German civil aviation policy –

A threat for long-term climate targets?

- preliminary version -

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Abstract

The objective of this paper is to analyse the implications of the potential share of carbon emissions from civil aviation in Germany’s long-term emission budget. It is argued that in the long-run aircraft emissions may cause substantial distortions to the national CO_2 (permits) allocation. By showing the ongoing strong increase in carbon emissions of aviation, the contradiction to the existing reduction efforts made by other industries in Germany becomes apparent. Therefore, this paper poses the question how the probable impacts of growing air traffic are compatible with German climate policy. The methodology is based on an analytical comparison between modelled contracting national emission pathways and scenarios of escalating aviation carbon emissions up to 2050.

Keywords

Aviation, Climate Change, Contraction & Convergence

Introduction

Air traffic has seen extensive growth in the past decades. Since 1960 global air passenger traffic has increased by nearly 9% per year and is expected to expand further by an average growth rate of almost 5% annually (IPCC 1999). It is one of the fastest growing sectors of the world economy in particular among modes of transport. Figure 1 illustrates historic world air traffic in terms of revenue passenger-kilometres (RPKs)[1]. The ICAO-CAEP forecast assumes a higher growth for international (4.9% p.a.) than for domestic (3.5% p.a.) flights, which results in a progression from 3 bn RPKs in 2000 to 7 bn RPKs in 2020 (see figure 2). According to the prognoses of Airbus (2006) and Boeing (2006) aviation growth is taking place at a higher rate and will lead to over 10 bn RPKs in 2025.[2] Air freight traffic is expected to grow even faster by 6% per year by 2025.

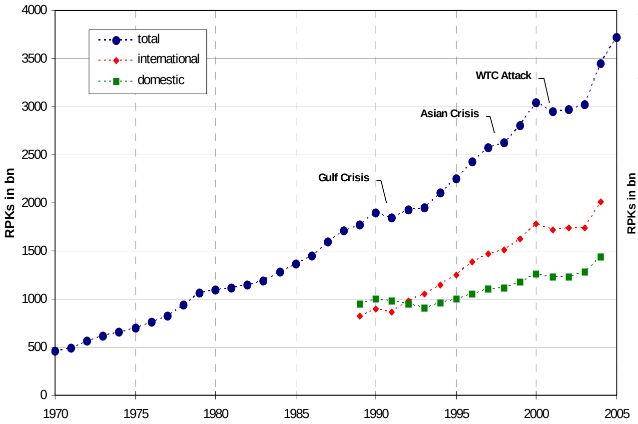

Figure 1: Historic world air traffic (data: ATA 2007).

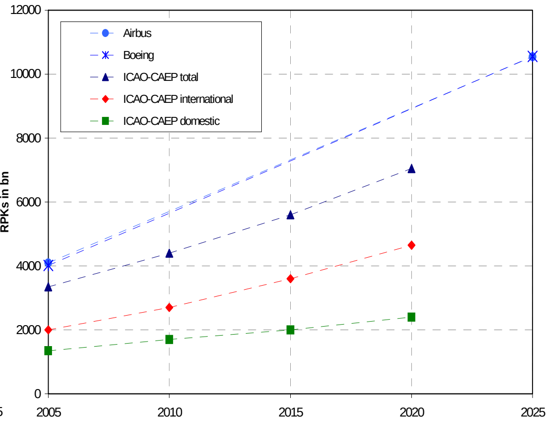

Figure 2: Forecasts world air traffic (data: Airbus 2006, Boeing 2006, DLR 2004).

Regarding its impact on climate change global air transport accounts for some 3% of worldwide anthropogenic CO_2 emissions. However, the total climate effect is about 2 to 4 times greater than those of CO_2 alone. Due to fuel burning at higher altitudes emissions have different consequences to those at ground level. Aircrafts emit nitrogen oxides (NO_x)

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[1] RPK is calculated by multiplying the number of revenue passengers travelling on each flight stage by the distance in kilometres between the ports. The distances used are Great Circle Distances. Therefore the number of passengers as well as the distances they travel are considered.

[2] The ICAO-CAEP study assumes lower growth rates and a lower level of RPKs in 2005 compared to Airbus and Boing, since the impacts of the World Trade Center attack in 2001 are completely within its forecast horizon from 2000 to 2020. Whereas the outlooks of Boing and Airbus begin in 2005 and 2006, they already include that the air traffic market has recovered from the terrorist attacks (growth rates of 14% in 2004 and 7% in 2005).

which form the greenhouse gas ozone[3]. In addition, aviation induces contrails which are assumed to enhance the formation of cirrus clouds. Both effects lead to further global warming and the potential total aviation radiative forcing could be twice as high as mentioned above (Schumann 2000 and Sausen et al. 2005). But there are still scientific uncertainties on this issue and further study is required before anything can be said conclusively. Although current air traffic contributes only a small amount to global response, the combination of expected rapid traffic as well as emission growth has the potential to turn it into a significant factor. And even substantial efficiency improvements in technology and operation have so far not been enough to compensate the effect of increased traffic.

