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Sustainable Aviation

The need for a European Environmental aviation charge

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SUSTAINABLE AVIATION

Introduction

A balanced and integrated policy for sustainable development of the aviation sector is needed. Aviation contributes 12% of the global CO_2 transport emissions. With a business as usual policy, emissions are expected to triple over the next 15 years, as compared to 1990. These predictions for future emissions of the aviation sector are not in line with sustainable development.

Against this background the Netherlands Society for Nature and Environment, in close cooperation with T&E, has started a research project into the feasibility of a European Environmental Aviation Charge. The results were published in March 1998.

In this policy paper, T&E describes the global environmental problems of aviation, and asks the question "When is aviation ecologically sustainable". It then looks at the role of different actors in society, and the policy instruments available for authorities. It describes the results and the conclusions of the above mentioned research and gives recommendations for a policy aimed at an ecologically sustainable development of the aviation sector.

The most important result from the feasibility study is :

> **This study reveals positive prospects for the implementation of a European aviation charge that is both environmentally effective and feasible. A charge level equivalent to 0.20 US$/litre of 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.**

T&E offers five policy recommendations in the last chapter, one of them on the introduction of a European environmental aviation charge

"In order to bring aviation developments into closer line with the need for ecological sustainability, a European environmental aviation charge should be introduced. Its aim should be to reduce emissions. A charge based on calculated emissions appears to be the most attractive option, possibly in combination with a landing and Take-off (LTO) emission charge. The EU should push the International Civil Aviation Organisation (ICAO) to introduce such a charge worldwide, but should also take on its own responsibility now and not wait for the ICAO. It is the view of T&E that without Community action, an international solution respecting the need for ecologically sustainable development of the aviation sector is unlikely in the foreseeable future.

1. The environmental impact of aviation

1.1 Introduction

The environmental effects of aviation are complex. This chapter provides essential background information on the nature and scale of the environmental impact caused by aviation. This policy paper concentrates on the environmental effects occurring at the regional and global level as a consequence of air pollution. It should be borne in mind, though, that at the local level millions of citizens are affected not only by gaseous emissions but also by noise. Another big problem that will not be discussed further in this paper is the (external) safety of citizens around airports.

1.2 Global and regional environmental impact of aviation

Air transport gives rise to a variety of emissions. Table 11shows emissions of aviation, the need for policy action and the most striking environmental effects.

Carbon dioxide (CO2) contributes to the greenhouse effect. CO2 is the main greenhouse gas preventing the earth from radiating its heat into space, thus causing an extra warming of the atmosphere. As a consequence, weather patterns will be disturbed, sea levels will rise and climate zones will shift so fast that plants and animals cannot adapt, leading to a disruption of the ecological balance. This problem will be further discussed in section 2.3.

Aviation makes a 12% (1990) contribution to aggregate global transport-related CO2 emissions (Michaelis, 1997) and 2.3% (1992) to aggregate global CO2 emissions (VROM,1995). Between 1990 and 1995 aviation CO2 emissions rose by over 30%. Comparing aviation with other modes of transport, it is evident that per passenger -or tonne-kilometre, aviation causes much higher CO2 emissions (see Figure 1 (Michaelis,1997)).

Nitrogen oxides (NOx) also contribute to the greenhouse effect. When emitted at an altitude of 9 to 13 km NOx disturbs the natural heat balance via the formation of ozone. The effects depend on location and season and are therefore difficult to compare with the global effects of persistent greenhouse gases such as CO2. The international scientific community gathered together in the IPCC, the International Panel on Climate Change, presently estimates that the indirect greenhouse effect of aircraft NOx emissions is of the same or a lower order of magnitude as that of aircraft CO2 emissions (VROM, 1995, Wit and Bleijenberg, 1998a). In addition, NOx contributes to the depletion of the ozone layer.

At an altitude of 18 km and higher NOx particles do not form ozone, but deplete it. NOx molecules also have an indirect ozone depletion effect via complex series of chemical reactions. (One example is that NOx molecules react with water to form nitric acid, which stimulates cloud formation in the polar regions. The surface of these clouds then acts as an catalyst for ozonedepleting chain reactions (Dameris et al., 1997). The scientific knowledge on these effects is poor. In the northern hemisphere, aviation is responsible for about one-third of the NOx at flight altitude. NOx also contributes to acidification. In terms of acid equivalents (a unit used for comparing acid immissions), the aviation sector contributes about 0.7% at the global level (VROM, 1995). As the emissions are regional, the effects will become manifest at the regional level. Since the majority of flights take place in the USA and the EU, the acidification caused by aviation can be expected to be higher there. At the local level, NOx is a threat to human health, as are particles, VOC, and SO2. Noise is probably the most health-damaging ‘emission’ at present. This policy paper is concerned primarily with the regional and global environment, however, and will not give further consideration to the wide range of local aviation problems.

