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Sustainable air travel

- A study of the effects an environmental tax on air fuel might bring.

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Abstract

The aviation industry has since its beginning had an accelerating growth. Simultaneously the emissions have increased, representing today 4.5 percent of the total anthropogenic greenhouse gas emissions.

These emissions are not accounted for in the Kyoto protocol reduction targets. Present inventory estimations would be greatly affected if this sectors emissions where to be included and the set target values would be hard to achieve within the given time period.

The environmental cost of air travel is not reflected in the market mechanism, causing an externality problem. This results in, from a social perspective, low market price and high demand.

Aviation is relieved from tax on fuel. Therefore this paper has considered taxation as an alternative mean to adjust the market and the possibility to reduce the greenhouse gas emissions. It is imperative to analyze the effects a tax on air fuel might bring if such a policy be realized.. This paper analyzes the consequences a tax introduction could bring socially, economically and from an environmental point of view.

Keywords: Air travel; tax; externality; greenhouse gases; emissions

1 Introduction

This section outlines the problem behind the increased greenhouse gas emissions caused by aviation. The intention is to give an understanding of the underlying reasons speaking for a tax on air fuel. The introduction is followed by the purpose, outline and method of the paper.

Aircraft is often described as energy efficient and as an environmental friendly means of transportation. Today air transport accounts for almost 4.5 percent of all greenhouse gas emission made by anthropogenic sources (Gössling et al, 2005). The present concentration of carbon dioxide in the atmosphere today is the result from the last 100 years, during which aviation has only been present for the last 50 (Åkerman, 2004). It is the fastest growing source of emissions and if present trends continue air transport might have an impact of similar magnitude in the middle of the twenty-first century as cars have today (Baumert, 2005, Penner, Lister & Griggs, 1999). Preventing this scenario requires further development of technology and operational modes. The Sustainable Aviation Report from (2005) states that though new technology can help to reduce future emissions but cannot solve the problem alone, which requires other measures such as governmental intervention.

Climate change is a natural part of earth's lifecycle shifting from colder to warmer periods. Hence, the increased temperature during the last century is partly explained by this natural cycle but also by the emissions of greenhouse gases released into the atmosphere by man (EPA, 2005a). Trees and oceans absorb these gases making it possible for the earth to reflect radiation back into the atmosphere. Today the concentrations of greenhouse gases are higher than the earth can absorb, resulting in increased global warming and increased temperatures, a greenhouse effect shown in figure 1 (NIVA, 2005).

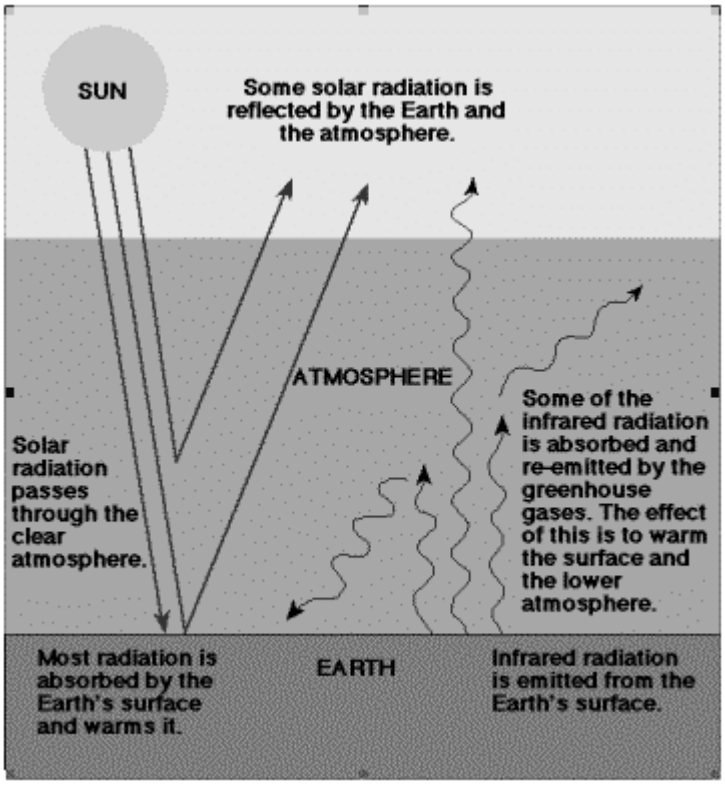


Figure 1. *Today the concentrations of greenhouse gases are higher than the earth can absorb resulting in increased global warming and increased temperatures, a greenhouse effect (NIVA, 2005)*

Emission can create different reactions due to the complexity of the climate system. The most familiar of the greenhouse gases is carbon dioxide, which in high amounts increases the temperature on earth (EPA, 2005a). There are other components making a large contribution directly or via chemical processes in the atmosphere, such as water, nitrogen oxides, sulphur oxides and soot (Åkerman, 2005). Due to the complicated reactions from water vapour and nitrogen oxides from aircrafts it is hard to calculate the effects of those greenhouse gases, but scientists consider that the reaction between carbon dioxide, water and nitrogen oxides creates a warming effect 2-5 times greater than that of carbon dioxide alone (Matthews, 2002, Penner et al, 1999).

Present political leaders and decision makers are aware of the existing problem with the greenhouse effect, which initiated the forming of the Kyoto protocol. The emission reduction targets of greenhouse gases adopted by the protocol are to be accomplished by the period of 2008 to 2012. However these figures do not include the greenhouse gas emissions from aviation (GOS, 2005). Adding the aviation emissions to the present national inventory would affect the set target values.

Emissions made by aviation causes negative externalities since the environmental costs are not taken into account. A result of an externality is that the market price is to low and may lead to inefficient economic allocations as to high emissions. A low market price will not reflect the true value and may in turn lead to a higher demand. This will not reflect the socially optimal level of production, and as a result the negative externality leads to overproduction. The main motive for environment regulations is to correct these types of distortions and also with the environment in mind aim to put a correct price in order to reach a better environment quality.

Today the fast-growing aviation industry enjoys tax exemptions on air fuel apart from other sectors. Implementation of a tax on air fuel has been prevented by ICAO rules and regulations according to Article 24 (see section two). Discussions concerning a joint tax on air fuel for all member states have been held within the European Union. The aim for a tax is to correct the external effects and in order to make aviation work towards a sustainable development.

1.1 Purpose

This paper has its origin in the existing environmental threats from increased concentrations of greenhouse gases in the atmosphere. I have in this paper searched for why and how the aviation emission causes a threat to the climate. The emissions from aircrafts are not covered by set reduction targets in the Kyoto protocol. I intend to look into how the aviation emissions if added into the national inventory would affect the targets set by the Kyoto protocol.

