked to a physical activity. Possible levy points are a landing charge, a route charge or a charge per airline company. As this charge option will be levied in European airspace, a route charge seems to be the most suitable levy point.
The revenues of this charge option would be allocated to the European level. These revenues could be collected by a European body connected with the EEA or redistributed based on allocation rules to be defined in an international treaty.
In both cases the revenues could be used for any or all of the following purposes:

---

139 One option for the purpose of aircraft certification is the ICAO database on engine emissions during the Landing and Take-Off cycle (LTO). Assumptions are then needed for the average flight path and load and for the quality of the fuel used. Another very simple approach is to calculate the average emissions per engine-airframe combination corresponding with a fixed flight distance. From an efficiency point of view this option is not optimal, because it charges short flights too much and long flights too little (relative to their respective emissions). This may, however, be politically acceptable, because for short trips other modes of transport can offer an alternative while for long trips they generally cannot.

- to finance environmental policy measures for the aviation industry, such as R&D and subsidies for cleaner aircraft;
- to compensate economic sectors hurt by the charge;
- to reduce general tax levels.

Figure E.2 shows how the first charge option is built up from different characteristics.

1

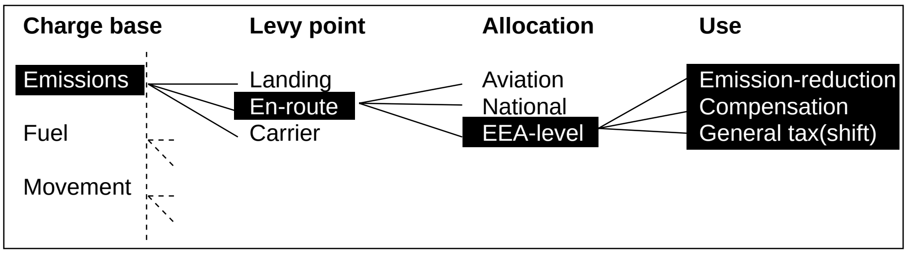


Figure E.2 Characteristics of charge option 1: emission-based route charge

2 Revenue-neutral emission charge (revenues to airline companies)

This charge would be levied on each kg pollutant (CO_2, NO_x, etc.) caused by an aircraft in European airspace. The difference from the first charge option is that the revenues are allocated to the airline companies. Recycling the revenues to the carriers implies that the charge is revenue-neutral. The levy point of this charge is a charge levied at the same time as the route air navigation services charge. Figure E.3 shows the composition of the revenue-neutral charge.

2

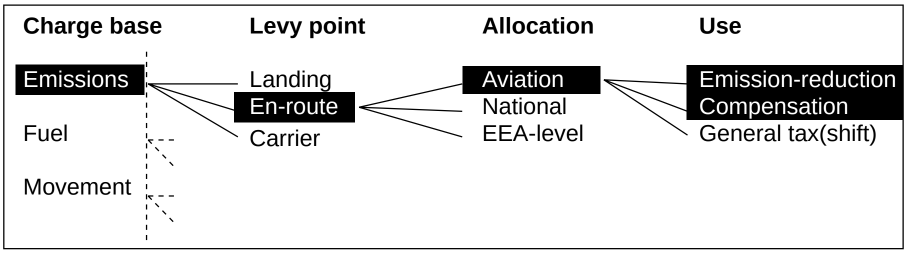


Figure E.3 Characteristics of charge option 2: revenue-neutral emission charge

A transparent and simple form for a revenue-neutral charge is for all (European and non-European) carriers to pay a charge related to their emissions in European airspace, with the same carriers being refunded the revenues in proportion to the number of passenger- and tonne-kilometres produced in the same geographic area[140]. Carriers with a good environmental performance receive more revenues than the charge they pay. On the other hand, carriers with above-average emissions per passenger- and tonne-kilometre are faced with a financial burden. Obviously, a revenue-neutral charge does not generate revenues for the treasuries.

3 Calculated emission charge on LTO only (revenues to national states)
This charge would be levied on each kg pollutant (CO_2, NO_x, etc.) caused by an aircraft during the Landing and Take-Off cycle (LTO cycle) at airports in the EEA. This charge would be levied at the same time as a landing charge. The revenues of this charge would be allocated to the national states corresponding with the LTO emissions of all (European and non-European) aircraft in the national territory of those states. The revenues can be used for any or all of the options mentioned above, under the first charge option. Figure E.4 shows the composition of the revenue-neutral charge.