Sulphur dioxide (SO2) is emitted by aircraft as a result of the sulphur content of the fuel consumed. It has an acidifying effect, but this is small compared with the acidifying effect of the NOx emissions. Water vapour (H2O) - like CO2 - is emitted as a result of the combustion of fuel. Particles are formed in aircraft engines due to incomplete combustionions. These aircraft emissions may make an significant 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 results in a net warming effect and the radiative effect of aerosols in a net cooling. At present our knowledge does not allow us to properly quantify these climatic effects. Scientific understanding of the indirect effects of SO2, soot (= particles) and water vapour emissions by aviation is still incomplete, and the possibility of these effects proving important, e.g. more important than those of NOx, cannot be excluded#2.

2. When is aviation ecologically sustainable?

2.1 Introduction

To answer this question we must operationalise the definition of sustainability. Unfortunately, there is no single definition of sustainability, but several hundred! The debate on the details will continue for quite a while, but the direction and the aims of development have become much clearer over the last few years. The European Federation for Transport and Environment (T&E) has made a significant contribution to making the concept operational for the transport sector with its publication “The concept of sustainable transport” (Kågeson, 1994). This chapter#3 will first reiterate the most important elements of this concept and translate them to the context of the aviation sector, while focusing on those elements that are important at the global level. Current forecasts of future aviation emissions will then be compared with the required sustainability targets.

2.2 Operationalising the concept of sustainable transport

World Bank economist Herman Daly has provided a frequently cited definition of sustainable development. In order to be physically sustainable, society's material and energy throughputs, according to Daly (1990), would have to meet three conditions:

- The rates of use of renewable resources may not exceed their rates of regeneration.
- The rates of use of non-renewable resources may not exceed the rate at which renewable substitutes are developed.
- The rates of polluting emissions do not exceed the assimilatory capacity of the environment.

The objectives of sustainable transport, then, must be to offer basic mobility to all citizens without damaging nature and the environment.

Thus, in the long term the volume of transport should never be allowed to increase beyond a volume that can be maintained without causing serious damage. The critical limit may, of course, change over time if, thanks to technical progress, we are able to reduce specific energy consumption, exhausts, noise and accidents (i.e. the damage per million passenger or tonne-kilometres). On the other hand, though, if the quality of air, water and soils is allowed to deteriorate still further (owing to damaging practices), mobility and other ecologically damaging activities will have to be diminished until we have reached a situation whereby our ecosystems no longer suffer from unacceptable stress.

2.3 Aviation and global sustainability

The greenhouse effect and ozone layer depletion are the two most important global issues in the context of aviation. We first consider the possible depletion of the ozone layer.The aircraft pollutant that probably plays the most important role in depleting the ozone layer is NOx. However, model calculations indicate that this contribution is expected to be small in quantitative terms. Scientific understanding of the indirect effects of SO2, 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. All things considered, knowledge concerning ozone depletion by aviation is still incomplete. According to the latest scientific insights, the ozone layer is likely to suffer 3% depletion due to aviation NOx emissions (VCÖ#, 1997). Aviation emissions of NOx and other ozone-depleting substances are expected to triple over the next 15 years. There are major concerns regarding the possible impact on ozone depletion of a new generation of supersonic airliners.

At the moment, scientific understanding of the complex atmospheric reactions is incomplete, and it is therefore not possible to indicate sustainable levels for the various polluting emissions. However, given the expected growth of the aviation sector on the one hand, and the potentially large effects of ozone depletion and the precautionary principle on the other, there is a need for policy action in order to move towards ecologically sustainable development in this area.

The second key issue is the contribution of aviation to the greenhouse effect. What reduction in emissions is required to achieve a level fulfilling the criteria for sustainable development? The most authoritative summary of the state of knowledge in this field was published in 1990 by the United Nations Intergovernmental Panel on Climate Change (IPCC 1990). The IPCC estimates that global mean temperatures may rise, from 1990 onwards, at between 0.2 and 0.5 degrees C per decade if we take no mitigating action i.e. in a 'business as usual' scenario. The best estimate is 0.3 degrees C per decade. The predicted rate of increase implies a global mean temperature of about 1 degrees C above the present value in 2025 and 3 degrees C higher in 2100.

Global climate change (such as that in the IPCC's business as usual scenario) will have very farreaching consequences. Weather patterns will shift, possibly causing storms that disrupt life in major population centres, massive rains in previously arid areas or droughts in regions that used to be fertile. The IPCC predicts that the sea level is likely to rise by 31-110 cm by 2100, with a best estimate of 66 cm. Globally, natural ecosystems will be permanently affected when, through adjustment, they have attained a new equilibrium, and transiently because of the high rate at which climate change is expected to progress. Global warming by 2-3 degrees above present-day levels will give the earth a mean temperature that has not occurred since the Eemian interglacial 120,000 years ago.