Aviation, contributes to greenhouse gas emissions as other means of transportation, still this sector is relived from fuel taxation. I have due to this fact chosen to look further into how a tax on air fuel could be used as an economic tool to decrease the greenhouse gas emissions and correct the existing market failure. This paper will make an analysis of the potential effects arising from a tax introduction. I have not looked further into other possible economical regulators, which can be alternatives for a tax when managing market failures.

This paper will be focusing on following questions:

(1) How does aviation contribute to emissions of greenhouse gases?
(2) How does the aviation emissions affect national greenhouse gas inventory in the context of the Kyoto-Protocol?
(3) How can a tax on air fuel reduce the emissions?
(4) Which effects will this a tax bring?

1.2 Outline

Following section will begin by present the aviation history followed by addressing over present tax regulations for aviation in order to understand the special regulations the industry have. Next section presents aviation and the environment, what impact it has on the environment and Sweden followed by a description how this affects the reduction targets set by the Kyoto protocol.

The forth section looks further into economical regulations with focus on taxes and how governments can use taxes to adjust the market and, in this case, the ability to reduce emissions. An analysis is then presented over the possible effect a tax on air fuel might bring, followed by conclusions and discussion.

1.3 Method

This paper has its origin in an immediate problem, aviation emission and its contribution to increased greenhouse gases in the atmosphere and market effects.
I have from this problem proceeded by asking questions and looked for answers within economic theory. Guided by theory I have rationalized and concluded my answers to these questions.

The material used consists of both secondary and primary sources. I have supported my work with different sources of written information like articles, magazines, books and homepages which all are considered to have a high credibility and can be found in the reference section. To get insight in the aviation industry, I have used data from the International Civil Aviation Organisation (ICAO), the International Air Transport Association (IATA), Luftfartsverket (LFV) as well as articles concerning the industry. I have also received help to collect data from; Magnus Schultzberg at the Ministry of Finance, Harald Rosén from Svenskt Flyg and Stefan Gössling at Lunds University.

2 Aviation history

Section two intends to give a brief summary over aviation history, rules and regulations. This part gives an understanding of the circumstances around tax introduction on air fuel and emphasize why the industry has tax exemptions today.

The aviation tax exemption on air fuel originates from the time when the aviation regulations where made in the end of the Second World War. The regulations, which are still in practice today, where on an initiative from the United States drawn up at the Chicago Civil Aviation Conference in 1944 (ICAO, 2005).

The convention laid the foundation for a set of rules and regulations regarding air navigation throughout the world. To enable an international agreement, issues such as airspace, price differences and taxation had to be dealt with on an early stage. To form joint regulations and rules the different views and opinion had to be agreed upon. A compromise was drawn up; a bilateral Air Service Agreement where detailed arrangements on air traffic were made, making it possible to fly between different states if the two states signed it (ICAO, 2005). The agreement consists of 96 separate articles of which only one mention taxation;

Article 24 - Customs duty

(a) Aircraft on a flight to, from, or across the territory of another contracting State shall be admitted temporarily free of duty, subject to the customs regulations of the State. Fuel, lubricating oils, spare parts, and regular equipment and aircraft stores on board an aircraft of a contracting State, on arrival in the territory of another contracting State and retained on board on leaving the territory of that State shall be exempt from customs duty, inspection fees or similar national or local duties and charges. This exemption shall not apply to any quantities or articles unloaded, except in accordance with the customs regulations of the State, which may require that they shall be kept under customs supervision.

(b) Spare parts and equipment imported into the territory of a contracting State for incorporation in or use on an aircraft of another contracting State engaged in international air navigation shall be admitted free of customs duty, subject to compliance with the regulations of the State concerned, which may provide that the articles shall be kept under customs supervision and control. (ICAO, 2005)

The International Civil Aviation Organization was established through the Chicago Convention to secure co-operation and to set regulations and standards for the civil aviation. Today almost 190 countries are represented in ICAO and it is a specialized agency within the United Nations with authority to develop new standards and make recommendations regarding all aspects of international aviation (ICAO, 2005).
This also means that the organisation certifies its own standard for emission and noise, the two main environmental problems that aviation causes (Penner et al, 1999).

Air transport has a huge influence in the world today; it is not only a carrier of people on their way on vacation or business but also a major player in the freight business. In the last fifty years air travel has become an everyday certainty which many people and businesses are dependent of. In Sweden it is the most common means of transportation among those travel abroad (Fink, 2004). The aviation industry generates 24 million jobs worldwide, serves over 1.8 billion passengers annually (IATA, 2005) and generates US$1,140 billion in annual gross output (Penner et al 1999). Statistics from IATA states that the revenue per passenger kilometres has had a growth rate of 27.6 percent and freight tonne kilometres had a growth rate of 26.8 percent (IATA, 2005). Counting Europe alone the air traffic (in terms of passenger-kilometers) has had a growth of 7.4 percent annually from 1890 until 2001 (EU, 2005a).

2.1 Aviation tax exemptions

All states signed to the ICAO are obligated to deliver tax-free fuel, according to article 24 (se above). Since all member states of the European Union are contracting to the ICAO, all consumption of air fuel and kerosene are declared with tax exemptions within the signed states (EU, 2005a).

Since ICAO does not prohibit national taxes on domestic aviation some European countries have or have had taxes related to aviation. Switzerland has added an emission tax on landing fees to encourage the use of lower emission aircrafts and to improve the technology. The tax revenues are used to finance emission reduction measures at the airport (Penner et al, 1999).

Sweden has never had a tax on kerosene, but during a period from1984 to 1987 a tax on air fuel existed for domestic flights (LFV, 2005). Except fiscal and transport political purposes this tax was introduced in order to speed up the development of burning chambers in aircraft engines. In 1997 the tax was dissolved due to that deregulation of domestic aviation and other changes made it hard to calculate the tax fair and by becoming a member of the European Union the tax were not consistent with the directives on mineral oils.

In January 1989 Sweden introduced an environmental tax similar to the one in Switzerland (LFV, 2004). This tax is revenue neutral and does not affect customer demand in the same extend that general taxes do (Penner et al, 1999). According to the Swedish tax law on energy all consumption of aviation is today tax free regarding energy taxes, carbon dioxide tax and sulphur tax (1994:1776). A tax on air fuel is considered to be too commercial, and private purposes are free from selective purchase tax (MoF, 2005). A tax on kerosene would from an international perspective conflict with countries international commitments. Here a domestic tax may lead to uneven competition and the airplanes would get refuel abroad.