Given the fact that international aviation is not covered by reduction targets agreed on in the Kyoto Protocol and is, at the same time, the major driver of further traffic growth particularly in Europe, this leads to a contrary development. The EU's total greenhouse gas emissions declined by 5.5% whereas carbon emissions from international flights of the EU-25 rose by 73% from 1990 to 2003 (European Commission 2005).[4] Aviation emissions are increasing while other sectors are forced to reduce emissions due to climate policy.

Keeping these considerations in mind, this paper is asking in principle whether aircraft emissions in the long-run may cause substantial intersectoral distortions to national emissions allocation in the three major aviation centres (North America, Europe, Far East) (see also Lee et al. 2004). In the following, this is analysed in detail for Germany, which is -apart from the UK- the most dominant aviation market in Europe. The question arises if there is a contradiction between the aims of the German Government to force greenhouse gas reductions in certain economic sectors on the one hand, and to meet the growing demand for aviation on the other.

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[3] Subsonic aircrafts generally cruise in an altitude range of 9-13km close to the tropopause where excessive concentration of ozone (O_3) increases the greenhouse effect. Only in the stratosphere between 20 and 30km is ozone an essential filter absorbing solar ultraviolet radiation (see IPCC 1999).

[4] In December 2006 the European Commission published a draft legislative proposal for including aviation into the EU Emissions Trading Scheme (ETS) (European Commission 2006). In particular the proposed design of inclusion provokes sceptical reactions. It is argued that the ETS will only play a small role in tackling the growing climate impact of aviation and that other measures are urgently required (see also T&E 2006, Friends of the Earth 2006, Germanwatch 2006).

Air traffic and emissions in Germany

Even though the German aviation market is already well established, it is still growing quite dynamically. Compared to the national real GDP growth of 1.4% p.a. from 1992 to 2005 (Statistisches Bundesamt 2006b) total German air traffic has increased by an average annual growth rate of 5.7% for the same period (in terms of RPKs). Due to a highly export-oriented industry and a share of more than 60% of all passengers travelling for leisure purpose with a strong preference for direct long-haul routes (see also Boeing 2006) substantial expansion takes place in international flights while domestic air traffic is quite matured (see figure 3).[5]

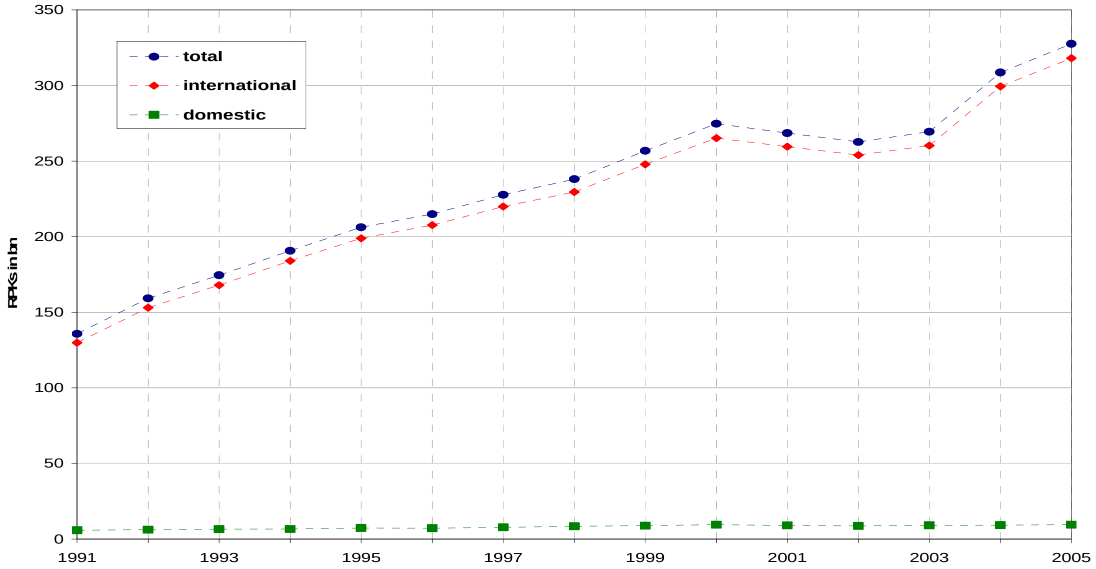

Figure 3: Passenger Traffic Performance Germany (data: Statistisches Bundesamt 2006a).