3

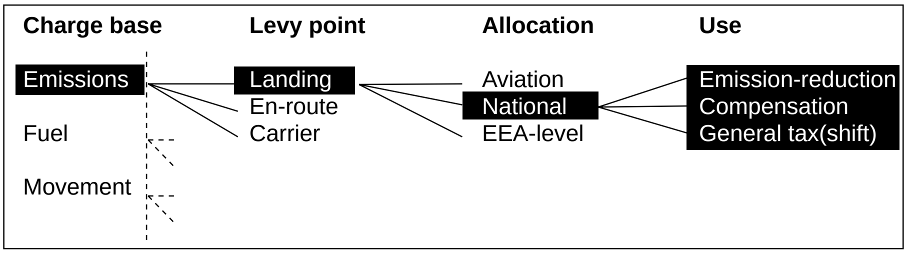


Figure E.4 Characteristics of charge option 3: Landing charge on LTO emissions

4 Charge on fuel bunkering (revenues to national states).
This charge would be levied on each litre of fuel bunkered by an aircraft in the EEA. Each country would receive the revenues from the charge on the fuel bunkered in their territory.

4

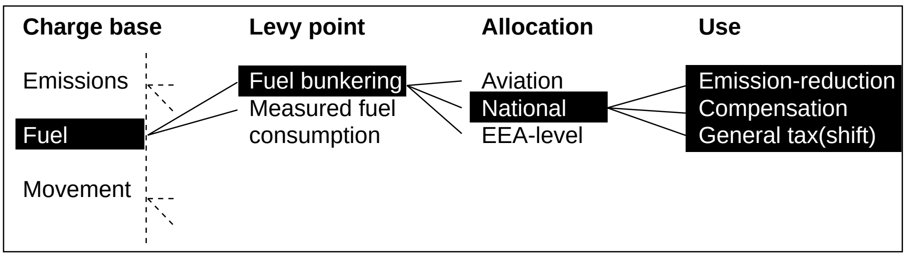


Figure E.5 Characteristics of charge option 4: charge on fuel bunkering

[140] A similar approach is followed in Sweden with respect to NO_x from electricity generation. Each power plant pays a charge per kg NO_x and the revenues are fully recycled to the electricity producers in proportion to the amount of power generated in kWh.

5 Movement-based ticket charge (revenues to national states)

This is a charge added to the ticket price. A suitable tariff structure of the ticket charge seems a specific tariff for each departure for an intra-European flight and a double tariff for each departure with a destination outside the EEA[141]. It seems logical in this option for each country to receive the revenues from the ticket charge on movements departing from their own airports.

5

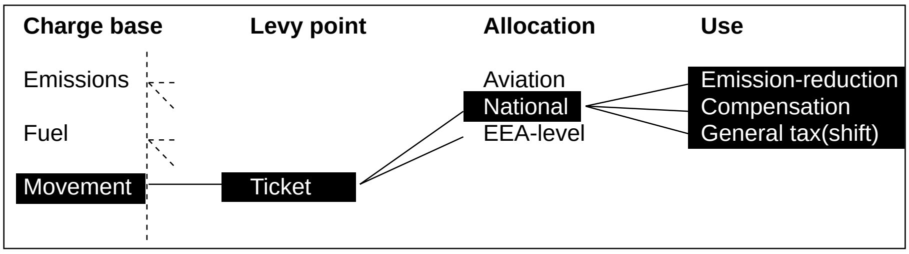


Figure E.6 Characteristics of charge option 5: ticket charge

[141] This structure is used by Norway for its national ticket charge.

F Results and use of the AERO model for this study

F.1 Introduction

This annex discusses the contribution of the AERO model[142] in the framework of this study and presents the results of the evaluation with the AERO model of three charge options with respect to environmental effectiveness and economic distortions.

In the project plan for this feasibility study (May 1996) an environmental and economic evaluation of charge options with the AERO model was envisaged. This plan was based on the offer of Hans Pulles of the Dutch Civil Aviation Authority (RLD) to use the AERO model. We were grateful for this offer, in particular because it can contribute to a more profound quantification of the effects of the charges considered in this feasibility study.
At the time of writing the project plan, it was not clear, however, whether the AERO model could contribute to the purpose of our study: on the one hand, because the research questions of our study were not defined precisely and, on the other, because it was not clear at that time whether development work on the AERO model would be completed in time for our study. For both reasons, an evaluation of the main thrust of the AERO model was planned during the third phase of this feasibility study in order to assess the extent to which the AERO model might contribute to *our* study. This annex reports the findings of this evaluation.
It should be stressed here that our evaluation of the AERO model is aimed at assessing the usefulness of this model for the purpose of our study and not, thus, at arriving at a more general evaluation of the model. For insight into the results of a general evaluation of the AERO model we refer to the CAEP committee that reviewed the AERO model in the second half of 1997.

Our research method was the following. As a first step we evaluated the main thrust of the AERO model for the purpose of our study, based on the following input:
- a presentation of the AERO model on 19 February 1997 in The Hague;
- a comprehensive description of the AERO model in various reports;

[142] The author wishes to extend his special thanks to Hans Pulles of the Dutch Civil Aviation Authority (RLD) for the offer to carry out some policy runs with the AERO model for this feasibility study. In addition, we would like to thank Mr Andre van Velzen of Resource Analysis (Delft) and Mrs Marlous Donkers of the RLD for carrying out these policy runs.