Despite the failures in agreeing on a tax on air fuel within the European Union principles has been agreed upon. The European Commission states that tax exemption should remain until the international legal situation permits imposition of such a tax (EU, 2005*).* In 1998 the Environment Ministers of OECD agreed on,

"-That prices of natural resources should - "as far as possible reflect the true environmental and social costs of production, consumption and scarcity." (Baumert, 2005)

Today's tax exemption makes air fuel the cheapest fuel in comparison to others, which may give the aviation industry competitive advantages towards other means of transportation.

The aviation industry and the ICAO are against taxes but in favour for a charge on services. The revenues from charges are retained by the industry and not by the state as general taxes do. In 1996 the ICAO adopted a resolution containing principles which should work as a guide if economic regulations would get introduced. These principles are:

- There should be no fiscal aims behind the charges.
- Charges should be related to costs.
- Charges should not discriminate against air transport compared with other modes of transport. (ICAO, 1998)

The tax exemptions where established over half a century ago which might raise the question if these reasons are still valid today?
50 years ago the tax system was not designed to deal with tax on aviation (Meijer, 2005). By the time the main regulations for aviation taxation was set taxes on fuel had as a purpose to finance roads and other infrastructure which air traffic did not to pay for. Today taxes main purpose is covering private consumption and as a political tool to redistribute between different income groups, correcting market failures such as external effects and to pay for public goods (Rosen, 2005). Since the 1950: s most countries have introduced taxes on chemicals such as carbon dioxide and sulphur.

In the beginning of aviation history taxes was considered to stand in the way for the airlines companies' possibility to grow and expand (Meijers, 2005). The aviation industry is today a fast growing industry and is no longer in need for protection. If nothing else, other sectors might be in need for help to compete against it. September 11th shocked the aviation industry and a turbulent time followed, but airline companies survived showing that the industry is strong and can compete even under hard circumstances. Zero taxes may be the most equal rate there is but this is only true if all companies have a zero tax rate. Tax exemptions on air fuel for the aviation industry can in itself pose as a threat against other transportation sectors that do pay tax on fuel.

After the Second World War the bilateral agreement and the joint regulations of ICAO worked to secure peace among countries (Meijer, 2005). Today world peace is more threatened by the rights to economical interests then by airspace trespassing. If tax exemption would be excluded from the agreement other laws and regulations would still be in practice. Before 1984 it was possible by law to make a deduction on used air fuel leading to administrative and practical problems (EU, 2005b). In 2002 the European Court of Justice ruled that the European Commission should replace the European-US ASAs with one community ASA. This makes it possible to exclude the open skies agreement, which prohibit taxation on aviation.

3 Aviation and the environment

Since the impact from air travel is an unfamiliar area, section three may clarify why and how the greenhouse gas emissions occur, and how this may constitute a threat to the climate and the society. This section will present the surrounding problem concerning how to estimate the emission by this sector and further, how this may affect the set targets by the Kyoto protocol.

When burning fossil fuels carbon gets released into the atmosphere and forms carbon dioxide. Oceans and threes can absorb less than 3 billion ton carbon per year. In 1995, 6 billion tons of carbon was emitted into the atmosphere, this equals one ton per person (Matthews, 2002). Air transport projected growth is estimated to five percent annually until 2015; during which it will use three percent more fuel per year. This scenario is followed by increased emissions of greenhouse gases (Penner et al, 1999). In 1992 civil aviation consumed 130 million tonnes of fuel and with the predicted growth trend these numbers are expected to be 300 million tonnes in 2015. The Intergovernmental Panel of Climate Change's (IPCC) third assessment report from 1992 states that aviation stands for 3.5 percent of all greenhouse gases comparing to all anthropogenic sources (Penner et al 1999), according to Gössling et al (2005) these numbers are today 4.5 percent.

Air travel is often described as environmental friendly and fuel-efficient mean of transportation. This might not be an appropriate description. The effect from aviation emissions is not only depending on the amount of emissions released but also mainly where and when the emissions occur (Åkerman, 2005). Due to the complicated reaction in the atmosphere aviation emissions causes a higher radiative forcing. This may constitute a greater threat to the environment than car emissions do today (Gössling et al, 2005).

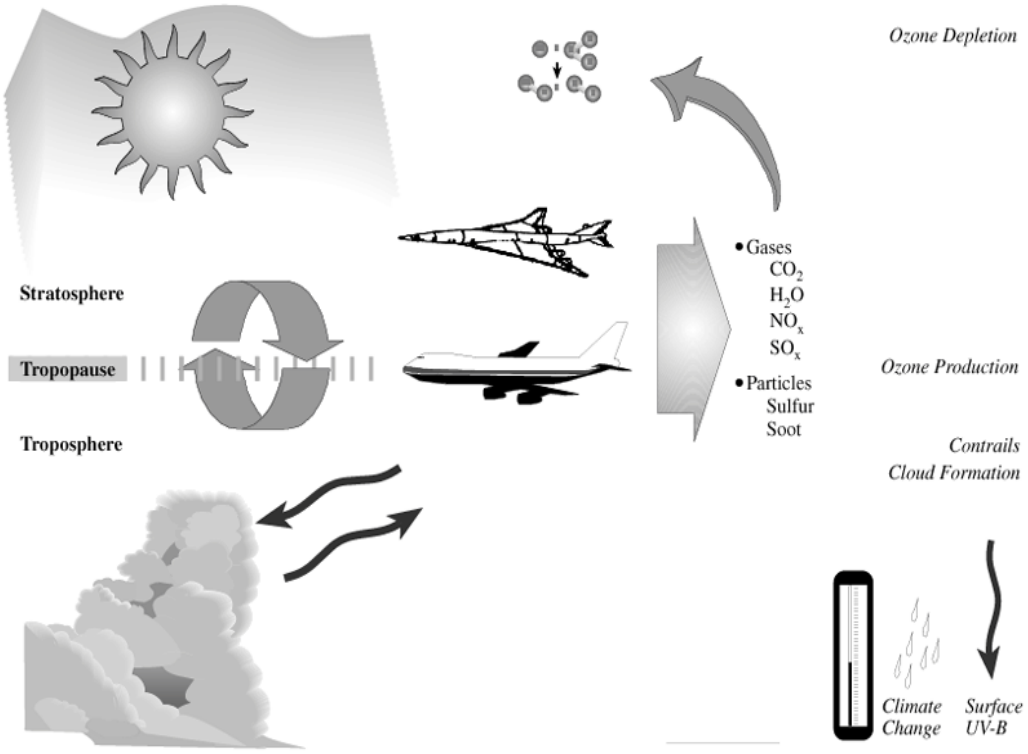


Figure 2. *The reaction between the atmosphere and aircrafts vary due to different gases. The effect is not only depending on the amount of emissions but mostly on where and when the emissions occur (Penner et al, 199).*

The reaction between the atmosphere and greenhouse gases varies, affecting e.g. the production of ozone, forming of condensation trails, cloud formation and ozone depletion among other as showed in figure 2 (Penner et al, 1999). This results in increased infrared radiation on earth, which causes a warming effect.