Not only Frankfurt Airport -as the third biggest hub in the world- is the main beneficiary of this development followed by Munich and Cologne/Bonn but also several regional airports have profited particularly from the successful market penetration of Low-Cost-Carriers (LCC) since 2002 (see also Statistisches Bundesamt 2006a, DLR 2005, DLR 2004, Airbus 2006). At present, any of the 37 airports is reachable for 95% of the population within 60 to 90 minutes. Germany offers the potential for ongoing expansion with such a dense and decentral airport grid (see figure 4). However, the most important airports are characterised by intense capacity utilisation while many others by rather low utilisation (DLR 2004). In regard to the forecasted continued increase of air traffic performance by an average rate of almost 5.5% p.a. through 2015 (Gresser et al. 2001) additional runway capacities are

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[5] In 2005 domestic air traffic in Germany accounts in terms of passenger numbers and of RPKs for 15% and 3% respectively (Statistisches Bundesamt 2006a).

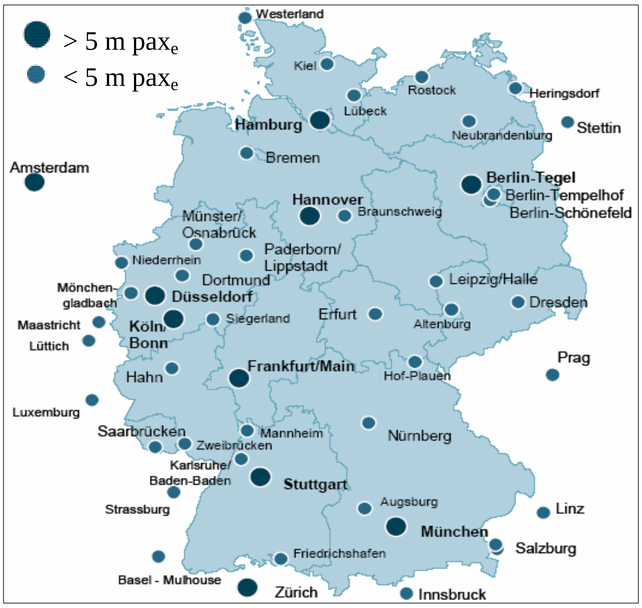

Figure 4: Airports in Germany (Initiative Luftverkehr 2004).

needed. Two are likely to be realized: in Frankfurt and in Munich (Urbatzka and Wilken 2004). According to these prospects the German Government emphasises in its national Airport Concept the outstanding significance of aviation for a modern economic system. It also underlines its positive impact on the competitiveness of business, on maintaining and creating jobs and on development of whole regions. Even though the Government claims that air traffic has to comply with environmental requirements, they simultaneously come to the conclusion that the national airport system has to meet the growing demand for aviation by expanding air traffic control as well as airport capacities (BMVBW 2000). In this context, further enlargement is mainly concentrated on the two hubs Frankfurt and Munich and on the other six airports with more than 5 m passenger-equivalents[6] per year (Initiative Luftverkehr 2005).

As a result of high growth in this sector, CO_2 emissions from aviation have risen considerably over the last few decades and are expected to continue to escalate in future.[7] Figure 5 illustrates carbon emissions from air traffic in Germany since 1990.[8] Thus, total aviation carbon emissions increase by an average annual rate of 3.1% from 1990 to 2004 and by 4.2%[9] excluding the effect of the September 11 attacks. As assumed from the traffic performance, international aviation contributes most to total aircraft emissions. But the figures do not reflect the actual share of cross-border air traffic since the Federal Environmental Agency applies a constant split of fuel consumption with a ratio of 20% for

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[6] Passenger-equivalents (pax$_e$) contain, besides the total number of passengers, air freight converted by one tonne of freight as the equivalent to 10 passengers.

[7] It would be out of scope for this paper to review all greenhouse gases. Therefore it concentrates on CO_2 emissions.

[8] Carbon emissions from aviation are reported in the National Inventory Report by the Federal Environment Agency. According to this, emissions are calculated on the basis of aircraft fuel sold in Germany which implies that only outbound flights are covered (complies with emissions allocation option 5 by the SBSTA, see below).