- input given by Hans Pulles of the Dutch Civil Aviation Authority and responsible for the AERO project;
- results of six policy runs with the AERO model.

Based on this first step, a draft annex was written. This draft was discussed with Hans Pulles (RLD, the owner of the AERO model) in order to discuss and to clarify some of our findings. Finally, this final version of this annex was completed.

The content of this annex is as follows:
- brief description of the AERO Modelling system (Section F.2);
- discussion of characteristics of the AERO model relevant to our study (Section F.3);
- presentation and discussion of calculations with the AERO model for three charge options (Section F.4);
- conclusions (Section F.5).

F.2 The AERO Modelling System

The AERO Modelling System is developed for the Dutch Civil Aviation Department by MVA Consultancy, the Dutch National Aerospace Laboratory and Resource Analysis. The system covers a sequence of steps from the description/generation of aviation demands to the assessment of the economic and environmental impacts of measures taken to reduce aviation emissions. The environmental impacts are considered in the context of emissions from other (ground) sources. The system is designed to allow for the analysis of a wide range of autonomous (economic, technical, political) developments and a great variety of measures (such as: regulation, taxation, operational and technical measures) to reduce the adverse effects of aviation. The modelling system allows specification of regional measures and includes the assessment of global and regional impacts of such developments and measures.

In AERO a distinction is made between three types of runs.
- Base run: Computation of the base year (1992) situation based on a given set of assumptions.
- Datum run: Computation of a future situation for a target year, based on a given scenario.
- Forecast run: Computation of a 'modified' future situation due to the effects of a policy.

Datum and forecast refer to the same future year, and can be regarded as two alternative futures: one without and one with measures. By comparing datum and forecast results, the effects of measures can be assessed. In Section F.4 results of all three types of runs are presented.
The AERO information and modelling system consists of the following 9 models:

1 Aircraft technology model (ATEC): fleet aircraft characteristics and prices.
2 Aviation cost model (ACOS): global (changes of) aviation costs.
3 Air transport demand and air traffic model (ADEM): aviation demand and aircraft movements.
4 Direct economic impact model (DECI): worldwide socio-economic impacts.
5 Macro-economic impact model (MECI): specific economic impacts for the Netherlands.
6 Flights and emission model (FLEM): flights and flight profiles and resulting emissions on a three-dimensional grid.
7 Other atmospheric immissions model (OATI): immissions from other (ground) sources.
8 Atmospheric processes and dispersion model (APDI): changes of atmospheric concentrations of relevant substances.
9 Direct and indirect environmental impact model (ENVI): environmental impacts of changes in atmospheric concentrations.

The above models are integrated in a software shell called AIMS (Aviation Immissions Modelling System), which facilitates the communication and interaction of the user with the AERO models and the internal communication and interaction between the models.

Base and datum results (Business as Usual)
The primary input for the base case is the so-called 'Unified Database' of passenger and cargo demand and aircraft movements. Base results have been verified against real-world data. For datum, various scenarios can be applied for various target years. At present, in AIMS 5 pre-defined scenarios are available for both 2005 and 2015. Four of these scenarios are based on information from the Netherlands Central Planning Agency, CPB. The fifth scenario has been composed by ICAO.

F.3 Discussion of characteristics of the AERO model relevant to this study

This section discusses the characteristics of the AERO model that are relevant to this study, in order to assess whether the specific research questions of this study could be investigated using the AERO model.
To this end, an assessment was made of the input data, the output and some of the model specifications. Below, the findings of this assessment are presented.

1 *Impact of charges on technology*
In general, a charge on emissions or fuel increases operating costs and will consequently generate incentives for the introduction of emission-reduction measures. In Chapter 3 of this study the following types of reduction measures were distinguished:
   a technical improvements (engine, empty weight and drag);
   b change of aircraft size and average distance flown;

c new aircraft design optimization;
d improvement of load factor;
e operational improvements (flight path, speed, flight handling procedures);
f reduced growth in passenger and freight volume.