Aircrafts uses enormous amount of fuel making the total amount of carbon dioxide per passengers as much as if every passenger would drive the same mileage (Matthews, 2002). Hence the shorter the flight the more fuel is used (and carbon dioxide) per passenger per kilometre.

The carbon dioxide emissions are a global problem affecting economies worldwide. Impacts caused by carbon dioxide such as health, global warming and environmental effects have been calculated in an analysis made by Electrowatt-Ekono Oy. This analysis states that the annual cost of global warming is SEK 8.78 million (Otterström et al, 2003). These figures are in reality much higher since neither the total costs nor the en route emissions are included. Estimations of aircraft emissions are still a new area that demands further progress. Other damages affecting the society economically and its inhabitants are health problems such as asthma and chronic cough, which have been connected with pollution. Costs for material damage such as loss or damage of crops due to whether and temperature changes are both affecting people and governments (Otterström et al 2003).

Global warming may in the future lead to severe weather changes. The temperature in Sweden is predicted to increase more than the global average. This may result in season changes with longer growth seasons, milder winters and overall severe weather (EPA, 2005a). Flooding and increased budgetary expenditure for rebuilding infrastructure such as bridges and roads are to be expected due to increased rain. All these damages can be related to greenhouse emissions and its effect on the climate but due to lack of reliable models and techniques these are hard to evaluate and hard to put a value on.

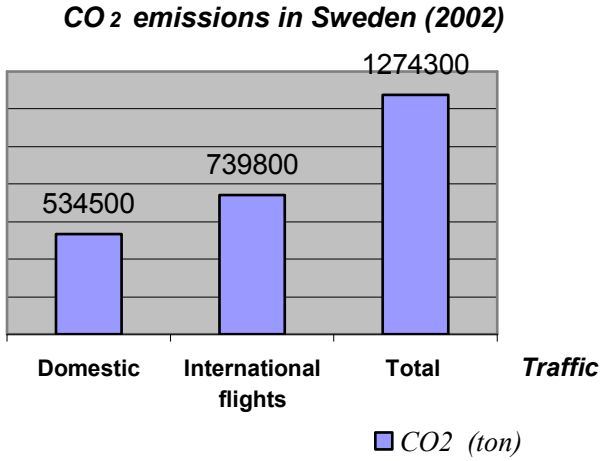
3.1 Aviation emissions and the Kyoto protocol

The European commission has adopted stabilization targets in order to stabilize the concentrations of carbon dioxide in the atmosphere at 450 ppm (parts per million). In 1995 a 60 percent cut in emissions was needed in order to meet this level. Future prognoses implies that the global emissions of carbon dioxide have to be cut by 37 percent by 2050 and by 70 percent by 2100 to meet the set stabilization targets (Åkerman, 2005).

The Kyoto protocol has entered into force, requiring the industrial countries to reduce their greenhouse gases equivalent to 1990 years emission levels by the period 2008-2012 (GOS, 2005). The European Union and its member states are aiming for a total 8 percent reduction, where the different states have different limits depending on the countries history of emissions (GOS, 2005). The emission reduction target for Sweden is set at 4 percent.

From 1990 until 2002 Europe has reduced their total greenhouse gas emissions by 3 percent while the carbon dioxide emissions made by aviation have increased by almost 70 percent (EU, 2005c). These figures do not include the effect of other greenhouse gases, which may increase these numbers by 2-5 times. Adding the aviation emissions to the present national inventory would greatly exceed the set target values. This scenario would demand further reduction of the emissions by the countries obliged by the set targets. To achieve a change in fossil fuel use all relevant activities should be included.

Scientists have today the knowledge and the ability to estimate the amount of greenhouse gases released in atmosphere more exactly. Different reports of aviation emissions vary from due to their various definitions of domestic traffic (Fink, 2004). This creates requires an agreement of norms in order to compare the different estimations. A question that may be asked is how these emissions are going to be estimated nation wise in order to reach the goals set by the Kyoto protocol? This can be done by three different approaches, the international, territorial- or the national estimations.



Traffic (2002)	Carbon dioxide CO2 (ton)
Domestic flights	534500
International flights	739800
Total	1274300

Figure 3*.This figure picture estimated aviation emissions from domestic and international flights in Sweden during 2002 based on data from LFV report in 2004 (LVF, 2004).*

Figure 3 shows the estimated aviation emissions from domestic and international flights in Sweden during 2002 (LFV, 2004). The estimations on total national emissions is based on only domestic destinations and on fuel bought within the country. International estimations separate all national fuel consumption according to IPCC guidelines. The data is calculated on all aviation fuel bought within the domestic country with foreign destinations (Fink, 2004). The Swedish Civil Aviation Association (SCAA) reports uses information from both domestic and international flights and can therefore be used in international comparison (Fink, 2004). Their estimations are based on statistic over aircraft type, fuel and emission consumption and the emissions estimated from flights between any two cities, domestic or international number of flights (Fink, 2004).

Year	*CO_2*
1990	56 065
1991	56 735
1992	54 958
1993	54 879
1994	59 233
1995	58 574
1996	62 062
1997	57 087
1998	58 142
1999	56 458
2000	55 855
2002	55 887

Table 1.

Table 1 gives overview of the total concentrations of carbon dioxide (CO_2) estimated for Sweden from the period 1990-2002.Estimated in Gg. Data based on figures from the SCAA (Fink, 2004. Gugele et al, 2002)

Year	*Tot GHG*
1990	70 566
1991	70 940
1992	69 127
1993	69 183
1994	73 634
1995	72 744
1996	76 423
1997	71 424
1998	72 545
1999	70 505
2000	69 356
2002	70 626

Table 2.

Table 2 gives overview of the total greenhouse gas (ghg) emissions in Sweden from the period 1990 – 2002. Estimated in CO_2 (Gg) equivalents. Data based on figures from the SCAA. (Fink, 2004. Gugele et al, 2002)

Table 1 and 2 show the concentrations of carbon dioxides and total greenhouse gases in Sweden during the time period 1990 until 2002. The total amount of greenhouse gases is the six gases covered by the Kyoto protocol. The estimations are based on IPCC Inventory Guidelines where aviation emissions are not included, mainly due to the lack of approved models and methods to use.

Example: carbon dioxide usage in air travel.

