Paul Peeters (editor)

TOURISM AND CLIMATE CHANGE MITIGATION

Methods, greenhouse gas reductions and policies

NHTV Academic Studies No. 6
TOURISM AND CLIMATE CHANGE MITIGATION

Methods, greenhouse gas reductions and policies

Edited by Paul Peeters

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Paul Peeters (editor)
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PREFACE

From Cheap to Sustainable

Tourism is and will always be a fascinating phenomenon, which dominates the international agenda at ever increasing pace. A logical consequence of its strong growth is that the role of tourism in relation to human-caused climate change increases. Nevertheless, the current scale of tourism is a relatively new phenomenon. Holiday entitlements were exceptional for centuries and almost always strictly related to holy days or other Church events. In those days, a holiday was spent in the direct environment, with entertainment on site, and hardly led to any inconvenience or global environmental problems. Climatic circumstances did not yet play a significant role. In the Netherlands we use the word ‘recreation’ in this respect, so as to indicate that the leisure experience takes place in one’s own, familiar environment. However, we also use the word ‘experience’ deliberately here, instead of ‘activity’. In this way, we denote that, in the course of time, people spend their leisure time in a totally different way with a high set of demands. Starting out with a small group of holiday-makers, whose chief preoccupation was to maintain the whitest skin possible, eliminating anything that could link them to work outdoors, tourism rapidly became characterised by consolidation and the ‘tanning craze’. The active pursuit of enjoyment swept across the world and a holiday exodus, several times a year, was the result. Due to the strong emergence of a number of Eastern European and Asian countries with extremely large population numbers, this development is far from over.

Tourism as a sociological and economic phenomenon has been a topic of study for decades. Studies of the global drawbacks are of a much more recent date, of the past 15 years approximately. The central theme of this publication concerns the negative effects of all this travelling on nature and on our climate in particular. The concrete effects need to be identified, models for the future need to be developed. And, which measures should we take, for instance by using alternative and cleaner modes of transport, to find the road towards a sustainable development of tourism.

All those cheap travel tickets lead to many unnecessary air and road kilometres being travelled, only to save a couple of euros. Dutch people who first fly from Amsterdam to Frankfurt with a price fighter, and then fly to New York, again passing Amsterdam on their way. A sizeable surcharge should serve them right.

Initially we thought that we would have ample time to control the harmful effects of climate change as a result of all this travelling. However, experience has shown that the warm and wet blanket, literally and figuratively, is heading our way at breakneck speed. Continuing along the same course is therefore not an option. At NHTV Breda University for Applied Sciences, sustainable tourism and transport is very high on the knowledge and research agenda. This publication is proof of that. A reversal is called for, not only in terms of politics, but especially in terms of the behaviour of the industry and the tourist. From cheap to sustainable, that is the transformation we have to achieve.

Breda, 27 April 2007

Hans Uijterwijk (Chairman of the Executive Board of NHTV Breda)
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Paul Peeters
MITIGATING TOURISM’S CONTRIBUTION TO CLIMATE CHANGE – AN INTRODUCTION

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Abstract — There is now broad scientific consensus that tourism accounts for a significant and increasing contribution to climate change. Mitigation strategies are thus of increasing importance to address emissions from this sector. This chapter outlines some of the shortcomings in calculating emissions from tourism, a result of unreliable and generalizing databases. The main goal of the chapter is, however, to provide an overview of strategies for reducing greenhouse gas emissions. This includes perspectives on policies. Overall, there is evidence that various measures are needed in order to reduce emissions from tourism to sustainable levels.

Keywords: climate change, mitigation, adaptation, policies, research agenda

1 Introduction

The ‘eCLAT Climate change and tourism conference’ organised by eCLAT (Experts in Climate Change and Tourism), held during 11-14 June 2006 in Westelbeers, The Netherlands, was dedicated to the subject of tourism and climate change mitigation. The objective of the conference was to fill in gaps in research, as identified in the eCLAT Tourism and Mitigation research agenda (eCLAT 2005). A total of 28 papers were presented, 12 of which were selected for publication in this volume. Three papers develop theories, six describe options for emission reductions, and three deal with the political consequences of mitigation.

Clearly, there is debate whether humanity should mitigate or adapt to climate change, with some advocates of adaptation claiming that this is the cheaper option (e.g. Lomborg 2006). However, the recent ‘Stern review’ (Stern 2006) shows that the long term cost of adaptation might be ten times larger than the long term cost of mitigation (for critical views on the report see e.g. Dasgupta 2006, Tol 2006). Just as these lines are written, a new report drafted by Sigma Xi and the United Nations Foundation on the relation between adaptation and mitigation of climate

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change has been put forward (Bierbaum et al. 2007). The subtitle of the report ‘avoiding the unmanageable and managing the unavoidable’ applies also to tourism and climate change.

Even within the climate and tourism research community there seems some polarisation between ‘adaptation’ and ‘mitigation’ (cf. Patterson et al. 2006). This polarisation may be a result of perspectives on the tourism & climate change problem as a “two-way street” (WTO 2003a): tourism impacting on climate change and tourism as being impacted by climate change. Consequently, most research deals almost exclusively with only one of these perspectives. This also meant that mitigation and adaptation have been seen as mutually exclusive options (Patterson et al. 2006: 342). An alternative conceptual model proposed by Patterson et al. (2006) is circular and dynamic, where the state of the climate triggers weather patterns and ecosystems, which in turn influence tourism resources and associated infrastructures, finally influencing tourist travel behaviour. Travel behaviour, such as the extensive use of aircraft, determines the amount of emissions associated with tourism, and thus its contribution to climate change. Even though the model is simplifying a number of interactions, which are complex or little understood (such as the interaction of global environmental change and destination choices), it is a good starting point covering scales from individual to global and showing some of the interrelationships between adaptation and mitigation, and the need for integrated scientific thinking and politically action.

The number of publications in climate and tourism research has, historically seen, been a bit out of balance. The bibliography on climate, tourism and recreation by Scott et al. (2006) reveals that until recently, research has focused almost exclusively on the role of weather and climate in tourism (see also Dubois et al. 2006b). In the 1990s, an increasing number of publications emerged, discussing the impacts of climate change on tourism, as well as how the tourism system might adapt. Only in the past four or five years, a larger number of papers on the impacts of tourism on climate change has emerged (see for example Åkerman 2005, Becken 2002, Dubois et al. 2006a, Gössling 2002, Høyer 2000, Peeters et al. 2007a, Peeters et al. 2007b, Peeters et al. 2005b). Still, most of this research discusses the impacts of tourism activities on climate change, i.e. tourism’s contribution to greenhouse gas emissions (GHG). Studies that touch the subject of mitigation strategies are scarce (some rudimentary attempts are provided by Gössling et al. 2005b, Peeters et al. 2006a, Peeters et al. 2007b). Studies integrating mitigation and adaptation within tourism seem unavailable.

In 2005, eCLAT drafted a research agenda with a focus on mitigation (eCLAT 2005). The agenda is divided in three sections. The first - methods/data - deals with the actual nature of the link between tourism and climate change. This includes technical questions, such as the calculation of the contribution of tourism to climate change, or emission factors for tourism transport, accommodation and activities. The second section - GHG emission reductions – focuses on methods to
reduce emissions. The last section – policy - addresses the consequences of mitigation policies for stakeholders and consumers, and discusses the inefficiency of current policies. The articles presented in this volume provide answers to several of these issues.

2 Tourism’s contribution to climate change

The most important greenhouse gas is carbon dioxide (CO$_2$). Carbon dioxide is emitted by tourism activities through the operation of accommodations (e.g. heating, cooling, washing, cooking), activities (e.g. for operating restaurants, bars, disco’s, cinemas, motorised sports, cable-cars and scenic tours) and transport of the tourist’s homes to their destination (e.g. by car, coach, train, ferry or aircraft). An important issue is tourism’s non-carbon contribution to climate change, this is greenhouse gasses other than CO$_2$ (see paper by Peeters, Williams and Gössling on page 29).

Despite uncertainties some first estimates of the extend of the share of GHG emissions caused by tourism (based on data from Bows et al. 2007, Gössling 2002, Graßl et al. 2003, Peeters et al. 2007a, Schellnhuber et al. 2006, WTO 2003b, WTO 2003c) can be given:

- world wide: 4-10% in 2000 (historical contribution to radiative forcing)
- in the developed world: 10-20% in 2000 (GHG emissions)
- in an unsustainable future (temperature rise of 3-5°C) world wide: 10-20% of radiative forcing in 2050
- in a sustainable future (with less than +2°C): 50-100% of radiative forcing in 2050.

A sustainable future requires global atmospheric concentrations of carbon dioxide (CO$_2$) to be below 450 ppmv (parts per million volumetric; see Graßl et al. 2003, Schellnhuber et al. 2006). In order to achieve this, a reduction of CO$_2$ emissions by 80% is required by 2050 for developed economies, leaving some room for growth in developing countries. The EU target to cut emissions by 20% (30% if other countries also start engaging in emission reductions) by 2020 is one step in this direction. However, current growth in aviation – the main contributor to tourism GHG emissions – is at odds with this target. With a doubling of aviation emissions every 15 years, somewhere between 2040 and 2050 aviation alone will be responsible for the total amount of emissions within the target, leaving no room for other sectors and no room for further growth of aviation (Bows et al. 2007, Bows et al. 2006). This conflict may induce political pressure from other sectors on the tourism sector and make the case for mitigation stronger during the coming decades.
Figure 1: Impact of technological development on ‘historic’ total aviation RF (including contrails, excluding cirrus).

Will technology solve this problem? Figure 1 shows that even in a ‘very high tech’ scenario, fuel efficiency will be just over 50% between 2000 and 2100. But even in this scenario there will be a very strong increase in radiative forcing of aviation by 2100, corresponding to 1.7 W/m², which compares to the total anthropogenic figure of 1.6 W/m² in 2000. It is clear that growth rates of aviation are a fundamental problem that will not be solved by technology alone.

Within tourism, about 87% of all emissions are caused by transport, 4% by activities and 9% by accommodations (based on data by Boeing 2005, Gössling 2002, Peeters et al. 2007c, and using an equivalence factor of 1.9 to account for non-carbon impacts for aviation; estimate for the year 2000). This leads to the question of how emissions are distributed over different modes of transport. Worldwide this is unknown, but for tourism by EU citizens the share of GHG emissions caused by air transport amounts to 75% of all tourism transport-related emissions in 2000 and may grow to 85% by 2020 (Peeters et al. 2007a). The car is most important in terms of tourism trips, accounting for 65% in 2000 (55% in 2020), while the share of rail plus coach is some 15%. Trip numbers will increase by 57% between 2000 and 2020; however, the growth of transport volume (in terms of distances travelled) will
be 122%, while GHG-emissions will increase by 90%. In conclusion, air transport accounts for a rather small share of tourism trips, while causing the majority of GHG emissions (within EU tourism).

3 Methods and data

The eCLAT research agenda identified four research issues: databases, emission factors, emission inventory statistical methods and tourism transport models. Global tourism databases fail to reveal information on transport flows, transport modes and domestic tourism. Some national statistics do gather data on domestic tourism, but lack international standardisation, making it difficult to compare and integrate data at a global scale. Transport data often lack information on tourism flows or use a definition for tourism that is at odds with those in tourism databases (Peeters et al. 2007a). Furthermore, data on number of nights per accommodation class and the number and character of tourism activities are not gathered on the global level at sufficient detail. This hampers an in-depth assessment of global tourism related emissions.

Reliable emission factors for different modes of transport are not easily found. Direct carbon dioxide emissions present the researcher with problems as there are large differences between different sources (see for example Peeters et al. 2007a, Roos et al. 1997, Somerville 2003), but the main issue is radiative forcing (RF) caused by non-carbon emissions from aviation (e.g. Forster et al. 2006). As this non-carbon contribution to RF is likely to have at least the same order of magnitude as the CO$_2$-related RF, it cannot be ignored. However, this factor appears to be a function of both future global emission scenarios and the growth rate of aviation-related emissions, both of which are far from constant. Multipliers can range between 1.3 and 3.4.

The literature provides only one example of the third research agenda topic, GHG emission inventories based on tourism satellite accounts (see Patterson 2003, Patterson et al. 2004). Patterson (2003) and Patterson et al. (2004) use the System of Integrated Economic-Environmental Accounts (SEEA), developed by the United Nations, showing that the eco-efficiency of the domestic tourism sector in New Zealand (eco-efficiency being defined as tons of CO$_2$ per million $ output) ranks 17th out of 25 sectors. When international tourism is included, the ranking slips down to the second last place (only the ‘basic metals’ sector ranks lower). This means that all other service sectors and most industrial and agricultural sectors have a better eco-efficiency. Note that in this study, non-carbon effects of aviation were not even accounted for.