[9] Averaging over 1990 to 2000.

domestic and 80% for international air transports (UBA 2006).[10] This conservative approach underestimates the actual contribution of the transborder air traffic in which the strong growth over the last 12 years has mostly taken place.[11]

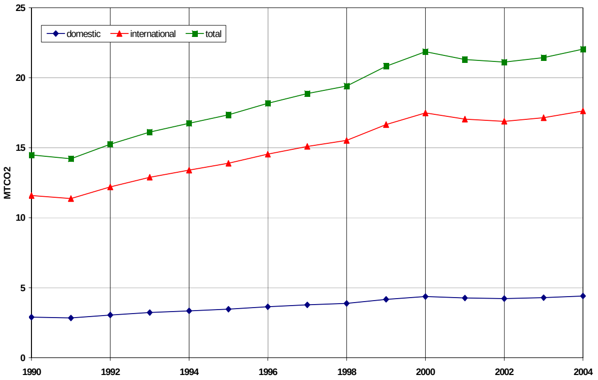

Figure 5: CO_2 emissions from aviation in Germany (data: UBA 2006).

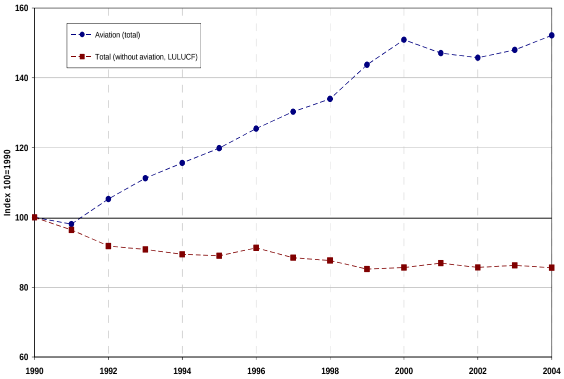

Figure 6: CO_2 emissions in Germany as an index of 1990 levels (data: UBA 2006).

Domestic and international aviation together accounted for 1.4% of total national emissions in 1990 and 2.5% in 2004. Even more crucial is the contrary trend of rising aviation emissions and abating total national emissions. Figure 6 shows air traffic and total national emissions (excluding aviation) each as an index of 1990 levels.[12] While carbon emissions from aviation have risen by 52.1% from 1990 to 2004, emissions from the other sectors in Germany have declined by 14.4%.

At this point the potential contradiction becomes obvious. Aviation emissions are allowed to increase while emission reductions from other sectors are demanded in order to achieve national climate targets. And an ongoing increase in aviation emissions is predicted for the future. According to its traffic forecast, the Federal Ministry of Transport assumes 40 Mt CO_2 by 2015 which implies an annual growth rate of 4.1% (Gresser et al. 2001).[13]

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[10] As mentioned above, international air traffic in Germany accounts in terms of passenger numbers for 85%and in terms of RPKs for 97%.

[11] In the German National Inventory Report 2006 aviation emissions are still calculated via the Tier 1 method (due to lack of data) which is the simplest methodology and is based upon an aggregate figure of fuel combustion for aviation (here: aircraft fuel sold in Germany) to be multiplied by average emission factors. The emission factors are averaged over all flight phases. By contrast, the Tier 2 method distinguishes between Landing and Take Off (LTO) emissions and cruise emissions. Both methodologies are defined by the IPCC (2000a) Good Practice Guidance in National Greenhouse Gas Inventories.

[12] LULUCF: Land Use, Land Use Change and Forestry.

[13] The air traffic outlook of the Federal Ministry of Transport contains as a base year 1997 and is predominantly based on data from 1996 to 1999.

In consideration of long-term greenhouse gas reduction targets, scenarios of air traffic emissions up to 2050 are required. These aviation emissions scenarios are generated in the following by an econometric approach which initially investigates the relationship between RPK and national GDP by the concept of cointegration. Corresponding to figure 7 a significant relation between these two factors is assumed.