Because species respond differently to climatic change, some will increase in abundance while others will decrease. Rare species with small ranges may become locally or even globally extinct. Food production may be affected by changes in precipitation. The ensuing changes in productivity may be either positive or negative, depending on how today's most important agricultural regions are affected. There is a great deal of uncertainty on this point.

The risk of heavy stresses and, at worst, a runaway greenhouse effect, argues in favour of observing the precautionary principle where carbon dioxide and other anthropogenic greenhouse gases are concerned. The precautionary principle has been stated over and over again to be the leading principle in European environmental policymaking. In fact, the EU treaty leaves no room for doubt; Community policy "...shall be based on the precautionary principle..." (TEU, 1992). Researchers at the Stockholm Environment Institute have recommended that the maximum temperature increase should not be allowed to exceed between 1.0 degrees C (low-risk limit) and 2.0 degrees C (high-risk limit) above the pre-industrial level.

This limit has been set to avert the risk of the global mean temperature exceeding the highest level to have occurred in the past few million years. The researchers also advise against accepting a change exceeding 0.1 degrees C per decade, the intention being not to exceed what, historically speaking, have been normal rates of climate change (Rijsberman and Swart, 1990).

To stabilise greenhouse gases at present day levels, immediate cuts would have to be made of 60% for carbon dioxide, 15-20% for methane, 70-80% for nitrous oxide, 70-85% for CFC compounds and 40-50% for HCFC-22. This is, of course, impossible. Stabilisation of the temperature level below the proposed high-risk limit can be achieved if global emissions of carbon dioxide are reduced by at least 50% by the middle of the next century. This will also meet the target of keeping the rise in temperature down to about 0.1 degrees C per decade. Further cuts are of course needed to undercut the low-risk limit.

A reduction of global carbon dioxide emissions by 60% by the middle of the next century will require something like an 80% reduction of Western European per capita emissions if all the Earth's inhabitants are to be assured of the same right to use fossil fuels. The percentage reduction of American per capita emissions would have to be over 90%. Differences in climate, transport distances and industrial emphasis may justify certain differences among countries, but if the global target is to be achieved there must be no major deviations (nor are these objectively justifiable).

2.4 Confronting future aviation emission trends with sustainability targets

Today, transport accounts for 20-50% of overall emissions of carbon dioxide in most countries. On average, this figure is 25% in the European Union and 33% in the United States. Aviation is currently responsible for 12% of global CO2 transport emissions. In 1990, aircraft emissions of CO2 and NOx accounted for between 2 and 3% of aggregate world emissions from the combustion of fossil fuels, as shown in Table 2.1.

Table 2.1. Aircraft emissions and their share in total emissions due to combustion of fossil fuels (coal, petroleum and gas) in 1990 [VROM, 1995].

	CO2 (Mt)	NOx (kt)	VOC (kt)	CO kt)	SO2 (kt)
aircraft	498	1,786	406	679	156
all sources (world total)	22,000	82,000	27,000	303,000	130,000
aircraft (% attributable to)	2.3	2.2	1.5	0.2	0.1

Civil aviation is a growth market. It is expected to grow faster in the coming years than the economy as a whole. This means that the economic importance of air traffic is set to increase relative to other sectors. Over the last two decades air travel has been the fastest growing mode of transport, and this trend is expected to continue. There will be a corresponding rise in the pollution caused by the sector, in both absolute and relative terms. That much is clear from calculations carried out for the White Paper of the Netherlands on Air Pollution and Aviation (VROM,1995).

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 2.2 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% of worldwide CO2 emissions by 2050, depending on many factors associated with economic growth (Oppenheimer, M. and Vendatham, A., 1994).

Table 2.2. Developments in world aviation emissions of CO2 and NOx for the period 1990 – 2015 for three economic scenarios [VROM, 1995]

	CO2		NOx	
	Mtonne	index (1999=1)	M(tonne)	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 CO2 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, CO2 emissions in other sectors are set to stabilise or decrease.

Allowing for the effect that environmental policy will have on other emission sources, under an unchanged policy regime aircraft emissions will become more significant. For the Netherlands it is estimated that in 2010 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. Other aviation emissions will rise in a similar growth path, similarly exceeding the sustainable development path by far.

From the evidence presented in this chapter it is self-evident that there is an immediate need for swift action at all policy levels: global, regional (e.g. EU), national, supra-local5 and local. The next chapter describes the potential contributions of different actors in society to solving the problem, the special responsibility of the authorities and the potential of a European environmental aviation charge as a policy instrument.