In this volume, the paper by Lamers and Amelung (page 51) provides an example of how to calculate GHG emissions of tourism in an arguably remote destination, Antarctica. The total average trip emissions – some 15 tons of CO$_2$ per traveller
equal to 3.5 years of global average per capita emissions, or 1.7 years of an average EU-citizen. One consequence is that it seems not very appropriate to label this kind of tourism ‘sustainable tourism’.

The paper by Verbeek and Mommaas (page 63) deals with the social context of transitions as a promising method to get better insight in emission reductions. They introduce the Social Practices Approach in an attempt to overcome the dualism of contemporary approaches to sustainable development – which are either structure or actor oriented – and concentrating on tourism practices instead of individual travel practices. The main objective of the research project is to analyse the actors with their lifestyles and routines in interaction with providers and infrastructure. The approach shows that consumption and production shape each other in a continuous process. The authors assume that consumers can make choices and thus make the difference in developments.

Overall, the main shortcoming of tourism and GHG emission study methods remains to provide reliable statistics on tourism transport flows and domestic tourism. The UNWTO databases do not provide the detailed data on transport distances and mode choices required for in-depth GHG emission inventories. The main problem is that these data do not include domestic tourism, which for large countries like the United States or China is a serious omission. Furthermore these data are inbound (arrivals) based and do not provide a full origin-destination table. A last problem is that most databases are expensive, and are provided mostly for commercial purposes, which often prevents scientific use.

4 Reducing greenhouse gas emissions

The eCLAT research agenda identifies four knowledge gaps concerning reduction of emissions: air travel efficiency, reducing transport volumes, improving energy efficiency in non-transport sectors of tourism and carbon off-setting. The number of off-setting schemes has grown exponentially from only 2 in 1992 to 6 in 1999 and more than 40 in 2006 (Gössling et al. 2007). Offsets are now seen as one way out of the climate change problem by airlines and other energy-intensive industries (see for example Milmo 2007). In this context it is interesting to note that unawareness of the climate change and air transport issue in tourism is still widespread. A recent survey found, for instance, that only 2% of tourism businesses made mention of attempts to reduce their contribution to climate change by reducing transport volumes (Lund-Durlacher et al. 2007).

In this context, Boon, Schroten and Kampman (page 77) show that off-setting cannot be a solution. One important aspect is the space available for compensation, if afforestation is the preferred strategy. The space for forestry schemes will run out worldwide before 2050, even if space is only used for compensating aviation emissions. As other sectors like car manufacturers, credit card companies and
oil companies also aim at achieving carbon-neutrality, space for offsetting carbon through plantations will run out shortly. Another issue is the 'wild west' character of the current market. Boon et al. show that large differences exist with regard to emission calculations and the cost charged per ton of CO2-compensation. As this market is still largely unregulated, it is difficult for the customer to chose a credible and efficient offset.

Another option for reducing emissions is to use aircraft in a more fuel efficient way. Travellers may not always take the shortest routes, as direct flights are often more expensive. Likewise, traffic flows may not be directed towards the shortest routes due to limitations set by air traffic management and congestion in air space. Williams, Noland, Majumdar, Toumi and Ochieng (page 91) discuss this issue. Their findings support the introduction of better technology, and integration of weather- and climate impact data into the traffic control system. The latter option may reduce non-carbon impacts, sometimes at the cost of a small increase in CO2 emissions. Furthermore, Williams et al. point out that political decisions need to be made soon if ATM in the EU is to include impacts on climate change.

Another issue to be discussed in the context of mitigation are alternative transport modes. If distances are shorter than 1500-2000 km, both trains and coaches can be viable options. Both cause down to 10% of the emissions per passenger kilometre caused by aircraft (Peeters et al. 2007a), and prospects for zero-emissions are high for electric rail transport. The Swiss Railways (SBB) run their system almost 100% emission free using their own small scale hydro-power stations and producing 16% of all passenger-transport and 28% of all goods transport at just 4% of the total energy needed for transports in Switzerland (SBB 2007). Van Goeverden (page 105) shows the prospects of long distance rail transport. Attractiveness of trains appears to depend on a low number of transfers, high speed, and high operating frequencies. Another important finding is that obligatory seat reservations appear to reduce demand for rail travel. This also has to be seen in the light of the fact that there has been a substantial decline in direct long-distances cross-border rail services in the last decades.

Public bus services as an alternative to car use is the subject of the paper by Guiver, Lumsdon and Morris (page 119). Their research shows that current public buses carry a significant share of passengers with access to cars. Public transport could reach a share of up to 30% of leisure mobility, which would not only reduce GHG emissions, but also a range of other local environmental problems. Guiver et al. identified several barriers to increased use of public transport. The main ones are marketing and communication: ‘public transport’ is no product that has been actively promoted and marketed.

Aguiar, Lourenço, Casimiro, Gonçalves and Santos (page 133) discuss the impacts of hotels in Portugal on climate change and show the adverse effects of climate change on the energy efficiency of accommodation. Simulations with a detailed hotel energy use model reveal that the increasing average temperature in
Portugal will lead to concomitant increases in energy demands, as cooling demand will overcompensate savings on heating. The current trend in Portuguese hotels develops already towards higher energy demand per tourist night. New EU legislation for energy performance of buildings is not likely to reverse this trend. The authors argue that accommodation should thus be included in tourism GHG emission mitigation schemes, even though their current share is less than 10%.

Another approach to reducing emissions is presented by Rheinberger, Schmied and Götz (page 143). Their representative survey for the German travel market reveals seven ‘target groups’ for specific action towards more sustainable holiday-making. Some interesting conclusions are reached. For example, attempts to persuade tourists to use ecologically more sound transport modes through sustainability arguments are apt to fail: only 2% of German rail travellers choose trains because of their environmental friendliness. A conclusion may be that eco-efficient tourism products can only be sold by focusing on their advantageous characteristics with respect to comfort, quality and price. Another observation is that the choice of air transport is often a consequence of long-distance destination choices. Marketing of attractive short haul destinations may help to raise shares of environmentally friendly transport modes.

In summary, the six papers in this section outline important strategies for reducing GHG emissions. More efficient aviation is one way to go, but achievable reductions of 10-20% will correspond to less than five years of current volume growth. Modal change from air and car to rail and coach has large merits, but this will address only a small share of emissions. Most emissions are generated by the relatively small share of medium- to long-haul air transport, where no alternative transport modes exist. The main mechanism for achieving significant emission reductions will thus be a shift of destination choices towards closer ones. This, however, is not seriously planned anywhere in the world, and remains one of the main challenges for achieving sustainable tourism.

5 Policies for mitigation

The 4th assessment report of the IPCC Working Group III (IPCC 2007) fails to recognise the potential long-term problem posed by aviation. First, the report does not refer to the discussion on convergence and contraction, i.e. a situation where aviation (as an emission growth sector) alone may be responsible for the amount of sustainable emissions in the EU (obliged to reduce emissions) by 2050 (Bows et al. 2007, Bows et al. 2006). This is in contrast to the report’s acknowledgement that efficiency measures can only partly offset the envisaged growth in emissions by aviation (IPCC 2007: 18). Second, the summary fails to see the evolution of hypermobile lifestyles. Urban planning and Transport Demand Management are the only aspects mentioned in connection to lifestyles (IPCC 2007: 16), ignoring
the role of tourist behaviour in mitigation.

The main topics identified by the eCLAT Research Agenda are the efficiency and effectiveness of economic instruments, the impacts and possibilities of inclusion of international aviation into international mitigation treaties (both Kyoto and post-Kyoto), socio-cultural aspects of mitigation measures and the problems with mitigation and the treatment of (air) travel in contrast to other means of transport. At the moment, international air transport takes advantage of several tax exemptions like VAT and excise duty on kerosene (Gössling et al. 2005a). Due to this situation air travel is relatively cheap compared to the private car, where both VAT and high excise duties on fuel apply, and to some extent cheaper than rail and coach. However, in several countries ticket charges as general taxes have been introduced (e.g. the UK, where the levels have been raised recently) or are planned (e.g. in the Netherlands by the new government that entered office in 2007).

So far international aviation (and international shipping) have been exempted from international emission reduction targets as defined in the Kyoto protocol. However, this is going to change, as the European Commission plans to include aviation in the EU Emission Trading Scheme (ESF, see European Commission 2006b) by 2011 (for intra-EU flights) and 2012 (for all flights to and from EU airports). According to an assessment by the European Commission (European Commission 2006a), the impacts on consumers are relatively low with an average increase of 1.6% of holiday costs per air based tourist trip. Note that this will only affect some 20-30% of all tourism trips. At the destination, some problems might in particular occur for island states that are economically dependent on air transport. On a national base this concerns Malta (virtually all tourists arrive by air) and Cyprus (94% by air). These two island states have a share of 0.3% of all tourism trips in the EU. The total cost for all tourism to remote regions may amount in the most effective Emission Trading Scheme (ETS) scenario to 80 million Euro. This is less than 10% of the total tourism revenues to these areas (European Commission 2006a). Note, however, that all calculations are based on prices of €30 per ton CO$_2$ traded in the EU ETS. The situation may change when caps are reduced below a threshold, where the industry runs out of cheap options for emission reductions as happened in the Californian RECLAIM scheme that aimed to reduce industrial NO$_x$ emissions (Soleille 2006).

The likelihood of the tourism sector reducing GHG emissions on its own is, for Small and Medium Enterprises (SMEs), discussed in the paper by Hall (page 159). Climate change appears to be a low level priority in SMEs. However, respondents considered climate change to be a potential issue in the future. Entrepreneurs would be more willing to accept governmental command and control measures when low-frequency, but high-impact weather or climate-related disasters were experienced in the area. Hall concludes that this is ‘suggesting the possibility of an issue-attention cycle in business behaviour’. Unfortunately the time lag between mitigation measures and their effect (in terms of avoided climate change) is measured in decades,
while business cycles cover a few years at most. Therefore policies are required to balance the short-term perspectives of entrepreneurs with long-term mitigation policies.

Policy makers may also struggle contradicting targets, as clearly illustrated by Robbins and Dickinson (page 169) in the case of tourism transport within the United Kingdom. Here, the Department for Transport aims primarily at reducing car dependency, while the Department of Culture, Media and Sports supports the growth of tourism, even though combined with more frequent use of public transport systems. Both departments attempt to achieve a modal shift from the car to public transport. However, the combined efforts failed to achieve a modal shift or reduced car dependency. The main cause for this policy failure is identified as the lack of an integrated transport and tourism policy that acknowledges the complexity of the problem of increasing number of trips and at the same time reducing car use. This same phenomenon persists at the European level, where tourism, transport and environment are covered by three separated Directorate Generals (DGs): DG-ENTR (DG Enterprise), DG-TREN (DG Transport and Energy) and DG-ENV (DG Environment). The policies and instruments directed by DG-TREN generally fail to specifically target leisure and tourism related transport, but also treat aviation as independent from ground-based traffic, with the exception of airport accessibility. The most recent tourism policy document published by DG-ENTR (Commission of the European Communities 2006) does not mention climate change as an issue for tourism and tourism transport and does not present any view on the interrelationships of environment, transport and infrastructure policies.

Integrated assessments like scenario studies may help to expose the discrepancies between different sectoral policies. The paper by Dubois and Ceron (page 189) shows how scenarios can be used to advise policy-making. Their paper describes a scenario for tourism in France, reducing emissions by a factor four by 2050. It shows the technical possibility for such a scenario, but also that it has to develop against almost all current social trends. Transitions may be accomplished if all aspects of relevance are considered holistically: technology, infrastructure (huge investments in the rail network), economic measures and social change. Given the huge emission reductions required, less emphasis on one solution, like the very strong modal shift to rail transport, immediately has consequences for other aspects, affecting total average (sustainable) mobility per individual per year.