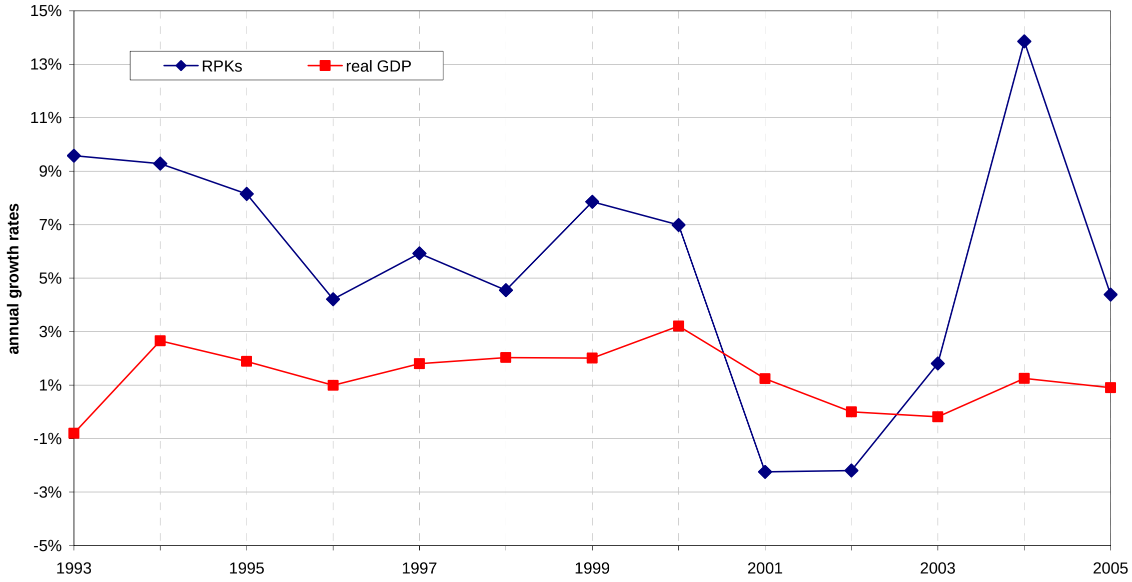

Figure 7: Air Traffic and Economic Growth (data: Statistisches Bundesamt 2006a/b).

In order to cover aircraft traffic completely, air freight data is converted from tonne-kilometre (TKM) into revenue-passenger kilometres equivalents (RPK_e) setting one tonne of freight as equivalent to 10 passengers.[14] Using historical data of period 1965 to 2005, a model of traffic demand per unit of GDP is then developed. Applying economic growth projections from the Intergovernmental Panel on Climate Change's (IPCC 2000b) Special Report on Emissions Scenarios (SRES) air traffic performance can be extrapolated up to 2050.

Since emissions have not risen as fast as RPK over the last few decades, the impact of aviation growth could be partially offset by technological and operational improvements. Therefore, future efficiency gains are considered in the aviation emissions scenarios by historical and projected rates of improvement according to sources such as IPCC (1999). Allocation of international aviation emissions to national inventory is based on option 5 recommended by the Subsidiary Body for Scientific and Technological Advice (SBSTA)

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[14] Each passenger accounts for 100kg including luggage; 1 RPK = 0.1 TKM (Statistisches Bundesamt 2006a).

of the UNFCCC (1997). This implies that all nations take responsibility for half of the aircraft emissions from international flights arriving at or departing from their airports.

- Unfortunately, it was not possible at the time of writing to run this model as the required air traffic datasets from the Federal Statistical Office will not be available before the beginning of February 2007. -

However, first indications are given by extrapolating aircraft emissions with two simple scenarios. Both of them, project aviation emissions to raise as forecasted by the Federal Ministry of Transport (BMVBW) until 2015 (Gresser et al. 2001). In the following period of 2015 to 2050, two different growth scenarios are used, selected from the IPCC (1999) report. The first scenario, called Fa1, implies a mid-range economic growth and improvements in fuel efficiency resulting in an average annual growth rate of 1.7%. In the second one, called Edh, aircraft emissions are assumed to escalate by 3.8% p.a. due to high traffic-growth. Figure 8 shows the corresponding emission paths.

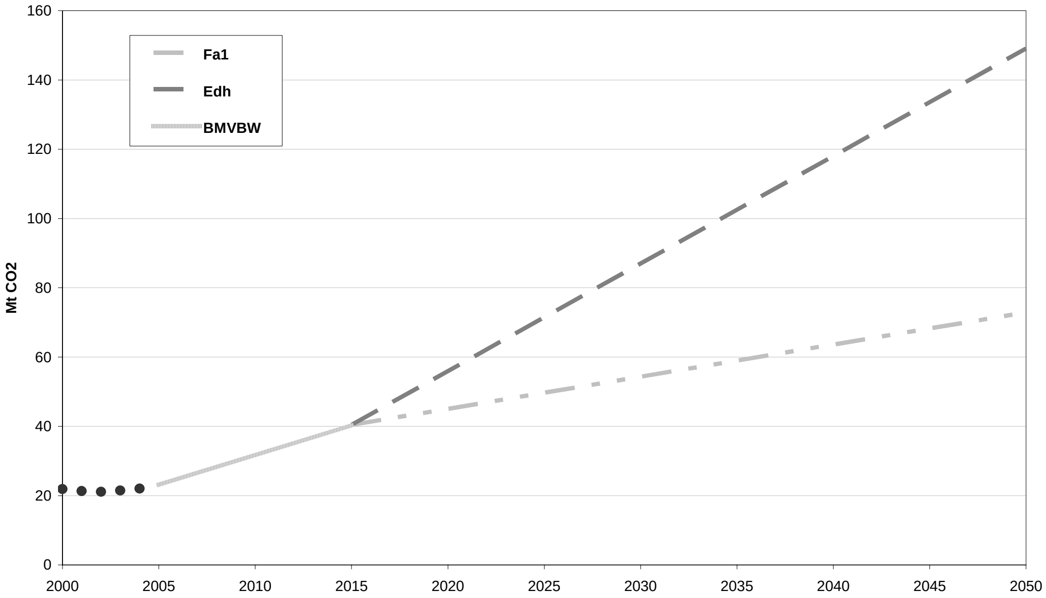

Figure 8: First indication of air traffic CO_2 emissions in Germany (data: UBA 2006, Gresser et al. 2001, IPCC 1999)