The environmental effects of a charge on emissions or fuel as calculated with the AERO model have, until now[143], depended mainly on reduced growth in volume (f) as a consequence of the charges. In addition, it is assumed in the AERO model that a fuel or emission charge leads only to a relatively small efficiency improvement due to a shift to more fuel-efficient aircraft. In the AERO model it is assumed that a fuel or emission charge will not lead to efficiency improvements due to more efficient operations (e) and/or higher load factors (d), according to Hans Pulles. Furthermore, the greater probable effect (see Chapter 3 of this report) of a fuel or emission charge on stimulating the development of more energy- and environment- efficient technology by manufacturers is not automatically considered in the AERO model. The AERO model assumes an autonomous fuel efficiency improvement of 1% per annum. Each user can put his own efficiency factor into the model. The assumed long-term efficiency improvement of 1% per annum does not correspond with the long-term efficiency potentials found in our review of the literature (see Dings et al., 1997). In a background study on attainable emission reductions[144] for this study it is estimated that the introduction of a fuel charge of 0.20 $/l (increase of the fuel price by 125%) would reduce energy consumption by about 30% between 1992 and 2025 compared with a Business as Usual trend. More than half this extra potential can be achieved by the development of advanced engine technology and aircraft design optimization. Based on interviews with manufactures of aircraft and engines, Hans Pulles assumes that the estimates given in international literature give an overestimate of future emission reduction potentials.
Even if the long-term reduction potentials are lower than those found in our literature review, it seems likely that the efficiency improvement after a fuel or emission charge is too low in the AERO model. We conclude this because in the AERO model it is assumed that a fuel or emission charge does not have any effect on operations, load factor or long-term technological efficiency improvement, which seems unlikely. Consequently, the policy results presented by AERO give an underestimate of the environmental effectiveness of a fuel and emission charge. In addition, there will be an overestimate of the operating costs, because the marginal costs of 'new technology' aircraft are, until a certain level, lower than the costs incurred by paying the charge and also lower than the profits lost due to reduced demand.

---

143 Results presented in the report on the Focal Point on Charges and results for this study.

144 *European aviation emissions: trends and attainable reduction* (Dings et al., 1997).

2 *Profit adjustment factor*

Crucial for the evaluation of potential economic distortions of a European aviation charge is the assumption to what extent airlines will or can pass on the cost of a charge to their customers. If a charge forces airlines to adjust prices differently, the changes in the profit margins of those airlines will also be different. In the AERO model the profit adjustment factor can be specified by the user as an input assumption. At the moment, however, it is still difficult to reproduce the actual profit adjustment of European compared with non-European airlines after the scenario run by AERO. For proper interpretation of the model results and to assess whether potential economic distortions arise after introduction of a European aviation charge it is important that real profit adjustment can be reproduced and clarified. Hans Pulles commented that they are working on this with the AERO team.

3 *Price elasticities of demand*

The price elasticities of demand used in the AERO model are presented in Table F.2. An average global price elasticity of demand of about -1.5 is assumed. For intra-EU demand an average price elasticity of -1.75 is assumed (see also Table F.2). These price elasticities are relatively high in comparison with estimates given by other sources. Oum *et al.* (1990) made a survey of price elasticities of demand for transport. Based on a number of studies they constructed the most likely range for the price elasticity of demand for leisure/vacation travel as being from -1.1 to -2.7 and for business travel from -0.4 to -1.20. ICAO (1995) report an average price elasticity of demand for air transport of -0.66 (see also Chapter 3).

4 *Output data*

Due to the fact that the AERO model is still under development and because of the time constraints of this project, it is not (yet) possible to obtain an overview of which key variables are of greatest influence on the modelling results. In addition, a sensitivity analysis should be carried out.

5 *Which charge options can be evaluated with AERO?*

The AERO model is currently suitable for evaluating the environmental and economic effects of a fuel charge, a ticket charge and a charge on CO_2 emissions. It is not yet possible to evaluate a charge on other aviation air pollutants.

Ideally, an additional module incorporating the shadow price per kg pollutant of each engine/aircraft should be added to the Aviation Operating Cost Model (ACOS) of AERO. As a consequence, the process of cost optimization would then also take environmental costs into due account.

6 *Which potential economic distortions can be evaluated with AERO?*

One aim of this feasibility study into a European aviation charge is to evaluate whether potential economic distortions would arise between

European and non-European (i) airlines, (ii) airports and (iii) tourist destinations. However, the AERO model is not designed to analyze economic effects on the disaggregated level of airports and the tourist industry. Therefore, only potential competitive distortions between EU and non-EU airlines as a group could be evaluated with the AERO model.
In addition, potential economic distortions among EU carriers due to a European aviation charge cannot be analyzed, because the AERO model cannot analyze effects at the level of individual airlines.

7 *Return of revenues in AERO*
Due to the limited time available, it was not possible in this study to analyse the net environmental and economic effects of the charge options after recycling of the charge revenues. In addition, the development of recycling options in the AERO model is still at an early stage of development.

F.4 Evaluation of three charge options by AERO

F.4.1 Results

In this section a quantitative estimate of the environmental and economic effects of the three charge bases is presented for a charge level corresponding with a fuel price increase of 0.30 $/l. These effects were calculated by performing a number of scenario runs with the AERO modelling system of the Dutch Aviation Authority.