In conclusion, there are various policies to reduce GHG emissions from tourism, but they require a substantial change in political attention on the issue. Clearly, the lack of scientific work in this area is also notable. Consequently, papers in this section rather show the failure of policies and politics than providing advice of how to proceed on a sustainable development path. In general it appears that integrated transport, tourism and environment policies may offer an effective way forward.
6 The links between mitigation and adaptation

Climate change is felt in several tourism sectors, with winter tourism being the most obvious example (e.g. Scott 2003). Adaptation has already become an important strategy, as through snow-making, or planning skiing resorts in higher altitudes. For mitigation, incentives for change will be less self-evident. First, emission reductions are investments that will only pay back after decades, and they are thus not considered viable in current business cycles. Second, only if the majority of sectors mitigate, there will be future benefits. With currently some 10% of total greenhouse gas emissions caused by tourism, the incentive is not sufficient for the tourism sector to act on its own. As shown previously, emissions from tourism grow at very high rates and may, in the EU, account for all sustainable greenhouse gas emissions by 2050. Public concern is growing and exerts pressure on the sector to act. Furthermore the first policy measures to control the growth of emissions in air transport, like the inclusion of aviation in the EU Emission Trading System by 2011/2012 (European Commission 2006b) have come in place. This means that international mitigation policies will change the transport landscape from cheap and fast (air transport) to slower and more expensive. Tour operators focusing on long-haul destinations might run into trouble if they do not consider this new situation. The same applies to destinations, as domestic and short haul tourists usually outnumber long haul tourists up to an order of magnitude (even in international city-destinations as Amsterdam, see Peeters et al. 2006a), thus generating a major share of overall revenue. It is up to destinations to focus their marketing and product development on short haul markets. For remote destinations in the world, with exclusive access by air, the situation is different. Adaptation can only be achieved by shifting to other markets. Away from high-volume-low-price to low-volume-high-price might be one solution. The clearest linkage between adaptation and mitigation is represented by the need for a paradigm shift in product development and marketing. Tour operators have to find innovative ways to sell more short- and medium-haul destinations with comparably slow transport modes and preferably a longer length of stay and thus higher revenue per trip. At the same time it may develop new products in areas and seasons where the climate for tourism improves. Innovation in this direction thus serves both mitigation and adaptation.

7 Research recommendations

The general picture evolving from this volume is that aviation and long haul travel contribute the largest share to GHG emissions, while it has at the same time the least opportunities to improve fuel efficiency, simply because aviation is technically mature. At the same time short-haul travel is still the backbone of tourism. The main challenge will be to change the current trend of the globalisation of tourism.
towards redeveloping domestic and short haul international tourism. Where most economic sectors can reduce emissions without changing lifestyles, this appears to be impossible for aviation-based tourism. Scientific support is required for policy makers and the sector to find ways to take up the challenge of behavioural change without negatively affecting the needs of both tourists and destinations.

Several papers in this volume indicate the need for data on tourism and transport volumes, and models for calculating GHG emissions. First of all data, on tourism transport flows per transport mode and on both international and domestic tourism are needed, but can so far only be estimated within relatively large margins. Furthermore, current data on tourist-nights per class of accommodation are insufficient. A publicly available database for energy and emission factors, for a large range of transport vehicles, including aircraft, trains, coaches, ferries, cruise-ships, vans and cars should be developed and maintained under the responsibility of an independent international body like UNEP, UNWTO or OECD. The same goes for energy and emission factors for a range of different kinds of accommodations. It is particularly important to understand this in the context of aviation, where alternative metrics for non-carbon radiative forcing are needed. Likewise, the cruise sector is currently relatively small (15 million tourists per year) but has the potential to become a main source for tourism related GHG emission. However it is very difficult to assess the number of cruise ships, their itineraries and emissions.

In the field of social studies of tourism behaviour, several lines of research can be identified. One is to identify the opportunities for tourists to act as agents of change in the transition towards low emissions tourism mobility. To what extend are tourists able to play this role and to what extend is their behaviour determined by supply and government rules? Consequently, more research is needed to provide a basis for stakeholders to shape the conditions to uncouple tourism growth and transport volumes/greenhouse gas emissions. For mass markets, sustainability is currently not affecting travel decisions, and strategies have to be found to encourage “low-carbon” behaviour. Another challenge is to identify the economic conditions which will allow soft mobility to be price-competitive. Related is further research on modal shifts. Already 8.1% of car-owning travellers to nature destinations in the UK use the bus, and prospects for modal shifts by removing a few barriers with regard to service or information seem good. Regarding railways, research should be directed at the consequences of obligatory seat reservations and the societal status of trains. A potential barrier for modal shifts may be personal preferences. There is a possibility that air and railways are separate markets, which would imply that modal choice precedes destination choice.

For buildings GHG emissions can be theoretically reduced by 100% using wind power and solar energy, as well as hydrogen as energy storage (Bode et al. 2003). Unfortunately climate change may increase energy consumption per tourist night, because energy savings on heating are over-compensated by cooling requirements. As the supplies of wind and solar power are limited, it is important not to overesti-
mate the potential of emission reductions.

With current knowledge it has become clear that (1) the GHG emissions of tourism are likely to grow at high rates, mainly due to increasing distances per trip and increased use of air transport, and (2) as effects of mitigation by improved technology and efficiency of operation are insufficient to actually reduce GHG emissions of tourism, so that in conclusion, (3) mitigation by reducing (air transport) volumes seems unavoidable. Two ideas emerge to solve this problem: bio fuel for aircraft (Robertson 2007) and voluntary compensation schemes. The potential for bio fuel is very limited according to most studies, unless world agriculture is intensified to European levels and global meat consumption is drastically reduced (Bergsma et al. 2007). The following numbers illustrate the limitations: current total agricultural area is about 5 billion hectares of which 3.5 billion are grazing lands. By 2020, total energy use is forecasted to be 600 EJ of which 88 EJ are oil for transports. Replacing this by biofuels will require between 0.75 and 5.0 billion of hectares. Voluntary compensation schemes, when using forestry as carbon-sink, use the same limited space as biofuels. Consequently, food production, nature and biofuels all compete for the same space.

In the light of these findings, we conclude that research on reducing transport volumes is extremely important to make mitigation strategies of tourism GHG emissions work. This means uncoupling the growth of tourism and the growth of passenger-kilometres by changing current mobility trends towards shorter and more frequent trips to longer and less frequent ones, and to shift destination choices away from long haul. Research can help the sector to develop and more effectively market low carbon tourism products, including emissions of transport. It may also help to identify regulatory conditions that supports such a product change. Better insight in the factors generating hypermobile lifestyles will help to fine-tune both measures and tourism products.

References


Online documents at URL http://eerg.massey.ac.nz/adobefiles/wordAM2.1_Patterson.pdf


Section I: Methods and data

Air transport greenhouse gas emissions
Paul Peeters, Victoria Williams & Stefan Gössling

The environmental impacts of tourism in Antarctica. A global perspective
Machiel Lamers, Bas Amelung

Sustainable tourism mobility: the social practices approach
Desiree Verbeek & Hans Mommaas
AIR TRANSPORT GREENHOUSE GAS EMISSIONS

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Abstract — Greenhouse gas emissions from air transport, and methods to calculate them, are not well defined in the current literature. While calculating the direct emissions of CO₂ is already cause for some debate, the contribution of other emissions and impacts — like nitrogen oxides (NOₓ), contrails, water vapour — to climate change still lacks a reliable metric. As aviation is the largest emitter of greenhouse gases within tourism, accurate estimates of carbon and non-carbon emissions are important. This paper presents some standardisation as well as general insights to assist researchers assessing the impact of aviation on climate change in scenario studies or evaluating mitigation policies. The IPCC introduced a radiative forcing index (RFI) to measure the role of aviation in climate change, which is in scenario studies or evaluations of policies often used as a kind of constant ‘equivalence factor’. The paper shows this to be inaccurate and proposes ways to account for both carbon and non-carbon climate impacts of air transport.

Keywords: air transport, climate change, emission factors, non-carbon impacts, radiative forcing index (RFI), scenarios

1 The role of aviation in tourism GHG emissions

Climatically relevant emissions cause a chain of impacts like: emission change → concentration change → radiative forcing change → temperature change → climate impacts → societal and ecosystem impacts → economic impacts (see Shine et al. 2005b: 282). Though the last two metrics will be the final goal of most climate policy evaluation studies, the number and magnitude of uncertainties increases sharply when going up the chain from emissions. Therefore the metrics at the starting point of the chain will be simpler and more reliable, but lack the detail often required by policy makers. In this paper we seek to present a method for calculating the contribution of tourism air transport to climate change and thus have chosen the radiative forcing level as a compromise between reliability and usefulness.

The impacts of tourism on climate change are increasingly determined by the
emissions of greenhouse gases (GHG) of air transport (Gössling 2002, Peeters 2005). Estimates vary, but it seems likely that more than half of all GHG emissions from tourism are caused by air travel. Most other emissions come from land- and sea-based transport. The contribution from accommodation and activities is less significant. Consequently, to understand the relationship between tourism and greenhouse gas (GHG) emissions, reliable estimates of air transport emissions and their contribution to climate change through radiative forcing (RF) are required. Such estimates are usually dominated by emissions of carbon dioxide (CO$_2$). However, for air transport the impacts of non-carbon emissions – like contrails and contrail induced cirrus - at least equal the impact of CO$_2$-related radiative forcing (Sausen et al. 2005).

The share of civil aviation was 1.8% of all CO$_2$ emissions from burning fossil fuels during 2002 (based on Eyers et al. 2004, Nakicenovic et al. 2000). The future share depends both on the air transport scenario defined and the world emissions scenario. Based on the AERO2K aviation scenario in 2025 the annual CO$_2$ emissions share will be between 1.7% and 3.5% for lowest and highest emissions of the SRES scenarios (Nakicenovic et al. 2000: 17). The AERO2K scenario is medium growth. IPCC (Prather et al. 1999: 195) gives also low and high growth aviation scenarios increasing the range of shares of annual CO$_2$ emissions from 1.6% (Fc1 aviation scenario combined with B1 SRES scenario) to 8.7% (Edh aviation scenario combined with A1FI). However, all these numbers exclude the impact of non-carbon emissions. These non-carbon impacts are all short-lived – most less than -10 days (Forster et al. 2006) – and have different impacts depending on where on earth they are released (Shine et al. 2005a). This makes it difficult to assess non-carbon impacts with the politically accepted Global Warming Potential (GWP) concept. GWP represents the “time integrated commitment to climate forcing from the instantaneous release of 1 kg of a trace gas expressed relative to that of 1 kg of the reference gas CO$_2$” (Fuglestvedt et al. 2001). A widely accepted time horizon is 100 years. Often the terms ‘equivalence factor’ or ‘CO$_2$-equivalent’ are used to indicate and include the contribution greenhouse gas emissions other than CO$_2$ to radiative forcing.

The contribution of aviation to global climate change can be calculated using anthropogenic RF as a proxy for global temperature change. For this Prather et al. (1999) introduced the Radiative Forcing Index (RFI), defined as the ratio of all aviation-related RF in a specific year to that of aviation RF caused by cumulated CO$_2$ emissions since 1940. Originally Prather et al. (1999) proposed an average value of 2.7 for RFI (excluding the impact of contrail induced cirrus clouds), calculating aviation’s cumulative contribution to global radiative forcing at 3.5% in 1992. In a more recent paper the RFI was reduced to 1.9, again excluding the impact of contrail induced cirrus (Sausen et al. 2005). Extrapolating to 2005, the contribution of aviation to all anthropogenic radiative forcing is rather in the order of 3.4-6.8% (own calculation; the range being a result of the consideration of radiative forcing for contrail induced cirrus for the higher number, see Sausen et al. 2005).
The contribution of emissions to radiative forcing is determined by the amount and nature of emissions as well as the time (day or night, summer or winter) and place (longitude, latitude and altitude) of release into the atmosphere. The amount of emissions is primarily determined by traffic volume, aircraft fleet technological efficiency and the air transport system operating efficiency. The technological efficiency of the fleet of civil aircraft is determined by the fleet composition (size, propulsion system, age of aircraft), and the state of maintenance. The operational efficiency considers factors like flight paths/speed schedules, occupation rates (passenger load factors), route choices and networks and additional freight on passenger aircraft.

2 Methods for calculating air transport emissions

2.1 Aggregate or compound

Basically two methods exist to obtain emission factors. An aggregated (bottom-up) approach would assess the properties of individual aircraft and aggregate these based on global fleet composition and performance (movements). In contrast, a compound (top-down) approach would have its starting point in total fuel consumption based on worldwide statistics (e.g. by the International Energy Agency, IEA), transforming fuel use into emissions and divide the result by global transport performance measured in passenger kilometres (pkm) or seat kilometres (skm) (data provided by e.g. IATA and ICAO).

To evaluate the impacts of tourism air transport in general, the aggregated method appears to be the most practical, and often only feasible way to commence calculations. Using a compound method requires detailed insight in the properties of every single flight and its impact on climate. Such information is seldom available to tourism researchers, though it would generate more reliable and detailed results.