As mentioned above, these scenarios contain simplified growth assumptions. Therefore they are intended to give only a sample of future carbon emissions from the aviation sector in Germany.

German Climate Policy: long-term emission targets

Within the Kyoto Protocol and the EU burden sharing agreement Germany commits itself to reduce greenhouse gas emissions by 21% compared to 1990 levels in the first commitment period 2008 to 2012. However, it is broadly recognised that further action is necessary to achieve stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous human-induced interference with the climate system (Blok et al. 2005). In March 2005, the European Council (2005a and 2005b) reaffirmed the ultimate objective of European climate policy: to prevent global mean temperature rising by more than 2°C above pre-industrial levels. According to the Council's conclusions greenhouse gas concentration should remain well below 550ppmv CO_2 equivalent. In this context the Council considers reduction pathways by developed countries in the order of 15-30% by 2020 and 60-80% by 2050 compared to the baseline levels of 1990.

However, according to the latest scientific findings, our climate reacts significantly more to greenhouse gas concentration than primarily assumed. Thus, to meet the 2°C objective at a low risk of overshooting, it is required to stabilise atmospheric concentration at 400 ppmv (Hare and Meinshausen 2004).

As the German government does not claim a position as a forerunner in climate policy, its National Climate Protection Programme (BMU 2005) is committed to the EU Council's higher conclusion. Germany adopted the 2°C target and the cutback of 60-80% by 2050. For the medium-term -up to 2020- it is willing to reduce emissions by 40% as against 1990 levels provided the rest of the EU Member States achieve abatement of 30% in the same period. Even though the European Union, as well as Germany, are thinking about emission reductions over the next 50 years it is still unknown what kind of post-2012 climate policy regime will be the international framework for these plans.

In this scope, the German Advisory Council on Global Change recommends the approach of contraction and convergence (C&C) as a post-Kyoto strategy with the intent of reaching the aim of equal per-capita emission rights (WBGU 2003). In the first step, global emissions have to be considerably reduced to a negotiated level of greenhouse gas concentration (contraction). This means, in particular, that industrialised countries must lower, while some developing countries are allowed to increase their per-capita emissions. In the next step, this process is prolonged until the per-capita emissions of all states are roughly equal up to the year 2050 (convergence). That way, all nations move towards per-capita equity in their greenhouse gas emissions.

In the following, this concept is used in order to generate national emission pathways corresponding to German long-term reduction targets, which are then compared with aviation emission scenarios in order to analyse the implications of air traffic in the national emission budget up to 2050.

Contraction and Convergence - reduction pathways

In the 1990s the Global Commons Institute (GCI) in London proposed a climate policy regime called “Contraction and Convergence” (C&C), which provided an allocation scheme of emissions for the whole world (Meyer 2000). This approach provides rather resource- than burden-sharing since it concerns the allocation of rights for using the atmosphere capacity to absorb emissions (den Elzen et al. 2005).

The C&C framework consists of two parts: Firstly, a long-term CO_2 concentration target is agreed on at an international level that would prevent dangerous anthropogenic interference with the climate system. This determines an overall emissions reduction path in order to reach the stabilisation level (contraction). Secondly, the convergence path is based on the principle that each person should be entitled to emit the same amount of CO_2. The resulting global emissions budget has to be divided between the countries in the manner that per capita emission allowances converge by a specified year (Meyer 1999). Therefore, the approach requires two essential international agreements: the concentration objective and the time of convergence. Since each nation’s total emission target is related to their population, the C&C model requests the stabilisation of population size at a chosen year. This reduces the incentive for countries to increase their population with the purpose of receiving more emission quotas.

Furthermore, the policy approach allows for permit trading in an international scheme in order to achieve global emissions abatement at the lowest costs and to balance out shortages in supply and demand of emission allowances.

By simultaneously contracting and converging, such a mechanism gives allocation to all countries and requires all nations to impose targets from the outset (Cameron 2003). Along with the German Advisory Council (WBGU) and the UK Royal Commission on Environmental Pollution (RCEP), the C&C concept is considered as a frame of reference for coping with climate change by several members of governments in both Annex-I and non-Annex-I countries (GCI 2004).