Flight distance here is 569 km, which can be equivalent to a journey from Ängelholm to Stockholm, Sweden. This scenario is calculated on an aircraft model jumbo 747 with an occupancy rate at 80 percent, which is considered to be relatively high rate since the global average rate is below 70 percent. 80 percent occupancy rate is equivalent to 370 passengers in economy class or 247 in business class.

This flight uses 75 kg fuel (99 liters) per passenger, which if it would be taxied as petrol in the UK would add extra SEK 758 to the ticket price. In terms of carbon dioxide this flight would release 697 kg (0.000697 Gg) carbon dioxide into the atmosphere.

Sweden has 9.000.000 millions inhabitants, if all of them made one trip annually equal to the example above this would contribute to 6273 Gg emissions of carbon dioxide into the atmosphere. Adding 6273 Gg with 2002 years of carbon emissions from table 1 the aggregated result will be 62 160 Gg which is a higher than 1990 years level. To meet the emission reduction targets set by the Kyoto protocol a 10% decrease in emission is needed.

100% of the population does not use aviation as a means of transportation but many people as so called frequent flyers flying many times a year. Domestic landings at Swedish airports in July 2005 had 714 257 passengers (LFV, 2005).

According to Gössling and Peeters (2005), 3 percent of the world's population are using air transport (180.000.000 people). Using these numbers with our example, 180 000 000 people flying a one way trop of 569 km would contribute to a carbon dioxide emission at 125 460 Gg *(125.460 000.000 kg)*.

(Matthews, 2004. Fink, 2004. Gugele et al, 2002)

4 Economical regulations

Section four gives an overview of economic regulations with focus on taxes and how governments can use taxes to adjust the market, and the possibility to reduce the greenhouse gas emissions.

Aviation contributes to increased emissions of greenhouse gases in the atmosphere, which affects the society. In economical terms the cost of increased emissions are not included in the market price causing an externality. The definition of a negative externality is that it appears whenever individual's actions affect the well being of another individual (Rosen, 2005). Private actors often do not consider the externalities since they do not regard the socioeconomic effects resulting in market failures. When a market fails governments can intervene and regulate the market with economical regulations e.g. taxes and subsidies. By internalizing external costs economical tools have the potential to reduce demand via higher ticket price. It also has the ability to reduce emissions and create incentives for development of low emission technology and to improve operational efficiency (Penner et al, 1999).

A tax on air fuel could be introduced at a national, sub-national and at a global level. A global tax is considered to be the optimal solution preventing competitive advantages between countries and increases the environmental benefits. Studies made by OECD, ICAO and CE recognize taxes as the most feasible alternative in order to decrease the aviation emissions (OECD, 1997. ICAO, 1998. Penner et al, 1999).

If a tax is introduced on air fuel the price will most certainly raise, the elasticity determines how the consumers will react on this price change. The lower the elasticity is for the demand for air travel the more incidence will fall on the consumers, with other words the consumers will be bearing the burden of the tax (Shotter, 2001). The demand on air travel depends on the possibility to substitute with other means of transportation.

4.1 Environmental taxes

Politically reasons behind environmental taxes are generally to create incentives for the industry to develop more environmental friendly and sustainable methods rather than to collect governmental revenues. Purpose with environmental taxes in theory is to correct the disturbance that externalities cause (Rosen, 2005). The question of which effect is the largest one may be hard to answer because many of the negative effects can be measured in monetary terms while the positive such as clean air etc is harder to put a value on.

The idea with taxes to correct market failures was suggested in the 1930s by the economist A. C. Pigou, thereby the name Pigouvian tax (Rosen, 2005). Given that the tax rate is put at an optimal level the polluter have to considerate the costs that pollution brings. According to Pigou an optimal environment tax rate should be put equal to the marginal environment damage indicating that a social effective production adjusted to the conditions of the market.

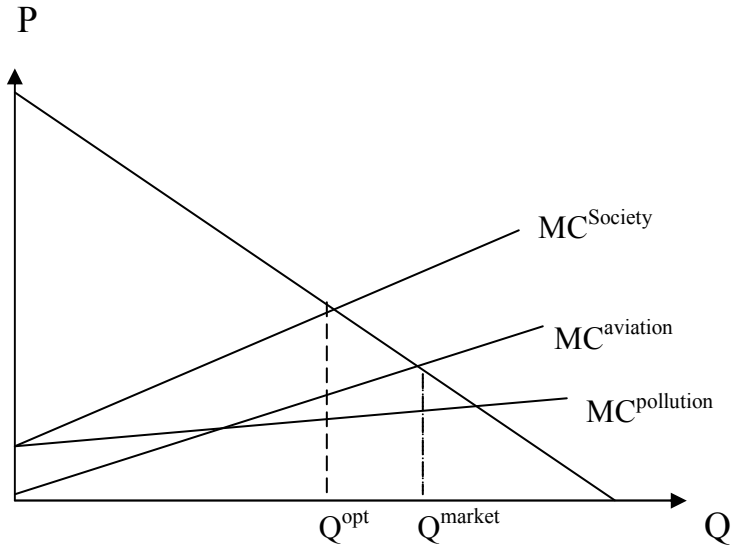


***Figure 4**. In the absent of a tax the marginal damage is not accounted for, demand equals Q^{market} which is not at a social optimal level results in a low market price.*

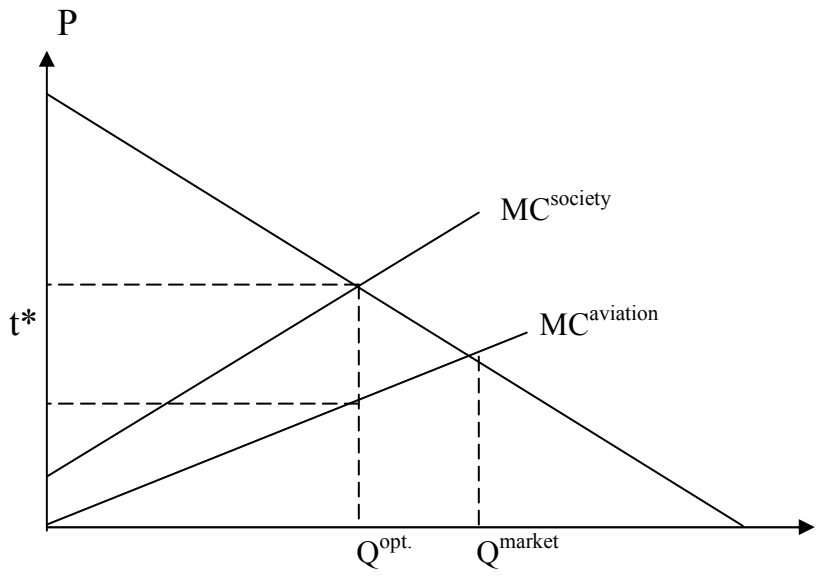


Figure 5. *Pigouvian tax; Consumers demand and the marginal damage are taken in consideration results in a social optimal quantity $Q^{opt.}$. t*, is the optimal tax which is equal to the marginal damage cost for the last produced unit up to the quantity $Q^{opt.}$ (Batt, 2002)*

Figure 4 and figure 5 show how pigouvian taxes affect the market. The marginal damage at Q^{opt} is equal to t* which is the Pigouvian tax. A tax increases the producers' marginal costs, which pays for each unit produced both to the supplier of the inputs and to the tax collector. This will shift the producers' marginal costs up to the same amount as the tax (Rosen, 2005). The Producer maximizes profit when marginal benefit equals the marginal costs, which occur when he produces $Q^{opt.}$ The tax forces the producer to account the costs of the externalities the production generates.