The effects of the following charge options were calculated with the AERO modelling system:
1 a fuel charge of 0.30 $ per litre, applied worldwide;
2 a fuel charge of 0.30 $ per litre, applied in the EU;
3 an emission-based route charge of 100 $ per tonne CO_2, applied worldwide;
4 an emission-based route charge of 100 $ per tonne CO_2, applied in the EU;
5 a ticket charge of 15%, applied worldwide;
6 a ticket charge of 15%, applied in the EU.

The following assumptions were made:
- The AERO model is defined in terms of regions. It is not possible to select the European Economic Area or the airspace of the EEA, which is the starting point of this feasibility study. In the evaluation below it is therefore assumed that the three charge options are introduced in the European Union instead of the EEA.
- In this study non-discriminative charges are considered, which implies that both EU and non-EU airline companies, passengers and freight are assumed to be subject to exactly the same charge. Thus, all carriers providing the same service are charged in the same way.

- For a fair comparison of the three charge bases, a charge level for the emission charge (100 $ per tonne CO_2) and the ticket charge (15%) was established which is equivalent to a 0.30 $/l fuel charge.
- The area of validity of the charges applied in the EU is as follows. On intra-EU flights all flight stages are charged and there are no differences between the three charge bases. However, on flight stages to and from the EU there are differences between the charges. In the case of a fuel charge, carriers pay the charge only on fuel bunkered in the EU and hence only about 50% of a round trip is charged.
  For the route charge it is assumed that half of the emissions of each flight to and from the EU are charged.
  For a ticket charge it is assumed that passengers or freight departing from the EU have to pay the charge. In addition, it is assumed that transfer passengers via the EU also pay the ticket charge on departure from the EU.
- Obviously, a ticket charge is always a straightforward addition to passenger fares, with the charge not being included in airline operating costs and revenues.
  A fuel charge or emission charge would affect both operating costs and revenues. To what extent these charges increase total airline costs depends on their share in the total operating costs of an airline. The general rule is: the greater the flight distance, the higher the share of fuel costs and the lower the share of total airport costs. In the AERO modelling system the average fuel costs for intra-EU flights are 7% of total operating costs, while for flights on the North Atlantic route this percentage is 15%.

Below, in Table F.1, the resulting estimates are presented for the year 2015, with 1992 as the base year. First the base results for the year 1992 are presented. The next column gives the datum results (Business as Usual) in 2015. In the following six columns the effects of the six charge options are shown for the year 2015.

Based on the findings in the previous section, it should be stressed that the figures presented in Table F.1 should be regarded with due caution, because of a number of limitations. The first limitation is that it is not yet possible to assess how (all) key variables in the AERO model change with each policy run. For example, to be able to adequately assess the environmental effectiveness of a charge option, it is useful to know how the various emission reduction measures (technology, operations, load, volume) contribute to total emission reduction as calculated in the model runs. Other key variables that are useful for a proper interpretation of the model results include the change of the market share of European and non-European carriers, change of the average load factor, and others. We discussed this limitation with representatives of the AERO model. They explained that these key variables are in the model, but that more time is needed to retrieve them from the model after the policy runs. Until then, adequate interpretation of the model results remains difficult.

A second reason to regard the modelling results with caution is, as already mentioned in Section F.3, that the impact of a fuel or emission charge on the development of more energy- and environment-efficient aircraft is not automatically considered in the AERO model. Representatives of the AERO model acknowledge this limitation, but explain that it is possible in the model to simulate this 'long-term technology effect' by imposing limits on the fuel efficiency of new aircraft. This option was not tested for the purposes of this study, however.

Table F.1 Effects of a charge on emissions, fuel and tickets applied worldwide and applied in the EU only, in 2015 compared with 1992 (profit adjustment factor = 1)

	base	Business as Usual	Emission charge 100$ per tonne CO_2		Fuel charge 0.30 $/l		Ticket charge 15%	
Unit	1992	2015	Global	EU	Global	EU	Global	EU
Traffic demand (in billion)								
- EU RTK[1]	-	188	157	171	156	169	163	172
- other RTK	-	745	621	734	613	732	649	736
- total RTK	277	933	779	905	769	901	812	909
Traffic demand (% change compared to Business as Usual)								
- EU	-	188	-16.1%	-8.7%	-17%	-9.9%	-13.2%	-8.2%
- other	-	745	-16.6%	-1.5%	-17.7%	-1.8%	-12.8%	-1.1%
- total	-	933	-16.5%	-3.0%	-17.5%	-3.4%	-12.9%	-2.6%
Environmental effects								
- Fuel consumption billion kg	144	278	-15.5%	-2.7%	-16.6%	-3.1%	-12.3%	-2.3%
- Fuel per RTK grams	520	298	301	298	302	300	300	297
Economic effects								
Operating result per unit RTK[2]								
- EU carriers 1992 US $	-	0.0185	-55%	-32%	-58%	-46%	-98%	-82%
- other carriers	-	0.0288	-4%	+1%	-3%	+2%	+3%	+3%
- total	0	0.0270	-12%	-3%	-12%	-3%	-16%	-9%

1 Aviation transportation volume is expressed in *revenue tonne-kilometres* (RTK). The number of revenue tonne-kilometres performed is equal to the summation of the number of passenger-kilometres, multiplied by the average weight of one passenger plus baggage (around 100 kg), and the number of tonne-kilometres of cargo transported.