3. Working together on ecologically sustainable aviation development

3.1 Introduction

All the various actors in society each have an obligation to take responsibility for contributing to the change from ecologically unsustainable development of the present aviation sector to ecologically sustainable development of the sector in the future. This chapter first touches on the role of the different actors, then focuses on the role of authorities at different levels, and finally homes in on the policy instrument of a European environmental aviation charge.

3.2 Actors in society

3.2.1 Users

Travellers, leisure trippers and businesspeople alike can contribute in this context, by choosing their flight more consciously, using those airlines that offer the Best Environmental Performance (BEP). Making fewer trips and instead staying longer also helps, as does considering other modes of transport. Businesses and institutions should set up policies to guide their employees. These policies could specify the BEP airlines that employees are obliged to use, as well as directions to use more environmentally benign modes of transport, such as rail, when travelling for less than, say, 12 hours. Introducing better planning and logistics, and re-thinking concepts -e.g. the just-in-time-concept-could save not only considerable volumes of air transport and pollution, but also money.

3.2.2 The aviation industry

The aviation industry has a responsibility of its own. Faced with the evidence that their emissions are set to triple in the next 15 years -even if one boldly assumes that autonomous technological improvements will continue at the same pace as they have done- the aviation industry should act now and show that it is a responsible member of society. With a few promising exceptions, the aviation industry has a generally poor record of environmental awareness compared with most other sectors in society. Airlines should purchase clean aircraft and encourage manufacturers to build even cleaner models. They should optimise use of their fleet and give fair and transparent information on their environmental performance. Airports should optimise use of their airfield, so as to minimise environmental impacts. Slot allocation and landing fee differentiation according to the environmental performance of aircraft might be useful instruments. Night flight bans should be the rule, not the exception. Manufacturers of aircraft and engines should see the environmental imperative as an opportunity, not as a threat. Being competitive in the environmental market will give them an advantage.

3.2.3 Authorities

International, European, national and (supra)local authorities each have their own obligations. First, they should protect the general public interest and the interests of those entities that cannot adequately protect themselves: the earth's ecology, future generations and citizens everywhere who are not capable of defending their own interests, e.g. against the (one-issue) interest of business enterprises. To this end they must take action to correct the failures of the market mechanism. Besides restructuring the fiscal system and applying economic instruments, authorities can and should use juridical and communication instruments to ensure ecologically sustainable development of the aviation sector.

3.2.3.1 Communication instruments

Citizens and companies need to be informed on the consequences of air travel. Currently, accurate information on the environmental performance of the aviation industry is not available to the general public, interest groups, scientists and indeed even policymakers themselves, because of the secrecy restrictions upheld by the aviation sector and because information is biased in favour of the interests of the sector. Authorities should take steps to ensure that accurate information becomes available and accessible. Currently, information is scattered, has many different formats and cannot readily be found. Information on the emissions of airframe/engine combinations is entirely lacking on the Internet, for example. Authorities should improve the accessibility of existing information. Finally, authorities should actively inform target groups. This can be done directly, for example through television, radio, newspapers, brochures and labelling schemes, or indirectly, by supporting those who provide this information.

3.2.3.2 Juridical instruments

Juridical instruments can be very effective. Citizens need to be protected. Noise regulations at airports, night bans and emission standards all have an important role to play in ensuring ecologically sustainable development. An example of a juridical instrument is the proposed European directive on limiting emissions of nitrogen oxides by civil subsonic jet aircraft (European Commission, 1997). The Commission has attempted to have this regulation adopted at the international level, by ICAO (International Civil Aviation Organisation), since 1991 and concluded in 1997; “The Commission considers it highly regrettable that ICAO has been unable to implement the CAEP/3 Recommendation [=stricter limits for NOx emissions, T.S.]. The Commission would prefer to see international solutions to the problems of this nature and ICAO is clearly the body where an agreement should be found. However, the Commission now sees the Community’s policy objectives with regard to aircraft emissions being frustrated. It is the view of all the Commission services involved ... that without Community action, an international solution... is unlikely in the foreseeable future. What the Commission is therefore proposing is ... to introduce this tighter emission standard into the Community aircraft fleet...” (European Commission, 1997). This standard is 20% tighter than the ICAO standard.6