In the 1960s Tullock took ideas from Pigou further. He meant that a Pigouvian tax could offer other revenues besides the externalities if the revenues are used to lower other distorted taxes and thereby increase social welfare (Goldstein, 2003). The idea with double profits is more known as double dividend. The idea with revenue recycling is founded on these ideas which is used in several European countries e.g. Sweden. The purpose is to use revenues from "green" taxes to lower other distorted taxes within the economy, such as income tax and social fees. The recycling may not only generate environmental gains but also lead to efficiency gains.

5 Analysis

An eventual tax introduction on air fuel might result in various effects. This section presents an analysis of the expected major positive and negative effects that have been identified.

"We have always known that self-interest was bad morals; we now know it is bad economics" Franklin D. Roosevelt (Rosen, 2005)

The intention with a tax on air fuel is to reduce the concentrations of greenhouse gases and thereby improve the environmental climate. An environmental tax policy has potential to limit growth by effecting demand and create higher occupancy efficiency. Reports from well known organisations recognize taxes as a feasible alternative preferred over other means in order to reduce global emissions effectively (ICAO, 1998, OECD, 1997, Penner et al, 1999). All taxes affect human behaviour and are more or less distorted. A tax implies increased costs for both airlines as for consumers due to the raised fuel price (ICAO, 1998). The increased consumer costs results in lower traffic demand and thereby a reduction in emission caused by aircrafts (ICAO, 1998). Due to consumer distortions caused by an increased ticket price a dead weight loss is added thereby worsen the social welfare (Rosen, 2005).

Low elasticity on demand indicates that the consumers are going to be bearing the burden of the tax. Short distance routes such as domestic flights can more easily be substituted by other means of transportation, which leads to a higher elasticity of demand. Elasticity of demand on long distance routes is expected to be lower than on shorter routes since these flights cannot be as easily substituted considering the time saving as for shorter flights. Therefore the ticket price cannot be raised in the same extent as for long distance routes. This results in a shared burden of the tax between the producers and the consumers. High demand elasticity demands a low tax rate.

In a simple economical model there is only one polluter and one victim, in real life the whole society may benefit from reduced emissions and better environmental quality. Air travelers might be the ones bearing the burden of a tax with increased ticket prices but will also share the benefits from improved environmental quality. A problem when estimating the positive effect of environmental policies is the attempt to put a monetary value on these effects. In order to interpret the results from environmental policies you require further development of appropriate economical models.

Another environmental standpoint for a tax introduction is to encourage technological improvements and innovations. A decrease in consumer demand may create incentives for suppliers and manufacturers in the industry to use environmental friendly equipment (ICAO, 1998). Switzerland has introduced a tax on landing fees where the revenues are used to finance such innovations (Penner et al, 1999). Sweden had from 1984 till 1987 a domestic tax on air fuel (LFV, 2005). The purpose with this tax was to speed up the development of burning chambers in the engine on the airplane type Fokker F 28. This change occurred and with it the environmental positive effect wished for. This shows that former tax policies have lead to development of more environmental friendly equipment (LFV, 2004).

Environmental motive are behind governmental regulations, but there are other threats arising from continued growth, which can be lowered by a tax. After September 11th the issue of security has been a pressing issue but it is not only the fear of terror(ism) that is a threat to the growth of aviation. Air traffic is growing rapidly where the European market stands for one third of all international traffic (EU, 2005a). During the last 30 years a five-fold increase of airports has occurred in the 15 member states within the European Union (EU, 2005a). With this growth follows the increased demand for better service, fewer delays and safety. Increased traffic in the air and on the ground creates problems such as delays and overloaded air traffic systems. The usual method to meet increased traffic is to expand and develop existing airports; this requires accurately estimations of the environmental impact in order to escape future problems. The technological improvements such as new traffic control equipment assist to control the increased air traffic and runway traffic. Also new landing procedures and better planning are crucial when it comes to secure the safety of passengers and staff (NLR, 2005).

Pigouvian tax has weaknesses but is a feasible method when correcting market failure. Implementing a pigouvian tax might raise the question, how to put a value on the damage caused by production and secondly, what is the optimal tax? In reality the optimal tax level is hard to find. The double-dividend perspective has been questioned; the main argument is that so-called tax interaction, that environmental taxes affect other tax bases negative (Rosen, 2005).

In Sweden and the western world the total tax revenues from tax on labor dominate the tax base while environmental taxes only represent a small share. Assuming constant employment rates an increased tax cannot compensate the lowering income tax. When the purpose to decrease emissions has been fulfilled the possibility to recycle the taxes will no longer be possible.

Revenue recycling would theoretically compensate a direct tax on labor with an indirect tax on labor, which may affect the range of employment negative. According to the economists Bovenberg et al (1993), revenue recycling may lead to a decrease in unemployment but the effect may be smaller than expected since a share will disappear into higher wages. Instead of employing further the reduced tax might lead to increased wages. The extent of compensation in unemployment is crucial for the result. If it falls due to revenue recycling reform the range effect of employment might be positive, although Holmlund et al (1998) regard a general reduced tax on labour not to give these effects.

Environmental taxes may increase the production costs in the taxed sectors affecting the market price, which in turn may lead to a general increased price level. A lowered purchase power leads to lowering real wages in theory. Other arguments say that the range of employment may diminish more than the income tax, which in turn may lead to increases real wages and unemployment. This results in a larger tax interaction effect than the revenue recycling-effect. These arguments are not always accurate but during the last 15 years they have been strong arguments in the tax debate (Goulder et al, 2000).

Opponents to a tax on air fuel do often use reasons such as economic losses for airline companies, bankruptcies, reduced bookings with consequences such as increased energy consumption per air traveller as argument (Rosén, 2005). For countries or big organisations such as the European community the fear is that a tax would create competitive advantages for other countries and regions without similar policies (Baumert, 2005, Penner et al, 1999).