2 The operating result per unit RTK equals the difference between total airline operating revenues and total airline operating costs, divided by the number of revenue tonne-kilometres in the same year.

Source: CE, based on AERO model calculations (RLD and Resource Analysis, 1997).

Table F.1 shows the effect of the charge options on trends in absolute fuel consumption by aviation and in fuel consumption per unit transported volume expressed in revenue tonne-kilometres (fuel efficiency) between 1992 and 2015. Both form a good indicator for the environmental effectiveness of the charge options. The table shows that total traffic demand decrease by relatively more after the introduction of all charge options than the decrease in total fuel consumption in 2015. Fuel efficiency (fuel consumption per RTK) remains about the same after all charges in 2015 compared with a Business as Usual scenario (without charges) in 2015. This result of the AERO calculations seems implausible, because in theory a fuel or emission charge equivalent to 0.30 $/l (a fuel price increase of almost 200%) would generate strong incentives to improve fuel efficiency over a period of more than 20 years. In addition, in our review of the literature[145] we found that a charge of 0.20 $/l would lead to a 25-35% reduction of fuel consumption between 1992 and 2025 compared with Business as Usual. Both theory and our findings in the literature indicate that the AERO model calculations underestimate the impact of a fuel and emission charge on the improvement of fuel efficiency. This can be partly explained by the fact that the possible impact of a fuel or emission charge on the development of new and more fuel-efficient aircraft is not automatically considered in the model. One might expect, however, that an increase in fuel price of almost 200% would also lead to higher load factors, larger average aircraft size and operational measures to improve fuel efficiency. As fuel efficiency remains the same after a fuel and emission charge, it seems that these possible effects might be underestimated as well.

A good indicator for evaluating the potential economic distortions between European and non-European carriers after introduction of a European aviation charge is the change in profit margin (operating result per unit transported) of both groups of carriers before and after the charge. The profit margin can be calculated by dividing the total operating result (total operating revenues minus total operating costs) of an airline company by the total volume transported per annum. Table F.1 shows the change (in %) of the profit margin of EU carriers, other carriers and all carriers as a total after introduction of the charge options compared with Business as Usual in 2015. It is shown that in the case of both a global and a European charge the profit margin of EU carriers decreases significantly compared to Business as Usual, while the profit margin of other carriers remains about the same.
In order to assess whether a European aviation charge would affect the competitive position of EU carriers, we used these results to test a hypothesis we had formulated: that the competitive position of EU carriers will deteriorate compared with that of non-EU carriers if the profit margin of EU carriers decreases more under a EU charge than under a global charge.
The results of Table F.1 indicate the opposite, however, the profit margin of EU carriers decreasing less under a EU charge than under a global charge. The hypothesis is therefore not confirmed by these calculations with the

[145] *European aviation emissions: trends and attainable reduction* (Dings et al., 1997).

AERO model. Hans Pulles assumes that this result, which is not plausible, can be explained by the current problems with the price adjustment factor in the AERO model, which regulates the extent to which charges will be passed on to customers.
The table indicates, furthermore, that in the case of a global charge the profit margins of EU carriers decreases by significantly more than those of other carriers. This can be explained in part by a much stronger substitution effect of surface transport in the EU. However, we cannot explain such a large difference in profit margin resulting from these calculations with the AERO model, and this result seems implausible because all carriers in the world face the same cost increase on all flight stages worldwide.
The two effects described above, which cannot be explained and appear implausible, make it difficult to clarify the value of the calculation result that, under a European aviation charge, the profit margins of EU carriers decrease by more than those of other carriers.

F.5 Conclusions

Based on the results discussed in this annex, we conclude that the calculations with the AERO model as described in this annex could not contribute in any significant way to the purposes of this feasibility study. The results of the AERO model are therefore not included in the main part of this final report. The arguments for this conclusion are summarized below.