3.2.3.3 Restructuring the fiscal system and use of economic instruments

Current tax structures have grown historically. While from a fiscal angle they may be optimal (although that is often not even the case), this historical structure is frequently sub-optimal from an environmental and employment point of view. With an average of two-thirds of the tax pressure on labour and less then 10% on environmental capital, this kind of tax structure steers the market in a wrong direction. The current tax exemptions for airlines and airports are one example. There is no VAT on international air traffic; tax- and duty free sales are allowed at airports; and there is no fuel tax on kerosene. These tax exemptions are both economically inefficient and unfair. In addition to restructuring the underlying tax structure, authorities can also use economic instruments to correct market failures. In developing 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 stimulate the market to find the best reduction measures at least cost. An effective environmental policy for the aviation sector should ideally be developed at the global level. However, experience shows that global policies develop slowly-too slowly. The EU has recognised this before: in the case of the NOx directive, for example. Environmental policy analyses also show that higher-level decision-making often benefits from and is accelerated by the stimulus and experience of forerunners at a lower policy level.

The next chapter focuses on the feasibility of a European aviation charge.

4. A European Environmental Aviation Charge

4.1 Introduction

The urgency of the need for efficient environment policy instruments for the aviation industry, given the expected growth in its global emissions (as described in Chapter 2), combined with the knowledge that economic instruments are a very good candidate and that global policy-making takes many, many years, prompted the Netherlands Society for Nature and Environment (SNM), in close cooperation with the European Federation for Transport and Environment (T&E), to initiate a study on the feasibility of a European environmental aviation charge. The results have been published in three reports: a main report (Wit and Bleijenberg, 1998a) and two background studies (Dings, 1998, and Wit and Bleijenberg, 1998b). This chapter describes the aims of the study, the criteria used, the results (environmental effectiveness and efficiency, economic distortions and legal constrains) and the conclusions of that study7. In Chapter 5 T&E's recommendations for national and EU policy are presented.

4.2 Aim of the study

The aim of the study (Wit, R., and Bleijenberg, A., 1998a) was: 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. It is also important to note the following demarcation of the study: 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 as both EEA and Europe. The feasibility study does not consider military aviation and considers so-called 'small air traffic' only in passing. The environmental aviation charge considered should be applied to all air transport, i.e. passenger, mail and freight transport. The study focuses on the passenger market. It is emphasised, however, that all air transport causes air pollution and should therefore be subject to the same environmental policy measures. A consequence of the choice to aim for a reduction in 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 be affected by environmental charges, however. 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 achieving less pollution. The principal aim of the aviation charges considered in the study is to reduce air pollution by aviation. Noise nuisance is not dealt with in the study. 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 as such, an environmental charge may generate revenue, however. The use of this revenue is considered in the study. 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 regime.

4.3 Criteria employed

The attractiveness of a European environmental aviation charge is determined both by its environmental effectiveness, being the aim of the charges considered in the 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 and conflicts with existing law. More in detail, the considered policy criteria are:

- environmental effectiveness;
- cost-effectiveness;
- distributional equity;
- transparency;
- subsidiarity;
- side-effects (economic distortions);
- enforcement;
- legal provisions;
- internal consistency.

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.

4.4 Results of the feasibility study 'A European Environmental Aviation Charge'

The first part of this section discusses the results concerning the design of a European environmental aviation charge. Five options were selected. They were selected because they combine among them all possible elements of the design of a European environmental aviation charge. The results concerning environmental effectiveness, economic distortions and the legal context are described in the following three subsections. The conclusions of the study are described in sub-section 4.5. T&E's policy recommendations follow in Chapter 5.

4.4.1 Results concerning the design of a European environmental aviation 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. The study focuses on three different charge bases:

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

The second choice relates to the level of the charge. In general, two types of argument are used in favour of introducing aviation charges. The first argument 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, the aim of the charges discussed in the report is to reduce air pollution.

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. The second approach involves internalisation of external costs. In this case the starting point is not an emission target but the notion that pollution is not presently incorporated into market processes. According to economic theory, these so-called external effects distort the optimum allocation of resources and result in a loss of welfare. Internalisation means that external effects - in this case air pollution from European aviation - are incorporated into market processes. Internalisation 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 the externalities of transport and develop internalisation policies8.

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. The second argument states that it is fair that aviation should pay taxes, as other modes of transport and other economic sectors in society do. Finally, the design of the charge needs to be completed by a choice as to the allocation of the revenues: to the national state, to the EU, or possibly in the form of a refund to the aviation industry. These three choices yield a vast number of possible options for a European environmental aviation charge. In addition, the level of the charge may have a major impact. In the main study, five specific options representing the whole range were further analysed. A certain charge level range has been chosen as a working assumption.