2.2 The aggregate method: emission inventories

The method used by Henderson et al. 1999 is based on the three-dimensional (latitude, longitude and altitude) global inventories of civil and military aircraft fuel burned prepared by Boeing, published in NASA reports and DLR (see references in Henderson et al. 1999; see also the Dutch AERO model, Pulles et al. 2002). Basically, these emission inventories use the following general approach: Transport demand + technology → transport supply → flights per aircraft type → flight paths per aircraft type → fuel consumption and emissions. The models are therefore based on the summation of the emissions of all individual flights. Flight emissions in the AERO model are represented by a full calculation of a standard flight profile, consisting of taxi out to the runway, takeoff, climb out to 3000 ft, continued climb, cruise, descent to 3000 ft, approach, touch down and taxi in to the gate, using ten generic aircraft types representing a range of seat capacities, capabilities and aircraft ages.
The Boeing/NASA method is based on the Official Airline Guide (OAG) database, which contains worldwide international and domestic city-pair flights giving departure and arrival times and aircraft type codes. The database is corrected for several smaller errors (double counted flights, unplanned departures from scheduled flights, replacing of aircraft types if no performance data are available) and then used to interpolate into ‘airplane performance data files’ to calculate fuel burn and emissions. These data files provide “time, fuel burned and distance flown as a function of aircraft gross weight and altitude for climb out, climb, and descent conditions. They also provide tables of fuel mileage (nautical miles per pound of fuel burned) as a function of gross weight, cruise Mach number and altitude for cruise conditions” (Baughcum et al. 1996b: 11). For the years 1976, 1984 and 1992 a number of 27, 36 and 76 different aircraft models respectively were used. In 1992 the number of aircraft types in the OAG database was around 250 (Baughcum et al. 1996b).

The emissions are calculated by summing up all emissions of all individual flight, as represented by equation (1) below.

\[
E_X = \sum_{n=1}^{N} \int_{t=0}^{T} EI_{X_n}(t) \cdot \dot{w}_{f_n}(t) \, dt
\]

In equation (1) \(E_X\) is the total emission of component X (i.e. CO, CO\(_2\), NO\(_x\), etcetera), the total number of flights, the integral gives the emission of component X for flight \(n\) with duration \(T\), \(EI_{X_n}(t)\) the emission index of component X as function of flight time and \(\dot{w}_{f_n}\) the time dependent fuel flow during flight \(n\).

The emissions of carbon dioxide and water are directly related to the amount of fuel. Table 1 gives these fixed emission indices. In this case, equation (1) is simplified to:

\[
E_{CO_2} = EICO_2 \sum_{n=1}^{N} \int_{t=0}^{T} \dot{w}_{f_n}(t) \, dt
\]

\[
E_{H_2O} = EIH_2O \sum_{n=1}^{N} \int_{t=0}^{T} \dot{w}_{f_n}(t) \, dt
\]

\[\text{Table 1: Emission indices for carbon dioxide and water (source: Baughcum et al. 1996a).}\]

<table>
<thead>
<tr>
<th>Emission</th>
<th>Emission index (kg/kg fuel)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EICO2 for carbon dioxide (CO(_2))</td>
<td>3.155</td>
</tr>
<tr>
<td>EIH2O for water (H(_2)O)</td>
<td>1.237</td>
</tr>
</tbody>
</table>

The emission indices of carbon monoxide (CO), hydrocarbons (HC) and nitrogen oxides (NO\(_x\)) do depend on the flight phase and atmospheric conditions and are calculated with the ‘Boeing Method 2’ (see Baughcum et al. 1996b: Appendix D) using equations (3) and (4):
Herein $EICO$, $EIHC$ and $EINO_x$ represent the emission indexes in kg/kg fuel for carbon monoxide, hydrocarbons and nitrogen oxides, $\Theta_{\text{amb}}$ is the inlet temperature range over ISA sea level, $\delta_{\text{amb}}$ the same for ambient pressure, $\Phi$ the actual relative humidity and $f_{\text{ICAO}}$ the measured emissions indices as a function of power rating as given by the ICAO engine database (ICAO 2001).

The most important assumptions are:

- standard atmospheric conditions (ISA), giving the standardised atmospheric parameters for use in equations (3) and (4)
- the fleet composition is fixed
- operational parameters (i.e. speed schedules, cruising altitudes, flying weight) are well defined and optimally chosen
- the Boeing/NASA inventories assumed standard 70% load factors for calculating the operational weight of the aircraft during the flight. AERO uses a variable combining passenger and freight load factor with respect to maximum payload weight as known from the flight-generating database.

Such assumptions cause some accuracy issues. “Total fuel consumption calculated as part of the NASA 1992 scheduled inventory was, on the average, 17% below that reported on DOT Form 41 for the ten major passenger air carriers considered.” (Daggett et al. 1999: i). This means that the practical attained fuel efficiency is lower than the one calculated with idealised flight-cycles based on all flights performed. Daggett et al. (1999) mention wind, higher than optimum flight weight and aircraft aging as reasons for the differences between calculated and measured fuel consumption.

On many flights, particularly long haul, both passengers and freight are carried. To get correct emission factors, the total fuel used for passenger transport must be distributed appropriately. This requires a conversion factor between freight and passengers. In statistics the performance is often given in revenue passenger kilometres (rpkm) and revenue ton kilometres (rtkm). Assuming between 88 and 100 kg per passenger a total in rtkm can be calculated (see Peeters et al. 2005a: Annex III). However, passenger cabins add more to the 'empty weight' of the aircraft than freight, due to the volume of seats, air conditioning, safety equipment, et cetera. Comparing passenger and freight versions of the same aircraft type, the full-freighter version has a freight capacity of between 150 kg and 220 kg for every available seat in the full-passenger high-density version (Peeters et al. 2005a). These factors are probably lower in combi aircraft. Therefore, the value of 160 kg/passenger given by Wit et al. 2002 might be a convenient average, though the actual value depends on whether the aircraft is weight-limited or volume-limited for that specific flight.
Emissions attributed to the passenger component of payload $E_{x\text{,pax}}$ can now be derived from overall emissions $E_X$, the number of passengers $V_{\text{pax}}$ (in pkm), the amount of freight $V_f$ (in metric ton kilometre) and the conversion factor $C\bar{W}_{\text{pax}}$ (the average weight in kg/passenger) using:

$$E_{x\text{,pax}} = E_X \cdot \frac{V_{\text{pax}}}{V_{\text{pax}} + \frac{1000 \cdot V_f}{C\bar{W}_{\text{pax}}}} \quad (5)$$

Equation (5) can also be used to correct emission factors for the freight share of payload carried. As emission calculations are based on full three-dimensional flight paths, it is possible to determine the total emissions per altitude layer. This is important with respect to the impacts of non-carbon GHG emissions like NO\textsubscript{x} and water vapour.

### 2.1 The compound method: emission factors

The compound method is based on global fuel burn statistics. It directly couples traffic volumes to emissions by using generalised emission factors (EF) and transport demand. The basic method couples the supply of capacity in terms of actual operational seat kilometres to the average emission factor with respect to skm represented by equation (6):

$$E_X = \beta_{x,\text{skm}} \cdot V_{\text{skm}} \quad (6)$$

However, often figures for volume and emission factors $\beta_X$ are based on pkm. So we need to be able to convert between skm, pkm or even just the numbers of tourists travelling between airports or cities at known great circle distances $d_{gc}$. For this we need conversion factors for seat occupancy rate $\eta_{\text{pfr}}$, average flight distance correction factor $C_{\text{dist}}$, an air traffic control (ATC) factor $\eta_{\text{atc}}$, a passenger behaviour detour factor $\eta_{\text{det}}$ and a wind correction factor $\eta_{\text{win}}$. The impact of distance flown can be taken into account by a correction factor $C_{\text{dist}}(d)$ (see Table 2) using the more or less constant medium haul emission factor $\beta_{x-LH,\text{seat}}$ for distances between 2000 and 5000 km.

<table>
<thead>
<tr>
<th>Distance flown (km)</th>
<th>Distance correction factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;500</td>
<td>1.86</td>
</tr>
<tr>
<td>750</td>
<td>1.39</td>
</tr>
<tr>
<td>1250</td>
<td>1.18</td>
</tr>
<tr>
<td>1750</td>
<td>1.09</td>
</tr>
<tr>
<td>2000-5000</td>
<td>1.00</td>
</tr>
<tr>
<td>&gt;5000</td>
<td>1.05</td>
</tr>
</tbody>
</table>

*Table 2: Relation between emission factor and distance flown (derived from data for medium range, medium size aircraft given by de Ceuster et al. 2004).*
The basic equations now are:

\[ E_X = \beta_{X-LH_{\text{corr}}} \cdot \sum_{u=1}^{N} C_{d_{\text{in}}} \left( \overline{d_u} \right) \cdot V_{\text{seat}_u} \]

\[ \overline{d_u} = \eta_{\text{ATC}} \cdot \eta_{\text{det}} \cdot \eta_{\text{wind}} \cdot d_{g_u} \]

\[ V_{\text{seat}_u} = \frac{d_u \cdot \eta_{\text{pov}_u}}{\eta_{\text{air}_u}} \]  \hspace{1cm} (7)

For a basic case: the number of tourists travelling between several places of origin and destination using air transport are known from UN-WTO and TEN-STAC (see the European tourism case described by Peeters et al. 2005b). Using a calculator like WebFlyer (2003) the great circle distances between country-pairs \( d_{g_{\text{in}}} \) are calculated. Than the volume of skm is found using an average seat occupation rate and the average flight distance \( d_{g_u} \) corrected for detours and wind. This average distance per country pair is used to find the distance corrections for fuel consumption (Table 2). The volume of long haul equivalent seat-kilometres is found by summing all country-pair corrected distances. This volume is multiplied by the emission factor \( \beta_{X-LH_{\text{corr}}} \) for long haul skm, resulting in total emissions.

Appropriate emission factors pose the following problem. Often these are given as passenger-kilometres, but it is not always known if this factor includes corrections for detours, wind, as well as correct occupancy rates. For long haul, Dubois et al. (2006) give values of 0.140 kg CO\(_2\)/pkm, while Roos et al. 1997 give values between 0.080 and 0.100 kg CO\(_2\)/pkm, and Peeters et al. 2005b 0.111 kg CO\(_2\)/pkm.

Åkerman 2005 uses as average for both short and long haul 0.14 kg CO\(_2\)/pkm for 2000, based on Penner et al. 1999. UNEP proposes 0.18 kg CO\(_2\)/pkm for short haul and 0.11 kg CO\(_2\)/pkm for long haul (Thomas et al. 2000). Most sources assume 70% average seat occupancy.

Reasons for the observed differences are the impact of distance on the per kilometre emission factor, as well as operational parameters, payload, and the difference between different (short or long range) aircraft models. For example, a flight from Amsterdam to Stockholm (a block distance of 1152 km) shows an emission factor of 0.091 kg/pkm when flown with a Boeing 737-800, but the value is 44% higher at 0.131 kg/pkm when flown with a Boeing MD81 (SAS Group 2004). If the aircraft types used are known, it is recommended to use these and correct for wind and detours (see Table 3). Generally the factors need not to be used if the transport volume is based on real capacity supplied in terms of seat kilometres.

Commonly used detour factors are 1.15 for short haul and 1.05 for long haul. These are based on the maximum attainable reduction of fuel consumption by optimising air traffic control (ATC), (Peeters et al. 2004). However another issue is the way tourists use the air transport system. The trend of deregulation in air transport has made it attractive for tourists to make detours for at least three reasons: (1) the
development of hub-and-spoke systems forces travellers to make detours, (2) the
development of low cost carriers increases the number of indirect routes costing less
than direct ones and (3) large alliances compete on long haul travel via their hubs,
seeking to attract passenger by offering lower prices for the combined feeder flight
and main flight. It appears such detours can add up to 10-15% to total distances
travelled and even more to total fuel consumed, because detours split flights up into
less efficient shorter flights (DeRudder et al. 2005).