For technical assessment of Contraction & Convergence, the GCI offers a spreadsheet-based model, called CCOptions, with which C&C profiles for Germany were generated, illustrated in figure 9.

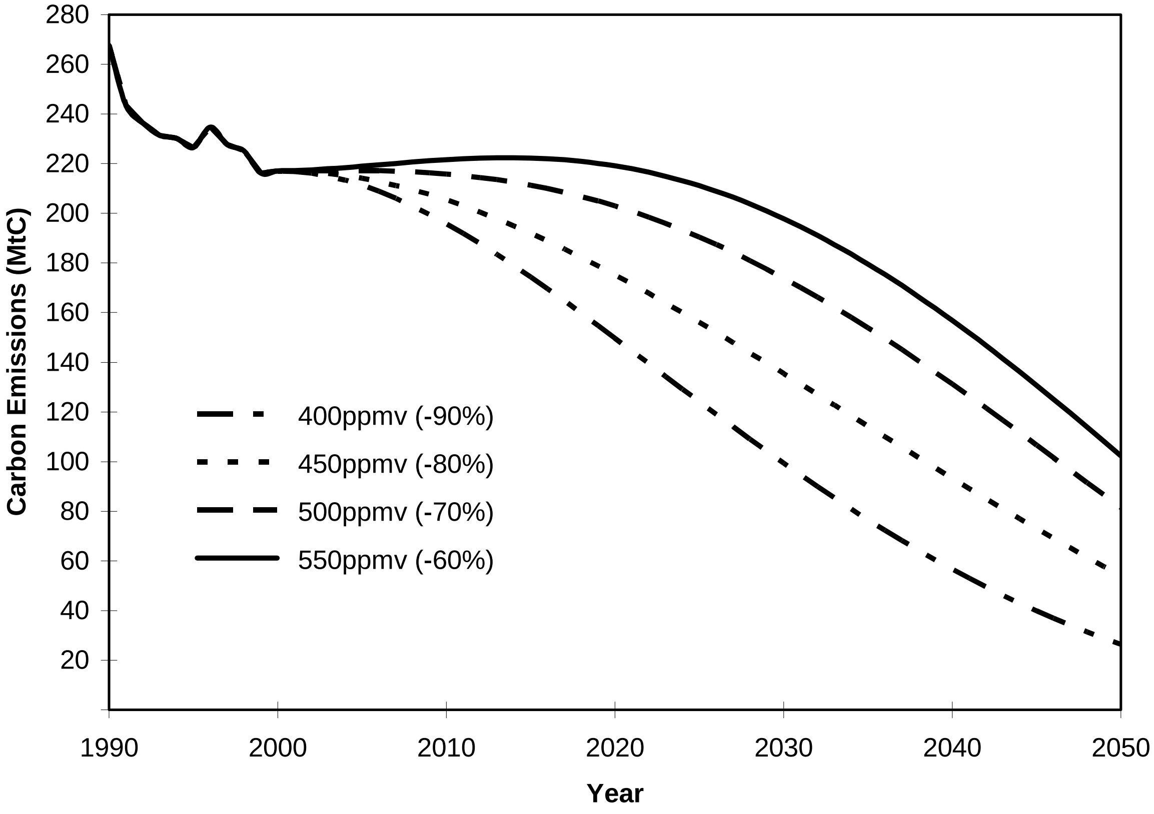

Figure 9: Contraction and Convergence profiles for Germany[15].

These profiles are in line with Germany's long-term carbon reduction target: 450ppmv is consistent with a reduction of 80% below the 1990 level in 2050, 500ppmv and 550ppmv with 70% and 60% respectively. To stabilise carbon concentration at 400ppmv -as current science recommends- emissions would need to decrease to 90% lower than the baseline level of 1990.

While working with the CCOptions model we have to take into account what kind of data are used and which emission sources are covered by the calculation. Two components are fundamental to the model: the population data is taken from the UN median population figures and forecasts, and the carbon dioxide data from the Carbon Dioxide Information

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[15] The C&C profiles for Germany were generated with the CCOptions model, each with a convergence date of 2050, excluding biogeochemical feedbacks from the carbon-cycle. To convert from MtC to $MtCO_2$, multiply by 3.67.

Analysis Centre (CDIAC) giving values for each year from 1800 and 2000 (Bows and Anderson 2005). The latter indicates that the model only includes carbon dioxide and not all relevant greenhouse gases as seen in the Kyoto's basket of six. Therefore, the atmospheric concentration levels in figure 1 refer only to CO_2 emissions; the equivalent net heating effect of the other GHGs is estimated to be around an extra 25%. When comparing these reduction paths with a scenario of ongoing aviation growth we have to consider that the underlying data set does not include carbon emissions from international aviation.