- Because of time constraints, the calculation results of the AERO model obtained for this study could not (yet) be fully explained by representatives of the AERO model, because some of the key variables required for proper interpretation of the results are not yet available.
- The AERO modelling results for this study indicate that the fuel efficiency of aircraft (fuel consumption per unit RTK) will not improve after introduction of a fuel or emission charge equivalent to 0.30 $/l. These modelling results seem implausible, because theory and the results of our literature review indicate that such charges would lead to a significant increase in fuel efficiency. Based on interviews with manufacturers of aircraft and engines, Hans Pulles (RLD, owner of the AERO model) considers the estimates given in international literature to be an overestimate of future emission reduction potentials, however.
- One aim of this feasibility study of a European aviation charge is to evaluate whether potential economic distortions would arise between European and non-European (i) airlines, (ii) airports and (iii) tourist destinations. However, the AERO model is not designed to analyse economic effects at the disaggregated level of airports and the tourist industry. Therefore, only potential competitive distortions between EU and non-EU airlines as a group could be evaluated with the AERO model.
- In order to evaluate whether a European aviation charge would create a competitive disadvantage for EU carriers compared with other carriers, we tested a hypothesis. This hypothesis is formulated as follows: the competitive position of EU carriers will deteriorate compared with those

of non-EU carriers if the profit margins of EU carriers decrease by more under a EU charge than under a global charge. This hypothesis was not confirmed by the calculation results of the AERO model for this study, which indicated that the profit margins of EU carriers would decrease less under a EU charge than under a global charge. This calculation result is difficult to explain and seems implausible. Hans Pulles explains some of the implausible results with reference to certain problems with a key variable (profit adjustment factor) in the AERO model.
On the basis of the current state of the AERO model we consequently conclude that the model calculations for our study provide inadequate information for evaluating whether a European aviation charge would create a competitive disadvantage for EU carriers compared with non-EU carriers.

G Landing and Take-Off cycle (LTO cycle)

Each aircraft and engine combination has its own particular emissions profile, elaborated according to the Landing and Take-Off cycle, and employing specific emission factors (grams of pollutants per kilogram of fuel) for each operating mode. This cycle is based on a flight pattern below 3,000 feet (approximately 900 metres) and is illustrated in the figure below.

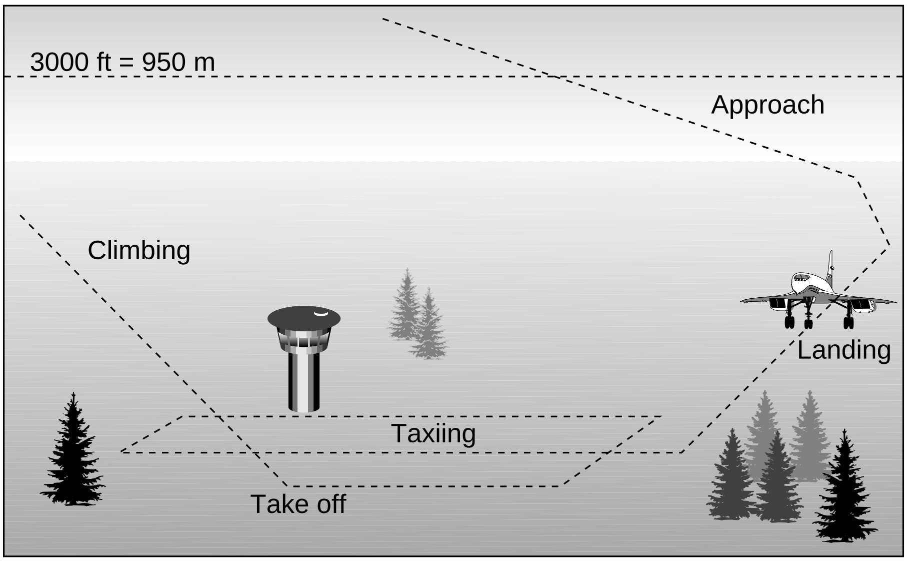


Figure G.1 LTO cycle (Landing and Take-Off cycle)

Table G.1 shows the thrust settings and durations assumed in the different phases of the LTO cycle. On this basis, the emissions of new engines are measured on a test-bed. This means that emission data on the LTO cycle are not measured during a real flight, but are determined in a test on the ground. This is because measurement of emissions (particularly NO_x) during a flight is not technically feasible or is very expensive.

Table G.1 Flight phase, thrust and durations for the LTO cycle

Aircraft operation	Engine power	Time in mode
Take-off	100%	0.7
Climb	85%	2.2
Approach	30%	4.0
Taxi/idle	7%	26.0

Source: ICAO, 1993.

Since the 1980s, ICAO has been setting standards for new sub-sonic jet engines with a maximum thrust greater than 26.7 kiloNewton. The standards relate to CO, VOC, NO_x and particles, and are contained in an annex to the Chicago Convention (Chapter 16, volume 2: Aircraft Engine Emissions). The standards are intended to reduce emissions in the vicinity of airports, and are based on the standard LTO cycle referred to above[146].
Attempts are being made within ICAO to counteract the adverse trend in NO_x standards further. In 1992, a decision was taken to tighten the standard in force since 1986 for new jet engines. This more stringent standard came into effect on 31 December 1995 for engine models going into production for the first time. For engines already in production it will take effect from 31 December 1999.