Table 3: the use of the different factors.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>When to apply</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\eta_{AFC}$</td>
<td>if only passenger flows on origin-destination relations are known</td>
</tr>
<tr>
<td></td>
<td>if emission factors are based on individual trips</td>
</tr>
<tr>
<td>$\eta_{det}$</td>
<td>if emission factors are based on individual trips</td>
</tr>
<tr>
<td></td>
<td>if only numbers of tourists on origin-destination relations are known</td>
</tr>
<tr>
<td>$\eta_{win}$</td>
<td>if emission factors are based on no-wind ISA conditions</td>
</tr>
<tr>
<td>$\eta_{sar}$</td>
<td>if the passenger flows are known and not the capacity of seat kilometres supplied</td>
</tr>
</tbody>
</table>

Table 4: Factors for calculating emissions by the aggregate method. The percentages in the last line give
the load factor assumed, as this determines the flying weight and thus the fuel consumption per aircraft
kilometre.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\eta_{AFC}$</td>
<td>SH: 1.15</td>
<td>Air France-KLM 2005</td>
</tr>
<tr>
<td></td>
<td>LH: 1.05</td>
<td></td>
</tr>
<tr>
<td>$\eta_{det}$</td>
<td>SH/LH: &lt;1.10$^a$</td>
<td>DeRudder et al. 2005</td>
</tr>
<tr>
<td>$\eta_{win}$</td>
<td>LH: 1.05</td>
<td>Daggett et al. 1999</td>
</tr>
<tr>
<td>$\eta_{sar}$</td>
<td>LH: 0.75</td>
<td>Peeters et al. 2005a, Peeters et al. 2005b</td>
</tr>
<tr>
<td></td>
<td>SH: 0.70</td>
<td></td>
</tr>
<tr>
<td>$\beta_{x-LH_{seat}}$</td>
<td>B737-800: 0.0581 kg/skm @ 2400 km/70%</td>
<td>SAS Group 2004</td>
</tr>
<tr>
<td></td>
<td>A320: 0.0567 kg/skm @ 2400 km/70%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A330-300$^b$: 0.0873-0.0655 kg/skm @ 5900 km/90%/25% freight</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A340-300$^b$: 0.1062-0.0797 kg/skm @ 5900 km/90%/25% freight</td>
<td></td>
</tr>
</tbody>
</table>

$^a$ Recent unpublished research at the NHTV Centre for Sustainable Tourism and Transport, Breda,
The Netherlands, has shown the average detour to add only 2.2% for EU travel and 5.3% of
$CO_2$ emissions for intercontinental based on a survey of the Dutch population (n=545; 2211
reported journeys). As the Netherlands are a small country and has a main European hub, these
figures can be considered a minimum.

$^b$ SAS does not correct for freight on board. For long haul they state up to 25% of payload will be
freight. The range gives values between 25% and 0% freight.
3 Non-carbon impacts

3.1 Metrics
Currently, most authors within tourism/transport scenario studies incorporate the additional warming from non-CO\textsubscript{2} impacts using a constant average factor of 2.7, often imprecisely referred to as an ‘equivalence factor’, but originally defined by Prather et al. 1999 as radiative forcing index (RFI), a metric defined as the ratio of total RF to that from CO\textsubscript{2} alone (Åkerman 2005, Dubois et al. 2006, Gössling et al. 2005, Peeters et al. 2005b, Peeters et al. 2007). The RFI considers the impacts of NO\textsubscript{x}-induced ozone increase and methane (CH\textsubscript{4}) decrease, direct impacts of H\textsubscript{2}O and soot, as well as contrails. The impact of aviation-induced cirrus clouds is usually excluded, due to large scientific uncertainties. RFI is also often used to compare the impacts of different transport modes. Generally the non-carbon impacts of car, train and ship are low compared to that of CO\textsubscript{2}: an equivalence factor of 1.05 has been proposed by Peeters et al. (2007) based on data by Gugele et al. (2003). Though it is difficult to calculate an ‘equivalence factor’ for air transport in a similar way, the need to incorporate non-carbon impacts is highlighted by the fact that, if measured over one year, the contribution of short-lived emissions to climate change may equal or exceed that of all historical aviation-related CO\textsubscript{2} emissions (Sausen et al. 2005). However, use of a constant RFI as a base for emission trading schemes has been criticised (Forster et al. 2006), as RFI depends on the growth rate of aviation emissions.

Assuming a constant equivalence factor is comparable to the use of Global Warming Potentials (GWP), which have been used to compare climate impacts of different greenhouse gases. GWP compares the impact of 1 kg of an emitted gas with that of 1 kg of CO\textsubscript{2}. As discussed in section 1, this is not correct given the substantial differences in lifetimes of greenhouse gases and the fact that specifically contrails are acting locally unlike the ‘well-mixed trace gases’ GWP was meant for. Furthermore, GWP is calculated using a pulse emission and describing the ratio in time-integrated impacts of that on RF. The impacts of very short-lived greenhouse gases can only be accurately compared with long-lived ones using sustained emissions (see Shine et al. 2005a, Wit et al. 2005). For indirect impacts, i.e. those attributable to the formation of greenhouse gases from emissions of other gases (such as formation of CH\textsubscript{4} and Ozone through NO\textsubscript{x}), no unequivocal scaling factor can be defined to convert these impacts, as for example shown for impacts of indirect CH\textsubscript{4} concentrations (Fuglestvedt et al. 2003: 290-291). As Forster et al. (2006) show, the GWP based ‘emission weighting factor’ (EWF) depends very much on time horizon chosen, with values between 1.2 (500 year time horizon) and 36.0 (1 year time horizon), compared to the RFI value of 1.9 as provided by Sausen et al. 2005). However, the 100 year EWF was calculated at 1.7, not too far from the RFI of 1.9 for 2000, which is based on historical values. EWF indicates, like GWP, the future RF ratio, integrated over a given period of time. EFW is by definition independent of the growth of aviation, which we will show is not the case for RFI.
An alternative to GWP may be Global Temperature Potential (GTP) (see Shine et al. 2005b and application for emission trading schemes by Wit et al. 2005). GTP ‘compares temperature change at a given time for either a pulse or a sustained emission change’ (Shine et al. 2005a: 15769, Shine et al. 2005b) consider two forms of GTP: GTP$_P$ for pulse emissions and GTP$_S$ for a sustained change in emissions. The relation between RF and temperature change has been simplified to a linear one\(^1\). By dividing the GTP of all emissions by that of CO$_2$ alone, a global Temperature Index (GTI) can be constructed (see Wit et al. 2005: 32). However, as GTP is calculated using a linear relationship between RF and $\Delta T$, it does not eliminate the basic problems with GWP as described previously. These may be addressed by using GTP$_S$ for the GTI, thus using time-integrated RF’s for sustained emissions. This would however be similar to using RFIs, the only difference being that RFIs are integrated over the past, while GTI is used for a future period of time defined by the user. As the future time period is a more or less arbitrary choice it is clear RFI is better defined.

### 3.2 Analytical approach

RFI calculations presented here start in 1992 using an average CO$_2$ emission growth rate for aviation of 4.5% up to 2000, based on data presented by Penner et al. (1999) and Sausen et al. (2005). The data and equations presented below all start at 2000 and assume a constant average emission growth rate between 2000 and the future required year. RFI is defined as follows:

\[
RFI = 1 + \frac{RF_{ac}}{RF_C} \tag{8}
\]

Radiative forcing by CO$_2$ rises in proportion to the logarithm of the ratio of the CO$_2$ concentration considered and a reference concentration. Houghton et al. (1997: appendix II) and Houghton et al. (2001: section 6.3.1) provide the following equation:

\[
\Delta Q = \frac{3.7 \cdot \ln \left( \frac{C(t)}{C_0} \right)}{\ln(2)} \tag{9}
\]

where $\Delta Q$ is the change in radiative forcing in W/m$^2$, $C(t)$ the concentration of CO$_2$ in ppmv in year $t$ for which the RF is calculated and $C_0$ the pre-industrial CO$_2$ concentration of 280 ppmv. Filling in the result of $\ln(2)$ the contribution of aviation CO$_2$ emissions to RF for a specific year $t$ equation (9) has been restructured to:

\[\text{Thus the main difference between GWP and GTP is its ability to integrate a sustained emission change, which of course can also be achieved defining a sustained 'GWP'.}\]
\[ RF_t = 5.34 \cdot \ln \left( \frac{C_g(t) + C_{av}(t)}{C_g(t)} \right) \]  

(10)

for which \( C_{av}(t) \) is the aviation related concentration of CO\(_2\) in year \( t \) and \( C_g(t) \) the global concentration of CO\(_2\) in year \( t \) excluding the contribution of aviation. Now equations for both \( C_g(t) \) and \( C_{av}(t) \) are needed. For both \( C_g(t) \) and \( C_{av}(t) \) a base year of 2000 is assumed (i.e. the year 2000 equals 0):

\[ C_g(t) = C_{g0} \cdot e^{C_{gexp} \cdot t} \]  

(11)

and

\[ C_{av}(t) = C_{av0} + C_{avexp} \cdot E_{av_{acc}} \]  

(12)

In these equations \( C_{g0} \) and \( C_{gexp} \) are parameters derived from curve fitting data for the IS92a scenario (Penner et al. 1999). Other scenarios can be built by changing these parameters. \( C_{av0} \) represents the total historical aviation related concentration of CO\(_2\) in 2000 and \( C_{avexp} \) the long term ratio between CO\(_2\) remaining in the atmosphere and CO\(_2\) actually emitted. This value has been found by plotting data from tables 6.1 and 6.2 published in Prather et al. 1999) and fitting linearly (see right graph in Figure 1). \( EA_{av_{acc}} \) is the accumulated aviation related CO\(_2\) emission since 2000 for a constant emission growth rate of \( \delta_E \) (as fraction per year), represented by:

\[ EA_{av_{acc}} = EA_{av0} + \sum_{t=1}^{T} \left[ E_{av0} \cdot \left( 1 + \delta_E \right)^t \right] \]  

(13)

with \( T \) the future year for which RFI is calculated with respect to the base year 2000 (i.e. \( T=0 \) for the year 2000), this can be rewritten to:

\[ EA_{av_{acc}} = EA_{av0} + \frac{E_{av0}}{\delta_E} \cdot \left( \left( 1 + \delta_E \right)^T - 1 \right) \]  

(14)

A special case is the case of zero growth in the above equation. This is undefined (divided by zero), but can accurately be approximated by choosing a very low value of growth (i.e. 0.00001).

For the non-carbon RF, the relation between annual CO\(_2\) emissions and the non-carbon RF are plotted in a first step, as found from atmospheric models with defined 3-D emission patterns as given in Table 6.1 by Prather et al. 1999), ignoring other interpolated values. Figure 1 shows the relation to be linear with total fuel burn and thus with total CO\(_2\) emissions. These figures are based on the assumption that no operational measures are taken to reduce the non-carbon contribution to
radiative forcing; thus routing, flight paths and supersaturated zones are assumed to be similar to present ones.

This results in the following:

\[ RF_{nC} = C_{nC} \cdot \left[ \frac{E_{aP0}}{\delta_i} \cdot (1 + \delta_i)^T \right] \]  \hspace{1cm} (15)

The RFI for year \( T \) (i.e. the year 2000 has \( T=0 \)) can be found using equations (11), (12) and (14) in (8) the following overall equation for RFI for the year \( T \) has been derived:

\[
RFI = 1 + \frac{C_{nC} \cdot \left[ \frac{E_{aP0}}{\delta_i} \cdot (1 + \delta_i)^T \right]}{\left( C_{aP0} + C_{aPd} \cdot \frac{E_{aP0}}{\delta_i} \cdot \left( \left( 1 + \delta_i \right)^T + 1 - (1 + \delta_i) \right) \right)} \cdot \left( 5.34 \cdot \ln \left( \frac{C_{aP0} \cdot e^{C_{aPd} \cdot T}}{\left( C_{aP0} + C_{aPd} \cdot \frac{E_{aP0}}{\delta_i} \cdot \left( (1 + \delta_i)^T + 1 - (1 + \delta_i) \right) \right)} + 1 \right) \right) \]  \hspace{1cm} (16)

In order to assess the climate impact of future aviation in year \( t \) it is thus recommended to calculate the \( \text{CO}_2 \) emissions for this year and to multiply the result by the RFI found with equation (16) or as indicated in Figure 2. For a time-series from 2000 the following values for the constants should be used (some parameters are valid for the IS92a scenario only):
Table 5: Values used for calculation of RFI in Figure 1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_{av0}$</td>
<td>Total historical contribution of aviation to CO$_2$ concentration in 2000</td>
<td>1.4703</td>
<td>ppmv</td>
</tr>
<tr>
<td>$C_{av,eff}$</td>
<td>Long term ratio between CO$_2$ remaining in the atmosphere and CO$_2$ emitted</td>
<td>0.3203</td>
<td>-</td>
</tr>
<tr>
<td>$C_{g0}$</td>
<td>Global CO$_2$ concentration in 2000 (IS92a scenario)</td>
<td>376.7</td>
<td>ppmv</td>
</tr>
<tr>
<td>$C_{g,exp}$</td>
<td>Exponent for calculating the IS92a future global CO$_2$ concentration</td>
<td>0.0061</td>
<td>-</td>
</tr>
<tr>
<td>$C_{n,C}$</td>
<td>Fixed ratio between 1992 non-carbon RF as updated from Sausen et al. 2005 and the total aviation 1992 CO$_2$ emissions given by Prather et al. 1999</td>
<td>0.1053</td>
<td>W/m$^2$/GrC/year</td>
</tr>
<tr>
<td>$E_{av0}$</td>
<td>Aviation total CO$_2$ emissions in the year 2000</td>
<td>0.2133</td>
<td>GrC/year</td>
</tr>
<tr>
<td>$EA_{av0}$</td>
<td>Aviation cumulative CO$_2$ emissions for the period 1950 – 2000</td>
<td>1.4709</td>
<td>GrC</td>
</tr>
</tbody>
</table>

The values (annual growth between 1992 and 2000 and the 1992 value for non-carbon RF have been chosen to reflect the data provided by Sausen et al. 2003). However, for the carbon related RF we have used IPCC values (Prather et al. 1999) but corrected these for the lower impact of CO$_2$, as indicated in section 6.3.1 by Houghton et al. (2001). This means that the 2000 RF for CO$_2$ in this paper is slightly lower than the value provided by Sausen et al. (2003).