International taxation of fuel is currently precluded by the bilateral air service agreements signed between countries, the main legal framework underlying the operation of international civil aviation. In 2002 the European Court of justice ruled that the European Commission should replace the European-US ASAs with one community ASA. This makes it possible to exclude the open skies agreement which prohibit taxation on aviation

Studies made by OECD, ICAO and the CE considered an introduction of a tax on air fuel (OECD, 1997, ICAO, 1998, Penner et al, 1999). They recognized taxes as a feasible option in order to decrease the emissions. The studies considered neutral revenues, which may be the most feasible alternative considering ICAO regulations. However this prevents governments from using the tax revenues for fiscal purposes or as revenue recycling.

A tax could be introduced at a national, sub-national and at an international level. A national tax for Sweden on air fuel is not expected to give the environmental effect wished for since the opportunity to refuel at a lower price abroad would be high. Technical improvements may get developed, but the negative effects such as profit losses and distortions will dominate. Failing to provide the environmental benefits prevents a national introduction of a tax on air fuel.

Tax introduction at a global level might prevent distortion of competition, avoid substantial long-term effect on air traffic growth and increase the environmental benefits (OECD, 1997, ICAO, 1998, Penner et al, 1999). A fuel price including the external cost has the possibility to reduce the aviation emission growth rate. In a study made by The Centre for Energy Conservation and Environmental Technology (CE) a scenario where the fuel price included the environmental costs (125% of the cost of fuel) resulted in a 50 percent reduction of the emission rate (Penner et al, 1999).

A European tax on air fuel among the member states would have the possibility to reach environmental targets. A large share of the European air traffic occurs within Europe and it may not be an alternative to go outside to refuel. According to the CE study such a threat would not be considered relevant due to the small-scale impacts (Penner et al, 1999).

A tax on air fuel should be taxed on the same basis as any other fuel. A tax on air fuel could be designed as the Swedish tax on petrol. The tax on petrol consists of two different taxes, an energy tax and a carbon dioxide tax. The tax on energy is in turn divided into two parts, first a fiscal motive and secondly a part that foremost regards the social costs related to traffic such as cost of roads, bridges and car accidents (EPA, 2005b). The tax on carbon dioxide has increased gradually since the introduction and today it is set at SEK 0.76 per kilogram (GOV, 2005). This tax is an example of an environmental tax which purpose is to reduce the carbon dioxide emissions and counteract increased emissions but also to generate a revenue income to the state.

Monitoring such a tax on air fuel can either be made according to EU law with the European Commission to watch over it. To implement a tax according to EU law binding contracts with the member states may be required for this alternative. Each country could supervise a joint tax introduction in order to reduce additional administrative costs. If an introduction is made gradually it may reduce the negative effects. The tax revenues could be used for fiscal purposes as revenue recycling or to finance development of more environmental friendly equipment. Due to the different governmental ruling within the European Union these decisions might also be best made domestically. If the revenues would be used to lower other distorted taxes e.g. income taxes, this might, apart from correcting the externality problem lead to additional efficiency gains.

6 Conclusions

The sixth section outlines brief conclusions presented in this study.

Aviation is, along with other means of transportation, responsible for increased emissions of greenhouse gases in the atmosphere. Due to the fact that the emissions are released in the atmosphere they give greater climate impacts then if the emissions where released on the ground.

By stabilizing the concentrations of greenhouse gases the reduction targets set by the Kyoto protocol can be realized. In order to achieve these targets, and to improve the environmental climate, all relevant sources causative to greenhouse gas emissions should be included for in the national inventory.

A tax on air fuel is a feasible efficient alternative in order to realize reduced greenhouse gas emissions in the atmosphere by affecting the market. Within a social optimal perspective by internalizing the external costs the result will be acceptable ticket prices and social optimal demand. Lowered demand may result in fewer departures and increased occupancy, and thereby in a reduction of greenhouse gas emissions. A tax may also create incentives to develop more environmental friendly technology.

A government intervention is an immediate approach to deal with market failure. Taxes create distortions and may bring additional costs, which will affect the aviation industry and its manufacturer with expected increased costs and profits losses. A substitution effect might arise from increased ticket prices and transportation business such as bus and train might benefit from this removal.

Future generations are the main beneficiary from the present efforts towards a sustainable development. Global warming affects economies worldwide; reducing additional environmental damages will prevent future expected costs for e.g. healthcare and infrastructure.

A national tax on air fuel in Sweden is an inappropriate alternative since it will not result in the environmental benefit wished for. A global tax would be the most efficient alternative with high environmental benefits and reduced negative distortions and effects compared to a national or a sub-national tax. This option is despite its effectiveness not a feasible alternative due to lack in global agreement. The European Court has made a future tax introduction possible for the member states. Since the European market stands for a large share of all international air travel a tax have the possibility to reduce the European emissions, which will make a great impact on the total emission made by aviation.

7 Discussion

This final section offers a broader discussion assumed from the conclusions presented in this paper.

Few are aware of the impacts made by air travel, which by many are believed to be an environmental friendly alternative means of transportation. In 1992 IPCC stated that aviation stood for 3.5 percent of all anthropogenic greenhouse gas emissions. These numbers are since frequently used by different organisations and others to underline the harmfulness of aviation. Due to the progressive growth of aviation these figures are today higher. It is imperative to repeat that only a small share (3 percent) of the global population participate in air travel and this demand is mainly emerged from the western societies such as the USA and Europe. Taking into consideration that these three percent stands for 4.5 percent of all greenhouse gas emissions makes this a large share of this group's total emissions. This forecast implies that impacts from aircraft emissions will be far greater in the future. New technology may help to reduce future emissions but cannot alone solve the problem, which require other measures such as governmental intervention.

Comparison between aviation and other means of transportation is problematic. The common comparison based on fuel use cannot be translated to aircrafts fuel use due to the complex reaction the emissions have in the atmosphere. Carbon dioxide released in the atmosphere has a three times higher effect than if released on ground. Including other greenhouse gases such as water and nitrogen oxides creates an even higher warming effect.

In order to estimate emission inventory accurately all relevant activities should be included, not only due to competition fairness but also in order to accomplish the stabilization target required for a sustainable future. The Kyoto protocol does not include reduction targets for the aviation industry and the emission released from this sector is accelerating as the demand continues to grow. Since 1990 the carbon dioxide emission within Europe has increased by 70 percent. If aviation emissions are going to be accounted for in the Kyoto protocol present calculations have to be updated. This will result in increased reduction levels for all countries. International norms of how to measure these emissions are required for further progress and are still to be agreed upon.