For further analysis the data for the CCOptions model is modified in the following manner: Updating the latest carbon dioxide data and assuming that emissions of Annex I Parties[16] develop according to their Kyoto targets and emissions of Non-Annex I Parties follow the business-as-usual (BAU) path until 2012. From 2012 onwards, all countries participate in the C&C system.

Impact of civil aviation on national emission budgets

> *- As mentioned above, the detailed aviation emission scenarios are not yet generated due to lack of data. Hence, only a short analytical comparison with the simple aviation scenarios from page 8 is given. -*

The following comparison is intended to give a first indication about the potential share of carbon emissions from aviation in Germany's long-term emission budget. Therefore, in

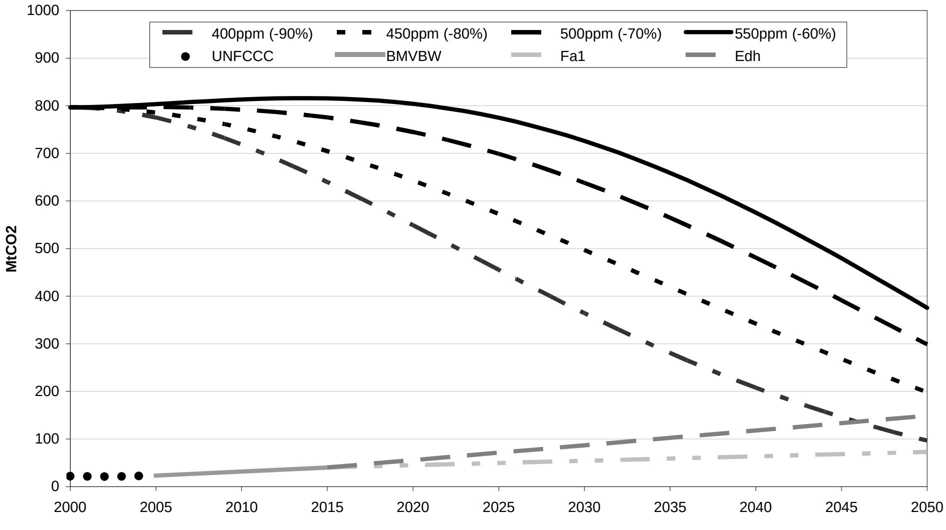

Figure 10: Contraction and convergence profiles compared with projected aviation emissions.

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[16] Emissions of Annex I Parties which have not ratified the Kyoto-Protocol are assumed to follow the BAU path.

figure 10 the contraction and convergence profiles are faced with the simple emission scenarios for air traffic in Germany. Depending on the growth scenario as well as on the preferred reduction target, the share of aviation in Germany's national carbon emission budget ranges between nearly 20% and 154% (see table 1).

Scenario	400ppmv (-90%)	450ppmv (-80%)	500ppmv (-70%)	550ppmv (-60%)
Fa1	75.51%	36.78%	24.41%	19.42%
Edh	154.41%	75.21%	49.93%	39.71%

Table 1: Share of aviation in Germany's national CO_2 budget in 2050.

In regard of the lowest and therefore probably the politically most feasible abatement objective (minus 60%) air traffic could consume almost 40% of the national CO_2 budget in 2050. This means that all other sectors have to decarbonise enormously in order to achieve the national reduction target. As already mentioned, the assumptions on growth rates are simplistic and intended to be illustrative but they are not completely unrealistic compared to the historical figures.

Conclusions

- The complete conclusion will follow as soon as the results of the analysis are available. -. Even though the global climate response of aviation is still small, this paper shows that there are potentially significant consequences for a country like Germany. The Fact that Germany is a large international hub for air traffic and the ongoing growing demand for long-haul flights may lead in a dramatically increasing share of aviation emissions in the national CO_2 budget. Allowing aviation emissions to increase as in a business-as-usual scenario while striving for a national reduction target in the order of 60% to 80% by 2050 compared to 1990 levels, this implicates that the other sectors have to reduce strongly their emissions - resulting in extensive fractions of Germany's CO_2 emissions allocation. This analysis attempts to quantify the share of permissible emissions which is required by the aviation sector and to what extent do the other sectors in Germany have to decarbonise until 2050. As this study requires simplistic assumptions for such long-term scenarios, it may only be hypothetical. However, this paper intends to point out the potential contradiction between allowing aviation emissions to increase, while demanding emission reductions from other sectors in order to attain climate objectives in Germany.

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