Figure 2 shows that the scenario growth rate has a large impact on RFI, causing the impact of non-carbon RF to become more important at high aviation emission growth rates, and less important at lower growth rates. This means that the total impact would decrease under a zero emission (relative) growth scenario. A zero impact growth scenario allows annual CO$_2$ emission to grow by some 3% per year, or more, if technological and operational efficiency gains are realised.
3.3 Numerical approach

The method described in section 3.2 requires assumption of constant growth of CO$_2$ emissions. However, in many scenario studies there is reason to assume periods with different growth rates for aviation (see Bows et al. 2006: 37-38) and varying rates for technological efficiency improvement (see Peeters et al. 2006). In such cases a numerical approach based on a spreadsheet is recommended. Such a spreadsheet must contain columns with the future year, the CO$_2$ concentration, the annual CO$_2$ emissions by aviation, the cumulative aviation emission, the aviation contribution to the CO$_2$ concentration, aviation CO$_2$ emissions related RF, non-carbon aviation related RF and RFI. Table 6 shows the first rows of the spreadsheet, the starting values for 2000 and the equations to be used.
Table 6: Example of first rows of scenario spreadsheet with starting values for the year 2000. Global concentration and the growth of aviation emissions per year at the choice of the researcher.

<table>
<thead>
<tr>
<th>Global</th>
<th>Aviation related</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>CO₂ concentration (ppmv)</td>
</tr>
<tr>
<td></td>
<td>Gt C</td>
</tr>
<tr>
<td>2000</td>
<td>370.5</td>
</tr>
<tr>
<td>2001</td>
<td>At choice (C8)</td>
</tr>
<tr>
<td>2002</td>
<td>…</td>
</tr>
</tbody>
</table>

Figure 3 shows an example of a low global carbon emissions scenario aiming at a maximum of 550 ppmv CO₂ concentration in the atmosphere to prevent global average temperature increase to become more than 2º C. Several aviation volume growth and fuel efficiency increase assumption have been made. The figure shows clearly how RFI varies with growth rates of emissions. When compared to the results shown in Figure 2 it is clear a low global emissions scenario tends to reduce RFI values.

It should be noted that while forecasts of CO₂ emissions are intrinsically linked to fuel consumption, the link between growth in radiative forcing for aviation’s non-carbon impacts and fuel consumption is sensitive to assumptions regarding the distribution of air traffic, as contrails and to some extent O₃ and CH₄ and their impacts are dependent on local atmospheric conditions along the trajectory of the flight. Another dimension to this issue is that for the same radiative forcing, the impact on global average temperature of an ozone increase depends upon the altitude and location at which it occurs (Joshi et al. 2003).
Figure 3: Example of some non-constant growth rate and aviation scenarios combined with a 'sustainable' global emission scenario aiming at 550 ppmv (based on Bows et al. 2006). Legend to Scenarios:
A. Aviation volume growth by 5.0% per year until 2015, followed by 4.5% until 2025 and 3.0% to 2100; technology 1.4% efficiency increase until 2015, followed by 1.2% until 2025 and 1.0% until 2100
B. Aviation volume growth as A; technology 1.6% efficiency increase until 2015, followed by 1.4% until 2025 and 1.2% until 2100
C. Aviation volume growth by 4.0% per year until 2015, followed by 3.0% until 2025 and 2.3% to 2100; technology 2.3% efficiency increase until 2015, followed by 1.6% until 2025 and 0.8% until 2100
D. Aviation volume growth by 5.5% per year until 2015, followed by 5.0% until 2025 and 3.0% to 2100; technology non-linear growth rates for long haul new aircraft efficiency increase regression (see Peeters et al. 2006)
E. Aviation growths as in D; technology non-linear growth rates for US jet fleet efficiency increase regression (see Peeters et al. 2006)
F. Aviation growth 5.5% until 2015 and 5.0% until 2100; technology as in D
G. Aviation growth 5.5% until 2015 and 5.0% until 2100; technology as in E.
4 Discussion

This paper discussed two methods to calculate the air transport related \( \text{CO}_2 \) emissions and its impacts on radiative forcing and several metrics to incorporate non-carbon impacts on climate change. The first two methods principally will give the same results. Choosing between them depends both on data availability and the purpose of the calculations. In most cases the compound method will be the appropriate approach as the aggregate method requires very detailed information on all flights involved in the tourism transport. For the non-carbon impacts more difficulties arise.

Table 7: Overview of methods to find emissions of \( \text{CO}_2 \) and impacts on radiative forcing of non-carbon greenhouse gases.

<table>
<thead>
<tr>
<th>Method</th>
<th>Short description</th>
<th>Most appropriate use for tourism studies*</th>
<th>Emissions of ( \text{CO}_2 )</th>
<th>Non-carbon impacts on radiative forcing and climate change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compound</td>
<td>The compound method directly couples traffic volumes to emissions by using generalised emission factors EF and transport demand. Relatively low level of data demand.</td>
<td>(1), (2), (3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggregate</td>
<td>The aggregate method finds total emissions by summing the emissions for all full three-dimensional flight-paths required for the transport volume under consideration.</td>
<td>(4), (5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GWP</td>
<td>Global Warming Potential (compares impact of pulse emission f 1 kg of trace gas on RF with 1 kg of ( \text{CO}_2 ) for a certain period of (usually) 100 years)</td>
<td>Not recommended</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RFI</td>
<td>as the ratio of all aviation-related RF in a specific year to that of aviation RF caused by cumulated ( \text{CO}_2 ) emissions since 1940</td>
<td>(1), (2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EWF</td>
<td>Emission Weighting Factor (as GWP but assuming sustained constant emissions)</td>
<td>(3), (4), (5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GTPP</td>
<td>Global Temperature Potential assuming Pulse emission (as GWP but RF converted to temperature impact assuming linear correlation between RF and temperature).</td>
<td>Not recommended</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GTPS</td>
<td>Global Temperature Potential assuming Sustained emission (as GTPP, but assuming sustained emissions of both trace gas and ( \text{CO}_2 ))</td>
<td>(2), (4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GTI</td>
<td>Global Temperature Index.</td>
<td>(3), (4), (5)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Legend to appropriate use:
(1) determine current share of historic (cumulative) aviation’s impact on climate change
(2) aviation’s impact on climate change in scenario studies
(3) impact of current emissions for the future
(4) multiplication factor for emission trade systems
(5) multiplication factor for carbon offsetting schemes
Due to the very different nature of the main non-carbon impacts (contrails and NO\textsubscript{x} emission induced methane and ozone concentrations) several theoretical and practical problems were encountered. The commonly accepted metric of global warming potential (GWP) cannot be used as the basic assumptions – medium to long-lived trace gases that are well-dispersed over the atmosphere – do not sufficiently apply to the aviation non-carbon climate impacts. Therefore several alternative metrics have been proposed (see section 3). These alternatives all have advantages and disadvantages. Therefore the most appropriate metric should be chosen based on the purpose of the calculation (see Table 7).

Based on Table 7 it can be concluded that none of the methods covers all purposes. For practical reasons of data availability, the compound method can as a second choice also be used for calculations regarding emission trading. Using RFI for carbon offset schemes is not recommended as it looks at the history, not the future of additional emissions. The proposed EWF for 100 years time horizon, calculated as a factor 1.7 is more suitable. For GTI no estimates are available, but it seems likely this will be not too far from the EWF if based on a time horizon of 100 years as well.

Current plans for inclusion of aviation in the EU emission Trading Scheme do not yet provide for non-carbon emissions, but ‘by the end of 2008, the Commission will put forward a proposal to address the nitrogen oxide emissions from aviation after a thorough impact assessment’ (European Commission 2006: 7). Implementation of the planned trading scheme could thus increase radiative forcing if the aviation industry becomes a net purchaser of permits from other sectors (Lee et al. 2000). This stresses the importance of incorporating non-carbon impacts. Though its volatile character complicates the use of RFI, it still is well defined at a given year now or in the future. Therefore using RFI with a regular (e.g. every five year) update of the value could be seen as a solution. Using EWF or GTI is more complicated as it requires the arbitrary choice of a time horizon, which has a very large impact on the result.

The use of radiative forcing as a measure to compare climate impacts of aviation has also implications for the identification and prioritisation of mitigation policies. For example, measures to eliminate contrail and cirrus cloud formation through changes in cruise altitude or routing away from ice-supersaturated zones would force aircraft to fly less efficient trajectories and so incur a CO\textsubscript{2} penalty (Williams et al. 2003). Using radiative forcing to compare impacts would suggest that this policy would have significant climate benefits as contrail-induced radiative forcing would be eliminated with only a marginal increase in radiative forcing from CO\textsubscript{2} (a small increase in annual CO\textsubscript{2} emissions would have a much smaller impact on the cumulative CO\textsubscript{2} concentration). A full comparison would, however, also need to take into account the future climate impacts of the additional CO\textsubscript{2} emitted, using a metric like EWF, and the evaluation of whether a net climate benefit would be achieved would depend on the time horizon chosen for analysis.
5 Conclusions and research recommendations

This paper has shown that there are differences in current models to calculate carbon and non-carbon emissions from aviation as well as the current and future radiation forcing caused by these emissions. The paper has sought to show differences in aggregate and compound approaches to emission calculations, as well as to provide recommendations of how to include non-carbon radiative effects in calculations of emissions. From the calculations it becomes clear that the inclusion of both carbon and non-carbon radiative forcing is important. Clearly, the results presented here show the growing significance of aviation as a contributor to climate change, which is of great importance in the context of the Kyoto-protocol. In the future, calculations of aviation-related emissions should be made in a consistent way in order to better understand the changing role of aviation in climate change and to identify suitable mitigation and compensation measures. The methods described are intended to give some standardisation for calculating the impact of tourism related air transport, both for CO$_2$ and non-carbon impacts.

The main conclusion of the paper is that current metrics can be used if caution is taken to the caveats around them and if the right metric is chosen for the right purpose as shown in Table 7. The non-carbon impacts on climate also require further development of metrics. A main cause for uncertainty is the relatively low understanding of the impact of contrails and contrail-induced cirrus on radiative forcing and the feedback loops between climate change and the local and global occurrence of these aviation related impacts. This requires further research and may affect the conclusions of this paper.

An interesting conclusion from the RFI evaluation is that for aviation CO$_2$ emission growth scenarios of above 2% per year the total historic radiative forcing of aviation will increase faster than this rate due to an increase of RFI. When growth is less than 2% the reverse will happen. This is valid for the next 50 years. At larger time horizons RFI stabilises at different values for different growth rates.

Finally we like to give the following research recommendations:

- Creation of a publicly available database for emission factors and emissions indices, both at individual aircraft level, generic aircraft types (like narrow body short haul jet, propeller and large wide body). Such a database should be developed and maintained under the responsibility of an independent international body like UNEP, UN-WTO or OECD.
- Further research on aviation scenarios and the impacts of measures and (technical and operational) developments of emission factors, emission indices, RFI and alternative metrics like the EWF (emission weighting factor) or GTI (global temperature index).
- Research to further our understanding of the impact of contrails and contrail induced cirrus clouds on the different metrics and the character of feedback loop
of climate change on the likelihood of contrail and contrail-induced cirrus cloud
development.