Estimates of charge level

approach	main assumption	level (expressed in $/l)
-internationalisation*	#low estimate	#0.06 - 0.08
	#medium estimate	#0.14 - 0.20
	#high estimate	#0.28 - 0.39
-CO2 emissions from aviation in 2020 at the 1990 level	#trend: 2% annual growth in CO2 emissions	#0.37 - 0.54
	#trend: 2% annual growth in CO2 emissions	#1.52 - 2.86
-general taxation	#minimum and average excise duty on diesel	#0.29 - 0.38
working assumption in this study		0.10 - 0.40

* only emissions, using moderate assumptions

The table shows a wide range in charge levels, which for comparison reasons only have been expressed as a charge per litre. This is not intended to reflect the idea that a kerosene tax is the best option. In the internalisation approach the charge levels are between 0.06 and 0.39 $/litre. In order to stabilise CO_2 emissions in 2020 at the 1990 level the charge level might have to be as high as 2.86 $/litre of fuel. At various points in the study a charge level ranging from 0.10 to 0.40 $/l was used as a working assumption. Specific calculations were made using a level of 0.20 $/l. With the know-ledge gained in the background study, five options were selected. They were selected because they combine among them all possible elements of the design of a European environmental aviation charge.

The following five charge options were selected for further consideration, not because they are the best, but because they represent the most practical choices:

1 Calculated emission charge (revenue 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 route10. As this charge 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.

2 Revenue-neutral emission charge (revenue to airline companies)

This charge will be levied on each kg of a 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 (according to an 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 EuroControl, on the calculated emissions of each specific engine/airframe combination during a flight. In addition, Euro-Control or another organisation 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. Carriers with a good environmental performance thus receive more revenues than the charges they pay. On the other hand, carriers with above average emissions per passenger - and tonne-kilometre are faced with a nett financial loss. Obviously, a revenue-neutral charge does not generate revenues for the treasuries.

3 Calculated emission charge on LTO only (revenue to national states)

This charge will be levied on each kg of a pollutant (CO_2, NO_x etc.) emitted by an aircraft during the LTO cycle at airports in the EEA. This charge will be levied at the same time as a landing charge. The revenue from 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.

4 Fuel charge package (revenue to national states)

This option is a package of three instruments in which a fuel charge constitutes the key instrument. This 'fuel charge package' comprises the following instruments:

- A charge levied on each litre of fuel bunkered by an aircraft in the EEA. The charge level corresponds with the average emissions of CO2, NOx, H2O and SO2 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 NOx. From this landing charge is deducted that share of the LTO emissions of NOx that has already been incorporated in the fuel charge. This charge generates an incentive to reduce the LTOspecific emissions of CO, VOC and NOx. 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 NOx emissions during the flight. Without such standards energy efficiency might be improved at the expense of higher NOx emissions.

Contrary to the other options, the researchers 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 due to NOx and VOC. A fuel charge complemented by 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 (revenue 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 EEA11#. It seems logical in this option for each country to receive the revenue from the ticket charge on movements departing from their own airports.

4.4.2 Results concerning environmental effectiveness

The emissions of the aviation sector can be reduced in various ways, which can be summarised as follows.

1. Technological improvement, broken down into engine improvements, weight reductions and reductions of drag-to-lift ratio.

2. New optimisation of aircraft design. The design of aircraft is highly optimised 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 passenger-kilometre (pax.km) or revenue-tonne kilometre (RTK) will decrease with increasing flight distance and increasing aircraft size.
4. Increase of load factor.
5. Improvement of flight operations. By flying better routes, minimising congestion and improving flight handling procedures, emissions can be reduced.
6. A reduction of the number of pax.km or RTK to be flown. The first five focus on a reduction of emissions per pax.km or RTK performed; the sixth is, obviously, a reduction of the actual number of pax.km or RTK: a volume effect.

The optimal charge stimulates all these possibilities. It was found that different charges have different environmental effects. In the table below, the left column shows the reduction potential of an option: improved technology has a high reduction potential, for example. The right column identifies the effect ofthe charge: a ticket charge has no effect on technology, for example, but leads to a large emission reduction stemming from volume reduction. A revenue-neutral charge has no effect on volume .

Qualitative indication of possible effects of an emission charge of $ 0.20 per litre

Aspect	reduction potential	effect of charge on CO2 emission(b)			
	1992-2025(a)	fuel charge charge	calculated emission charge	revenue-neutral charge	ticket charge
volume	high	+	++	0	++
technology	high	++	++	++	0
size/ distance	moderate	0/+?	0/+?	+	0
optimised design	high?	++	++	++	0
load factor	moderate	+	+	++	00
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.

If it is assumed that autonomous emission reductions will continue to take place at the same pace as they have done over the past few decades, aviation emissions will rise from an index of 100 in 1992 to 300 in 2025.