146 *Government policy of the Netherlands on air pollution and aviation* (1995).

H Measuring and calculating emissions

As for constructing an emission-related charge base, it is important to know whether it is possible to measure the quantity of emissions sufficiently accurately or to use reliable data. To ensure that measured emissions correspond closely enough to real emissions is very complex, in particular because the emissions from a flight on a certain route depend on operational characteristics. The following factors are important: type of airframe/engine, journey length, load factor, cruising speed and flight altitude. Another factor which influences the level of emissions of a particular flight on a certain route is congestion. This factor can hardly be influenced by airlines, however.
There is a complex interplay between many of these factors, and it appears difficult to measure the real per-flight emissions of a particular aircraft on a certain route. Below we discuss the current state of the art of determining the chargeable volume of emissions.

As mentioned before, the most effective charge is one on the actual emissions of each flight, but this option does not appear to be technically feasible or cost-effective. For this reason it is important to know what standard emission data sets might be used or calculated to take due account of different factors (engine, airframe, flying characteristics, load factor) that might influence total flight emissions, during both the LTO and the cruise phase.

Since 1981 ICAO has established standards[147] for engine emissions which cover NO_x, CO, HC and particles. These standards are based on the aircraft landing and take-off cycle (LTO)[148] and do not cover emissions during the cruising phase. For the purpose of certification of aircraft, an ICAO database on engine emissions produced during the LTO is available.
The UK Defence Research Agency (DRA) has already analysed the airframe/engine combinations of 20 of the world's major airline fleets using the ICAO database. DRA is also working on emissions during cruising.
Both Boeing and DLR (Germany) are working on methodologies to calculate cruising emissions from LTO cycle information. In the Netherlands the National Aerospace Laboratory (NLR) recently constructed a set of emission data for airframe/engine combinations. This database also contains emissions during cruising. These calculations of cruising emissions are estimated by means of modelling. The initial impression is that it is possible,

---

[147] These are included in Annex 16 to the convention on International Civil Aviation.

[148] The standard LTO cycle defined by ICAO is below 3000 feet (about 900 metres). See Annex B for a short description.

for a particular airframe/engine combination and a certain route, to determine the chargeable volume of emissions during the LTO and cruise phase.

In practice, however, emissions for a particular airframe/engine combination on a certain route differ from the calculations based on modelling. This is due to differences in flight characteristics, congestion and load factor. As has already been noted, these effects are very complex and further research is necessary. However, certain remarks can be made based on the opinions of several experts:

1. The first reason why the real emissions of a particular flight may differ from the calculations of currently available models is that airlines lower their average fuel consumption on long-haul flights by up to 15% because of different climb characteristics.
   The implication of this development is that models should be adapted to reflect the real-world emissions of current aircraft. As it is assumed that all airlines show similar behaviour to optimize flight performance, it can be concluded that there will be no substantial differentiation among particular aircraft and flights as a result of changes in climb characteristics.
2. A second reason why real emissions might deviate is that according to experts there is an average fuel inefficiency of 10% in Europe owing to congestion and limited airspace. However, airlines currently have little scope for influencing the bulk of this 10%, because of the limited capacity of air traffic control and air control management inefficiencies in Europe. European countries and aviation authorities are discussing this issue in order to resolve these problems.
3. A third reason why real emissions may differ is the impact of the load factor on emissions. A first, rough calculation shows that the effect of difference in load factor is significant. A 10% increase in load factor results in an emission reduction of about 6% per passenger-kilometre.

At first sight the conclusion is that calculation of emissions for a particular airframe/engine combination on a certain route seems possible. The ICAO database of emissions during the landing and take-off cycle (LTO) in combination with modelling work carried out by different institutes might serve as an initial estimate for establishing an emission-related charge. For calculating emissions accurately and close to real emissions it is also important to take into account the remarks of the experts referred to above.

Evidently, there are major interests in the aviation sector and it is therefore to be expected that modelling results may give rise to considerable debate. For this reason, it would be wise to base emission charges on certified data, because these are more or less internationally accepted.

I Basic data and units used

The following basic data and units were used in this study:

Table I.1 Units and properties used in the study

Proporties and units		Value
jet fuel properties	density (kg/l)	0.81
	energy content (MJ/kg)	43.4
	sulphur content (%m/m, mass percentage)	0.046
	SO_2 emission (g/kg burnt)	0.92
	CO_2 emission (kg/kg burnt)	3.160
	H_2O emission (kg/kg burnt)	1.251
	price in BaU variant	$ 0.60 / gallon
1 pound (US/UK)		0.45359 kg
1 gallon (US fluid)		3.7854 l
1 statute mile (US/UK)		1.609344 km
price of 1 litre Jet A1 kerosine		0.16 US dollar
US dollar		February 1998