**Acknowledgments**

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THE ENVIRONMENTAL IMPACTS OF TOURISM IN ANTARCTICA. A GLOBAL PERSPECTIVE

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a International Centre for Integrated assessment and Sustainable development (ICIS), Maastricht University, Maastricht, the Netherlands

Abstract - Tourism in Antarctica is a global commercial industry with growing numbers of tourists visiting the Antarctic by different modes of transport and engaging in a range of activities. Right from the beginning, there have been academic and political concerns about tourism’s impacts on Antarctica’s ecosystems, flora and fauna, which as a result have been relatively well researched and addressed. Global impacts have so far not been included in environmental impact assessments of Antarctic tourism. In this paper it is argued that this is a serious omission. Antarctic tourism’s contribution to climate change is shown to be considerable, with aviation and cruises being the main sources of emissions. Arguably, tourism to the Antarctic ranks among the most energy intensive segments in the tourism market. It is discussed whether tourism to Antarctica can be sustainable in the long run, being fully dependent on long-haul trips.

Keywords: Antarctica, tourism, greenhouse gas emissions, environmental impacts

I Introduction

In the course of the past four decades, tourism has established its current status of legitimate Antarctic activity. After an initial period of slow growth, tourism development took off in the late 1980s and early 1990s. The total number of tourists taking part in Antarctic travel itineraries exceeded 30,000 in the season of 2004/05, and is projected to continue growing in the future (see Figure 1). Antarctic tourism is also becoming more and more diverse. The classic ‘Lindblad-style’ Antarctic expedition cruises, involving small to medium sized ships, rubber boat landings and educational programmes, are now complemented with large cruise liners, overflights and fly-sail operations, as well as adventurous activities such as helicopter excursions, kayaking, scuba diving, mountain climbing, and cross-country skiing (Bastmeijer and Roura 2004, Stonehouse and Crosbie 1995).

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Tourism volumes remain modest compared to the size of the continent, but they are strongly concentrated in space and time. Most tour operations take place in the Antarctic Peninsula area, because of its geographical proximity and absence of sea ice (Stonehouse and Crosbie 1995). Biodiversity is relatively high in this area, in particular around the ice-free landing sites used by tourists. Arrivals are clustered in the short Antarctic summer season of about four months (Cessford 1997), coinciding with the science activities of the National Antarctic Programmes (NAPs) and the breeding season of most penguins, seabirds and seals.

The (potential) environmental impact of tourism in Antarctica was recognised in an early stage by tour operators, policy makers and academia. In 1991, the Protocol on Environmental Protection of the Antarctic Treaty was adopted (and ratified some years afterwards), which regulates all human activities in Antarctica, including tourism. Around that same time, the International Association of Antarctica Tour Operators (IAATO), the Antarctic tourism industry association, introduced a range of environmental procedures and standards for its member companies. In more recent years, tourism appeared on the agendas of the Antarctic Treaty Consultative Meetings (ATCMs) several times, resulting in a number of tourism-related measures, such as site-specific guidelines for several frequently visited tourist landing sites (Bastmeijer and Roura 2004).

In academia, a range of empirical studies have appeared since the early 1990s.
about the desirability, implications and manageability of tourism in the fragile, pristine and extreme Antarctic environment. The impact assessments among these studies have been limited to local effects, i.e. those directly affecting Antarctica itself. This paper argues that the scope of assessments should be widened. Tourist trips to and in Antarctica have prominent global impacts, in addition to the local ones. Antarctica is a very distant destination, in particular for the majority of tourists that come from the Northern Hemisphere (see Figure 2). The long-haul air travel and Antarctic cruises result in probably large, but unknown volumes of greenhouse gas emissions. The aim of this paper is to produce an estimate of these emissions. But first, an overview of the environmental impacts of tourism in Antarctica identified in the literature so far is provided in the next section.

![Origin of Antarctic tourists travelling to the gateway cities (2004/05).](image)

Source: IAATO (2005b)

## 2 The environmental impacts of tourism in Antarctica

In the Antarctic tourism context, De Poorter (2000) defined the concept of ‘environmental impact’ as “the result of an environmental component being exposed to an output from an activity.” Environmental components can be physical (land, water, air), biological (flora, fauna), and non-material (values). Outputs can take various forms, such as emissions, trampling, noise, and the visual presence of people. Only impacts to the physical and biological environment are addressed in this section.

Rubbish disposal and littering are among the most direct and visible effects of tourism. This visibility may partly explain the considerable academic interest for
these impacts (see e.g. Bastmeijer and Roura 2004, De Poorter 2000, Hall 1992, Hall and Johnston 1995, Hall and Wouters 1995, Hofman and Jatko 2000, Mason and Legg 1999, Molenaar 2005). Cumulative impacts on frequently used sites may be more difficult to monitor and control. Such impacts may take place at or near landing sites, through damage to unique geomorphologic features, souvenir hunting, footpath erosion, and soil erosion (see e.g. Bastmeijer and Roura 2004, De Poorter 2000, Hall 1992, Hall and Johnston 1995, Stonehouse 1994). The marine counterpart of this type of terrestrial impact is the damage that ships cause to the marine environment by anchoring in frequently visited places (De Poorter 2000, Hofman and Jatko 2000, Molenaar 2005). In addition to the mechanical damage done to marine and terrestrial environments, tourism also impacts on the environment through emissions to water, air and soil. Hall (1992), Hall & Johnston (1995), Bastmeijer & Roura (2004), Molenaar (2005) report on the pollution of marine and coastal regions through oil and fuel spills and sewage dumps, whereas Bastmeijer (2004), De Poorter (2000), Hall (1992), Hofman and Jatko (2000), and Molenaar (2005) report on the contamination of the atmospheric and terrestrial environment with particulates and chemicals emitted by ships and aircraft.

Tourism influences the Antarctic ecosystem in a number of ways. First of all, the contamination, littering and damage that tourist activities bring about may have an impact on organisms. Stonehouse (1994), Hall & Johnston (1995), Hall & Wouters (1995), Cessford (1997), Mason & Legg (1999), Hofman & Jatko (2000), De Poorter (2000), Bastmeijer & Roura (2004), and Molenaar (2005) report on the damage done to vegetation, such as mosses and lichen, through trampling or vehicles. Second, the mere presence of tourists is sometimes enough to disturb wildlife and modify wildlife behaviour (Naveen et al. 2000, Pfeiffer and Peter 2004, Stonehouse 1994). Finally, ‘stowaways’ may be transported by the ships and aircraft used by tourism operators to transport tourists to the Antarctic. Hall (1992), Hall & Johnston (1995), De Poorter (2000), and Frenot et al (2005) discuss the risks of introducing exotic flora and fauna as well as animal and plant diseases.

So far, scientific assessments of the impact of tourism have not revealed major environmental impacts or changes caused by tourism (Hofman and Jatko 2000). In 1994, Stonehouse (1994: 209) concluded that “preliminary results suggest that the number of tourists currently deployed, and under the gentle but strict codes of practice prevailing, have very little immediate impact on ecosystems at many of the sites they visit.” This does not mean that tourism development is harmless, however. For a start, tourism has grown substantially since 1994 and is expected to continue growing in the future. Furthermore, the cumulative impact of tourism is not well understood. Researchers have only started to come to grips with this concept and realise its implications (Bastmeijer and Roura 2004, De Poorter 2000, Hofman and Jatko 2000). In addition, most research has focused on the impacts on terrestrial animal life, whereas the impacts on the marine environment received much less attention. The picture is thus far from complete.
One of the main omissions may be the lack of a global perspective. The environmental impact assessments of tourism have so far focused on the impacts in Antarctica itself. Even the work on atmospheric pollution is limited to emissions in the Antarctic region. This local focus is in stark contrast with recent academic insights that suggest that the bulk of global tourism’s environmental impact is associated with (origin-destination) transport (Gössling 2002). Transport contributes to a range of problems, of which climate change may be the most important. The objective of this paper therefore is to make an initial calculation of the volume of greenhouse gases emitted by Antarctic holidaymakers.

3 Methods and Data

Tourism-induced emissions have their origin in transport, accommodation and tourist activities. In the Antarctic case four sources of emissions are discerned: origin-destination (OD) transport (i.e. transport to and from the gateway cities), (expedition) cruises, overflights, and land-based expeditions. The approach taken to estimate emissions from each of these sources is briefly described below.

The continent of Antarctica is very remote, and poorly connected to the international transportation networks. There are only a handful of entry points, usually called gateways, including Ushuaia in Argentina, Punta Arenas in Chile, and Christchurch (Lyttleton) in New Zealand. Ushuaia is the main ‘hub’ for ship-born tourism, while Punta Arenas is the main basis for air connections to Antarctica. These gateway cities usually have air connections with a large airport, typically located in the same country or in a neighbouring nation.

In this paper, it is assumed that passengers travel to the relevant gateway cities in two stages: from the home country to the largest hub airport in the gateway country, and from that hub to the gateway city. Since the individual flight plans are unknown, all passengers are assumed to depart from the largest airport in their respective home countries. To estimate the CO₂ emissions associated with reaching the gateway cities first the total travelling distance was calculated (in kilometres) between the main airports in the home and gateway country, and between the gateway hub and the gateway city. Distances were calculated using the web-based Great Circle Mapper tool (gc.kls2.com). Travelling distance was multiplied by the number of tourists travelling and the emission intensity, i.e. the amount of emissions per passenger kilometre (pkm). Data on the number of tourists, their nationalities, and the vessels used are available from the IAATO website, www.iaato.org. Since actual flight distances are usually longer than the Great Circle distances (e.g. due to detours), a correction factor is applied, following Gössling et al. (2005) and Watterson et al. (2004).

A few simplifying assumptions were made. In the first place, all international tourists were assumed to pass through only two gateway cities: Ushuaia (for the
Antarctic Peninsula) and Christchurch (for the Ross Sea Region). Ushuaia is the dominant gateway city in South America; the position of Christchurch is less dominant, but the competing cities of Hobart (Australia) and Bluff (New Zealand) are at very similar distances from the main origin markets. Second, origin-destination transport for the overflight segment was not considered, as detailed information on the nationalities of the passengers in this segment is not publicly available. Third, the number of countries of origin considered was limited. Only the 21 countries that were the source of more than 100 tourists, covering almost 97% of all tourists, were considered individually. The characteristics of the remaining 3% were assumed to be equal to the average of the first 97%.

The emission estimates for the four major segments in Antarctic tourism were based on the amount of fuel used per day (in the case of ships) and per kilometre (in the case of aircraft). In the case of ships, technical specifications on fuel use were not available. Fuel use estimates were therefore produced based on gross tonnage using the coefficients suggested by Trozzi and Vaccaro (1998). Special attention was paid to the differences in fuel use of ships when operating in “cruising mode” and in “hotelling mode” (e.g. when on and off loading passengers in gateway ports and near landing sites). The report by Trozzi and Vaccaro (1998) also provided information on this issue. The duration of all individual trips by all individual ships in the 2004/05 season is documented by IAATO (2005a). No information was found on the relative share of time that is spent on cruising and hotelling respectively during cruise expeditions. It was assumed that all cruise vessels are loaded and unloaded at gateway ports in one day. In addition, based on two reports of the “typical Antarctic expedition cruise” (Rubin 2005, Splettstoesser et al. 2004), the time spend in cruising and hotelling modes were estimated at respectively 75% and 25% for expedition cruising.

Land-based tourism, serviced by aircraft, comprises a minor share of Antarctic tourism. Two IAATO member companies conduct land-based tourism activities, namely Antarctic Logistics and Expeditions (ALE) and Aerovias DAP. In its “Multi-Year Application to the US Environmental Protection Agency”, ALE reports on the environmental impact of their activities, including CO$_2$ emissions (ALE 2003). The Chilean Aerovias DAP conducts tourist day flights and two-day trips to King George Island using two relatively small aircraft. IAATO (2005b) reports on the number of flights made and the number of passengers taken. Using the emission coefficients proposed by Watterson et al. (2004), an estimate of CO$_2$ emissions was obtained.

The Australian companies Croydon Travel and Quantas organise over-flights across East-Antarctica from different Southern Australian cities, using Boeing 747-400 aircraft. Over-flights are also organised from Punta Arenas by LanChile with Boeing 737-200 aircraft. IAATO (2005b) reports on the number of passengers taken, the number of flights made, the routes flown and/or the flying time. An estimate of the CO$_2$ emissions was produced using the coefficients suggested by Watterson et al. (2004).
4 Results

The total flight volume of OD transport is estimated at 728 million passenger kilometres (pkm), of which 713 million pkm are linked to Ushuaia/Punta Arenas and 15 million pkm to Christchurch/Hobart. Total CO$_2$ emissions (pkm x emission coefficient) are estimated at 90 thousand metric tonnes. Multiplying total CO$_2$ emissions by the higher forcing potential at cruising altitude yields an estimate for total emissions of CO$_2$ equivalents, being 243 thousand metric tonnes. In absolute terms, tourists from the United States are the dominant factor in passenger kilometres and emissions. This is a result of relatively large numbers of tourists and moderate travel distances. Tourists from other countries (in particular Japanese travelling to South America and Europeans travelling to New Zealand), however, do worse in relative terms. Emissions caused by Japanese tourists travelling to Ushuaia are estimated to be almost twice as high as those caused by their American counterparts.