These worst case scenarios is by some claimed to be unrealistic and that new technologies will be in hand to reduce the emission in the future. To rely on new technologies to be developed can be a risky strategy. Research and innovation breakthroughs can take a long time and sometimes it will not be possible to carry out new ideas.

Taxes used in order to prevent further emissions can create problems due to the distortion but among other "bad" means taxes has shown to deal with environmental problems effectively. The industry is opposing government intervention and for the time being law also prohibits it. Due to the European Court ruling a tax introduction is possible within a near future. The motivation for such an intervention is to create a socially optional level of demand and this by putting a correct price on air travel, a price where all the cost is reflected.

A national Swedish tax on air fuel would not lead to decreased emissions of greenhouse gases due to the possibility to refuel abroad. The lack of environmental benefits and thereby the positive effects aimed for exclude this alternative in order to reduce the emissions made by aviation.

A global tax on air fuel have the possibility to reduce the greenhouse gas emission in the atmosphere while preventing distortion of competition and avoiding long-term effect on air traffic growth. However it may appear as the best solution it might not be feasible. The threat of global warming demands immediate measures. Agreement of a global tax is hampered as long as large states such as the USA and Australia oppose such a tax and this solution may take a long time.

Since Europe stands for a large share of the total international air traffic, by reducing the emission on the European market a large share of the total greenhouse gas emission would get reduced. The incentives made by the European commission to implement a tax on aviation are a way to deal with this problem. A tax on air fuel among the member states would have the possibility to reach environmental targets. The treat of refuelling elsewhere is not considered relevant due to the small scale impacts.

In order to reduce the additional costs and to prevent disagreements between the states how to use the tax revenues the responsibility and supervisions can be handed over to each individual country. A tax on air fuel could look like the Swedish tax on petrol, which is divided into an energy tax and a carbon dioxide tax which is set at a fixed price per kilogram. The tax revenues from this tax has fiscal purposes or as revenue recycling.

If a tax would be introduced air transport might get substituted by other means of transport such as train and cars on shorter distances due to the increased ticket price. Between distances further apart for example between Kiruna and Malmö in Sweden, where air travel would mean great time saving and a higher consumers price. Result of a tax would probably be fewer departures and more passenger efficient flights. If governments would use the tax revenues to lower other taxes, e.g. income taxes, this would give lowered expenses also for the aviation industry in terms of lowered labour expenses. If this would lead to efficiency gains according to double dividend can only be speculated, many economists suggest that it will while others are more doubtful.

Today societies worldwide are affected by the damage caused by greenhouse gas emissions partly caused by aviation. For example, if the climate gets disturbed in Sweden other parts on the globe may face consequences such as e.g. increased flooding in the future. This is followed by increasing costs for governments through e.g. medical costs or costs from repairing, replacing and reconstruction infrastructure. Consequences of increased global warming such as more frequent severe weather results in increased costs for healthcare, compensation for damaged crops, flooding and material damage.

The reasons behind the aviation tax exemptions are out of date and it takes a big organization, like the European Union to bring the aviation industry along into a sustainable future. The aviation plays a significant part in our everyday life and it is necessary to take this in consideration when a tax is introduced. The demand on aviation affects employment but also other means of transportation, suppliers and manufacturer to the industry.

This paper have not looked further into how tax exemption affects fair competition, however it is worth mentioning that this is another incentive for a tax introduction to make different transport sectors compete on equal terms and with it pay for all its costs. A general problem in the transport sector is that different means of transport pays in different extents for its external costs.

8 Reference

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9 Glossaries

Acidification: "the process whereby air pollution – mainly ammonia, sulphur dioxide and nitrogen oxides – is converted into acid substances" (EEA, 2005).

Anthropogenic: Caused by humans

ASA - Aviation Security Audit Section

Atmosphere: Gas formation surrounding the Earth (SMHI).

CAEP/4: *Committee on Aviation Environmental Protection* Fourth Meeting)

Carbon dioxide (CO_2): One of the greenhouse gases in the Earth's atmosphere

Cirrus clouds: The most common form of high-level clouds composed of mainly ice particles.

Condensation trails: the white trail that can be seen behind aircrafts consists of frozen ice crystals.

EPA: Swedish Environmental Protection Agency

Eutrophication:. "enhanced primary production of marine algae due to excessive supply of nutrients from human activities, independent of the natural productivity level of the sea area in question" (EEA, 2005)

Gg**:** Gigagram, 1 Gg = 109 g = 1 kilotonne (kt) = 1 000 000 kg, 1 ton = 0,001 gigagram

GOS: Government offices of Sweden

Greenhouse Effect*:* Warming of the earth's surface due to the greenhouse gases ability to absorb the infra red radiation (SMHI, 2005).

Greenhouse Gas: A gas that absorbs radiation (infrared) emitted by the Earth's surface and by clouds. The gas in turn emits infrared radiation from a level where the temperature is colder than the surface. The net effect is a local trapping of part of the absorbed energy and a tendency to warm the planetary surface (UNEP, 2005).

IATA - International Air Transport Association

IPCC - The Intergovernmental Panel of Climate Change

Neutral revenues: the revenues from a tax does not go too the state but back to (here) the aviation industry.

Nitrogen oxide (N_2O): One of the greenhouse gases in the Earth's atmosphere

NIVA: National Institute of Water & Atmospheric Research

Methane (CH_4): One of the greenhouse gases in the Earth's atmosphere

Ozone: One of the greenhouse gases in the Earth's atmosphere absorbs a great part of the infrared radiation (SMHI, 2005).

PPM*:* Part per million

Radiative forcing: "the change in the balance between radiation coming into the atmosphere and radiation going out. A positive radiative forcing tends on average to warm the surface of the Earth, and negative forcing tends on average to cool the surface." (UNEP, 2005)

Revenue recycling: Purpose is to use revenues from "green" taxes to lower other distorted taxes within the economy, such as income tax and social fees. The recycling may not only generate environmental gains but also lead to efficiency gains from the trading system, commonly called the 'double dividend.'

SNEPA - The Swedish National Environmental Protection Agency

SMF - Swedish Ministry of Finance

Stratosphere: The layer of the atmosphere above the troposphere, 15-50 km from the surface of the earth (SMHI, 2005).

The Sustainable Aviation Report - This report was established by four sectors; the airline, airport, aircraft and engine manufacturers and by air navigation service providers in Britain in 2005.

Troposphere: The layer of the atmosphere closest to the earth, from 0-15 km above the surface (SMHI, 2005).

Water vapour (H_2O): One of the greenhouse gases in the Earth's atmosphere