Both the emission charge and the fuel charge package are expected to be effective in reducing air pollution from aviation. Based on a review of available research, it is estimated that a gradual increase of 0.20 $/l in fuel price, or an equivalent emission charge, will reduce air pollution to around index 200 in 2025.The positive environmental impact of these two charges is high, because both types of charge generate incentives with regard to most kinds of environmental improvement. These relate to aircraft technology, optimised 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 is 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 to index 225 by 2025.

The LTO emission charge 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. It will reduce emissions to index 275 by 2025. The movement or ticket charge also has relatively low environmental effectiveness: roughly one-third that of the emission or fuel charge. It will reduce emissions to index 260 by 2025. 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.

4.4.3 Results concerning economic distortions

If a European environmental aviation charge leads to substantial economic distortions, the feasibility of such a charge will be reduced. The study therefore devoted considerable effort 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.

As a first step, the price increase is considered more closely. A charge corresponding with 0.10 to 0.40 US$ per litre of 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.

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

price increase	500-km flight	2000-km flight
per ticket (one-way)	1.50 - 6.50 $	4.50 - 19.00 $

This 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 airports12.

Next, it is important to stress that the charge is non-discriminatory. Both European and non-European carriers are faced with the same charge regime 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 convert the cost increase due to the charge into a price increase or, 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 average annual growth will be reduced from 4% without a charge to 3.7% over a period of 30

years, following the step-by-step 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. One extra merger compared to 'business as usual' might be sufficient to counterbalance the smaller home market and achieve the same scale efficiency.
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 any significant 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 significant 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 airspace 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 flight 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 $/l will generate any substantial shift towards tourist areas outside Europe. Furthermore, consideration might be given to introducing mitigating measures for some tourist areas in the event of significant distortions. A fuel charge is more vulnerable to economic distortions among airports and tourist areas than an emission charge. On intercontinental flights the sensitivity with respect to these potential economic distortions is even greater. On a flight of 6000 km the potential gain of shifting origin or destination to an airport just outside Europe is estimated at around 30 US$. It is hard to judge whether such a gain will have any substantial impact on travel behaviour.

The potential economic distortions of a movement-based charge are somewhere 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 distortions13.

4.4.4 Results concerning legal issues

It has been frequently stated, especially by the industry, that the Chicago treaty forbids the introduction of environmental charges and/or taxes. The International Institute of Air and Space Law in Leiden, the Netherlands, has undertaken a legal analysis of the proposed options.

Neither an emission nor a movement-based charge face serious legal obstacles 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.

Although the Chicago Convention (Article 15)14 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 exclude a levy being raised on fuel emissions. There is also no prohibition against levying a fee on tickets or air traffic control. In the case of a fuel charge, it is expected that many bilateral Air Service Agreements (ASAs) will have to be adapted. With respect to ASAs between the participating European countries this will not constitute a (political) problem. Adapting ASAs between any participating country and a non-European country might generate 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 only intra-European flights 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 distortions than a charge on fuel bunkers for all departures from European airports.

4.5 Conclusions of the feasibility study ‘A European environmental aviation charge’

The following conclusions were drawn by the researchers:

- This study reveals positive prospects for the implementation of a European aviation charge that is both environmentally effective and feasible. A charge level equivalent to 0.20 US$/litre of 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.

- 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. A charge based on calculated emissions appears to be the most attractive option and is most probably feasible. The potential economic distortions15 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.

- A fuel charge package16. 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 fewer legal obstacles than a fuel charge on all departing flights from Europe. However, the consequence is 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.

- The environmental effectiveness of a movement (or ticket) charge is roughly only one-third that of the other two charge bases. In addition, 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 would 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 (It has already been implemented by Norway and Great Britain).

- 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.

- A revenue-neutral emission charge is most probably feasible. Its potential economic distortions are likely to be negligible. Also, 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. One crucial difference compared with the emission charge concerns 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 the 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.

T&E's policy recommendations for ecologically sustainable aviation

A balanced and integrated policy for sustainable development of the aviation sector is needed. The predictions for future emissions of the aviation sector (+300% in 2025 compared to 1992) are not in line with a sustainable development path (e.g. IPCC-recommended reduction targets). T&E proposes to take the following measures:

1. A European ban on any form of direct or indirect financial support to the aviation sector.

This is required to create a level economic playing field and s fully in line with the aim of liberalising the European air transport market. It would also benefit the environment as it means a cut in public funding of the most polluting mode of transport per passenger kilometer. The ban would apply to both airports and airlines.

2. Abolition of all tax benefits for the air transport sector.

At present, the zero-rated VAT on air tickets is an exception to normal EU financial practice (in that all goods and services are taxed except those relating to international trade). Abolishing this zero-rating on 'domestic' flights -which will ultimately mean within the European Economic Area- would raise the price of European flights. A VAT on air tickets and kerosene should be introduced. Currently, kerosene is exempted from excise duty. This situation is not fair as it distorts competition among modes. It is not efficient, because it 'over'-stimulates aviation which is relatively the most polluting mode of transport. The exemption for excise duty for kerosene should be lifted. There is also an exemption for duty and VAT on 'tax free' goods sold at airports and in-flight. According to calculations by a Dutch research institute, abolition of these concessions for flights within the EU would lead to a 2.7% rise in the price of air tickets. As stated earlier, T&E fully supports the proposed abolition of tax free sales by 1 July 1999.17

3. Introduction of a European environmental aviation charge.

In order to bring aviation developments into closer line with the need for ecological sustainability, a European environmental aviation charge should be introduced. Its aim should be to reduce emissions. A charge based on calculated emissions appears to be the most attractive option, possibly in combination with an LTO emission charge. The EU should push the ICAO to introduce such a charge worldwide, but should also take on its own responsibility now and not wait for the ICAO. It is the view of T&E that without Community action, an international solution respecting the need for ecologically sustainable development of the aviation sector is unlikely in the foreseeable future. An emission charge equivalent to 0,20 $/litre will reduce the growth of emissions to 200%, compared to 300% in a business as usual scenario. In order to stabilise CO2 emissions in 2020 at the 1990 level using only the instrument of an aviation charge, the change level might have to be as high as equivalent to 2.86$/litre of fuel. It is clear that the level of the charge should be optimised to bring about, in a well-balanced package with the other measures proposed, ecologically sustainable development of the aviation sector.

At present aviation emissions are not allocated. T&E advocates that two principles should be adhered to:

- Allocation should take place in such a way that no 'gaps' occur, e.g. such that emissions above oceans are not attributed, and,
- Allocation should go to a policy level that can take responsibility for the required reductions, that is to say to the policy level capable of introducing and enforcing a targeted policy. The latter principle implies either the community or the national state. The revenue should be allocated to the policy level responsible for the reduction targets of the allocated emissions.

Use of the revenue is a political decision. Of course, slower growth in the aviation sector will mean lower job growth in aviation, but the argument that T&E's strategy would be bad for the economy as a whole is just not true. In fact, studies carried out in other transport sectors indicate that if some of the funds raised through this measure were used to reduce taxes on labour, more jobs would be created overall than if the aviation sector were left untouched. Furthermore, an emission charge in European airspace will not have any noticeable impact on competition between European and non-European carriers.

T&E's strategy would lead to higher prices for air traffic. An emission charge equivalent to 0.20 $/litre would make a one-way ticket for a 2000 km trip 10-15 $ more expensive, depending on the aircraft type. This would affect locations such as islands accessible only by boat or air. However, this can never serve as an argument against a sound environmental policy for the total volume of air traffic, of which flights to such places form only a tiny fraction. Governments that feel they have a public obligation to the citizens living in these remote areas should perhaps be allowed to buy these trips in the market at their true cost and make them available to these citizens at reduced prices that reflect this public obligation concern.

4. Communication on the environmental effects of aviation.

Citizens and companies need to be informed about the consequences of flying. Currently, accurate information on the environmental performance of the aviation industry is not available to the general public, interest groups, scientists or even policymakers themselves, because of the restrictions maintained by the aviation sector and because the information is biased in favour of by the interests of the sector.

Authorities should ensure that accurate information is available as well as accessible. Currently, the information is scattered, has many different formats and cannot readily be found. (For example, information on the emissions of airframe/engine combinations is presently entirely lacking on the Internet). Authorities should stimulate the accessibility of existing information. Finally, authorities should actively inform target groups. This can be done directly, for example, by means of television, radio, newspapers, brochures and labelling schemes, or indirectly, by supporting those providing this information.

5. Tightening of aircraft emission and noise standards.

The guiding principle should be to promote maximum use of the best available technology (BAT). At present, international standards lay down maximum levels for NOx emissions and noise generation. These must be tightened as soon as possible because the long delay in bringing new aircraft technology into operation means that polluting and noisy aircraft will be with us for some time anyway. With regard to emissions, the EU is setting an example by introducing NOx standards that are stricter than the current ICAO limits18. This will not adversely affect the competitiveness of European carriers.

With respect to noise, the standards should protect citizens living around airports: an 8-hour night ban throughout the EU should be standard, so that airports can no longer compete at the expense of citizens' health. Noise regulations should be made dynamicly stringent, so that in future fewer people are affected than today, even if the aviation sector quadruples over the next 15 years. If flights come in at night, noise landing charges should reflect the severity of the disturbance of night-time rest. In the Dutch government's calculations of noise disturbance, one night flight carries the same weight as 10 daytime flights.

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