In the 2004/05 season, four ships were used for cruise-only trips, while a few dozen were used for expedition cruises. An estimated 53,020 tonnes of fuel was burnt, encompassing 44,550 tonnes by expedition cruises and the remaining 8,470 tonnes by cruise-only ships. Total emissions of ship-borne tourism are estimated at 169,666 tonnes of CO$_2$, which is equivalent to 6.16 tonnes per passenger. Clear differences can be indicated in emissions per passenger, which reflects differences in the number of passengers transported relative to the gross tonnage of the ships.

Qantas performed a total of 4 overflights with a Boeing 747-400, carrying a total of 1568 passengers. According to their report at AV-web, a distance of some 11,000 km is covered per trip, using 150 tonnes of fuel (Clarke 2004). Using the emission coefficient proposed by Watterson et al. (2004), the CO$_2$ emissions per trip are estimated at 472 tonnes of CO$_2$ per flight or 1,890 tonnes of CO$_2$ in total.

Lanchile performed a total of 9 overflights with a Boeing 737-200, carrying a total of 462 passengers. No distances travelled, fuel use or emissions were reported for these flights, but emissions could be estimated from the information on the emission performance provided by Watterson et al. (2004) and the flight plan (IAATO 2005b). Emissions by LanChile were estimated at 29.2 tonnes of CO$_2$ emissions per flight, or 263 tonnes of CO$_2$ emissions in total. Total CO$_2$ emissions related to overflights in the 2004/05 season were thus estimated at some 2,153 tonnes.

ALE (2003) projected total CO$_2$ emissions related to their operations in the upcoming 2003/04 season at 1,801 tonnes. The bulk of these projected emissions (1,783 tonnes) would be related to air transport, i.e. flights between Punta Arenas and the Antarctic field camp at Patriot Hills. These figures were recalculated based on the actual number 190 clients and 14 flights that ALE handled in the 2004/05 season (as opposed to the prospect of handling 100 tourists on 7 flights in 2003/04 in the report). Based on this, the emissions for the 2004/05 season were estimated at 3,422 tonnes of CO$_2$. Operating from Punta Arenas, Aerovias DAP transported a total of 657 tourists on 29 flights to King George Island for land-based activities.
in the 2004/05 season (IAATO 2005b). To be able to respond flexibly to demand, DAP used two airplanes: a King Air 200b (King Air) with a capacity of 12 for small groups, and a De Havilland DHC-7 (Dash 7) with a capacity of 54 for larger groups. It was reconstructed that 21 flights were made using the King Air and 8 flights using the Dash 7. The distance flown by both airplanes was from Punta Arenas to King George Island and back, which corresponds to a distance of 1,255 km one way. Assuming a detour factor of 1.05, and using the coefficients for fuel use provided by Watterson et al. (2004), total fuel use was estimated at 44 tonnes of fuel, corresponding to 139 tonnes of CO$_2$.

Table 1 gives an overview of total greenhouse gas emissions related to Antarctic tourism. Total emissions are estimated at 428,234 tonnes of CO$_2$-equivalents. In per capita terms this corresponds to an average of 15.10 tonnes of CO$_2$-equivalents per tourist trip. This figure excludes overflights and tourists travelling with DAP, because the country of origin of these tourists is not known. Given the relatively small numbers pertaining to these categories of tourists, this exclusion does very probably not have major implications for overall results.

<table>
<thead>
<tr>
<th>Activity</th>
<th>CO$_2$ (t)</th>
<th>CO$_2$-eq (t)</th>
<th>CO$_2$-eq/capita (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OD Transport – South America</td>
<td>88,290</td>
<td>238,384</td>
<td>8.70</td>
</tr>
<tr>
<td>OD Transport – NZ/Aus</td>
<td>1,784</td>
<td>4,817</td>
<td>8.71</td>
</tr>
<tr>
<td>Expedition cruises</td>
<td>142,561</td>
<td>142,561</td>
<td>6.33</td>
</tr>
<tr>
<td>Cruise-only</td>
<td>27,104</td>
<td>27,104</td>
<td>5.39</td>
</tr>
<tr>
<td>Land-based - ALE</td>
<td>3,422</td>
<td>9,181</td>
<td>48.3</td>
</tr>
<tr>
<td>Land-based - DAP</td>
<td>139</td>
<td>375</td>
<td>0.57</td>
</tr>
<tr>
<td>Overflights - Qantas</td>
<td>1,890</td>
<td>5,102</td>
<td>3.25</td>
</tr>
<tr>
<td>Overflights - Lanchile</td>
<td>263</td>
<td>710</td>
<td>1.54</td>
</tr>
<tr>
<td>Total</td>
<td>265,453</td>
<td>428,234</td>
<td></td>
</tr>
<tr>
<td><strong>Total (excl. overflights and DAP)</strong></td>
<td><strong>263,161</strong></td>
<td><strong>422,047</strong></td>
<td><strong>15.10</strong></td>
</tr>
</tbody>
</table>

Origin-destination air travel and cruises dominate emissions, accounting for almost 90% of total amounts. Cruises are the single largest source of CO$_2$ emissions, but air transport is most important in terms of radiative forcing (CO$_2$-eq emissions) as a result of non-carbon impacts. In relative terms, the per capita emissions of land-based tourism are striking. The small numbers of tourists involved, the long distances travelled, the large aircraft used, and the safety measures taken result in an impressive amount of emissions of close to 50 tonnes per tourist, including transport to and from the gateway cities.
5 Discussion

With per-capita emissions of around 15 tonnes CO$_2$-eq, Antarctic tourism is a very energy intensive industry. In 2005 global CO$_2$-eq emissions amounted to an average of some 4.3 tonnes per capita. For developing countries this figure was much lower (e.g. 1.14 tonnes/capita for India) than for the USA (21 tonnes) and the EU-25 (9 tonnes). The emissions produced during the typical two-week holiday of an Antarctic tourist equal the emissions produced by the average European in twenty months time.

Also when compared to other tourism destinations, Antarctica is an extreme case. Average per capita emissions for Antarctic tourists are more than forty-three times as high as the per capita emissions of an average visit to the Rocky Mountains (0.35 tonnes of CO$_2$-eq/capita), and three times as high as those for visits to the Seychelles (4.76 tonnes of CO$_2$-eq/capita), another typical long-haul destination (both examples from Gössling et al. 2005). Antarctica does not have a home market, fully depends on long haul transport for origin-destination transport, and on energy-intensive expedition ships and cruise-liners for accommodation.

Tourism is sometimes considered an important vehicle for promoting the need for the preservation of the Antarctic wilderness. This ‘ambassadorship’ (Maher et al. 2001) of tourists comes at a large cost, however. Greenhouse gas emissions from tourism aggravate the problem of climate change, of which Antarctica itself is a major ‘victim’. The Antarctic Peninsula has witnessed an increase in average annual temperature of 3° C since the 1940s, causing the disintegration of ice-shelves, and creating opportunities for the success and distribution of exotic species (Crosbie 2005). With the previous discussion in mind, labelling Antarctica as an ecotourism or sustainable tourism destination as is sometimes done (Splettstoesser et al. 2004) may well be misplaced.

Considerable uncertainties still exist in the presented estimates. There are ongoing debates about the magnitude of non-carbon contributions to climate change; emissions vary considerably between different types of aircraft; and per-capita values critically depend on occupancy rates. Also, the method for calculating emissions from (expedition) cruises is crude, as it does not take the wide variety in ships used into consideration. Technical specifications on, for example, fuel use should be made generally available by tour operators or the industry association. On the other hand, it is very likely that overall emissions were underestimated in this study as emissions from expedition staff, ship crew, non-reported tourists, inflatable boats, helicopter operations, etc. were not taken into account. Especially the first two categories are significant, because Antarctic tourism is a labour-intensive industry. The authors’ judgement is that these non-represented emissions may well be larger than the margin of error in the calculations.
6 Conclusion and research agenda

In this paper a first inventory was made of the greenhouse gas emissions produced by tourism to and in Antarctica. The local environmental impacts of tourism in Antarctica have been recognised in an early stage, and addressed in both official and self-regulatory governance regimes. The global environmental impacts of visiting Antarctica, however, have been systematically overlooked in academic studies and environmental impact assessments. As it turns out, this is a serious omission. The long distances travelled, the modes of transport used, and the safety measures taken results in emissions close to 15 tonnes of CO₂-equivalents per typical tourist trip. This is extremely high, even for an energy-intensive industry such as tourism. Total emissions added up to some 0.4 Mtonnes of CO₂-equivalents in the season 2004/05, which is a moderate amount in the grand scheme of things but only because numbers of arrivals are still limited.

The results presented provide a strong case for including global greenhouse gas emissions in any future environmental impact assessments of Antarctic tourism, such as the ones performed to meet the requirements of the various domestic implementations of the Environmental Protocol to the Antarctic Treaty. Without a doubt, this can be done in a more sophisticated way than is shown in the current analysis. More accurate studies would require improved data availability of ship-based emissions, as detailed information is currently difficult to access.

A fundamental question remains, especially for Antarctic tourism operators: Is there a long-term future for Antarctic tourism? In the absence of a domestic market, trips to the South Pole region unavoidably imply long-haul travel. To make matters worse, the Antarctic tourism industry is currently extremely dependent on visitors from the Northern Hemispheres. To compensate for the large distances travelled, large efficiency gains in air travel are required, and these are not in sight for the next few decades. In addition, Antarctica and other long-haul destinations are vulnerable to any policies that would lead to substantial increases in transport costs (e.g. carbon taxing). Albeit taking place in a distant location, Antarctic tourism is very strongly connected to global developments.

Our paper gives rise to the following research questions:

• Is sustainable tourism possible in a destination as remote as Antarctica, or other destination totally dependent on long haul flights?
• How will Antarctic tourism develop in the next decades; and how will this affect both the local and the global environment?
• What policy measures can be developed to mitigate the global environmental

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1 This would however only be possible for emissions of ships and aircraft below 60° South since the Environmental Protocol to the Antarctic Treaty is only applicable to this area of the world.
impacts of Antarctic tourism; and how can they be effectively enforced in the complex Antarctic governance structure?

- What are the global environmental impacts of the cruise industry; how will the global cruise industry develop in the coming decades; and to what extent is energy efficiency taken into account in the development of new cruise vessels?

References


IAATO (2005b) IAATO Overview of Antarctic Tourism 2004/05 Antarctic Season. Antarctic Treaty
SUSTAINABLE TOURISM MOBILITY: THE SOCIAL PRACTICES APPROACH

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Abstract - Sustainability is a known topic in tourism research. However, research shows a dualistic approach to sustainability, being either structure-centred or actor-centred. Furthermore, research is too generic, concentrating on tourism as such instead of on specific meaningful holiday practices. In our view mitigation of climate change caused by tourism mobility is only possible when the dualistic approach is overcome and practice-specificness is taken into account. In this paper the Social Practices Approach is introduced. It is a contextual model of consumption that combines an actor-oriented approach with a system of provision perspective of consumer behaviour. Its focus is on the social practice itself in which actors with their lifestyles and routines on the one hand, and provisioners and infrastructure on the other hand are analysed in interaction. The Social Practices Model offers the insight that consumers and producers shape each other through the production-consumption chain.

Keywords: Tourism mobility, sustainability, practices, consumption junction

1 Introduction

Tourism is one of the most important industries of the world economy and one of the most important aspects of people’s lives as well. Over the last couple of decades it has become normal practice to go on holiday. It has become an unquestioned part of the consumption behaviour. It seems that going on holiday has become a civil right. The tourism industry can lead to much economic gains, but unfortunately to much environmental and socio-cultural damage as well. There is a growing tension...
between the positive aspects of tourism and the negative impacts of tourism on the environment and on social and economic inequalities. Tourism needs a way out. In this paper the focus will be on the mobility component of tourism, because mobility is the most important aspect of tourism behaviour when aiming for mitigating climate change. By definition tourism is impossible without transport. Tourism and mobility entail each other and are economic key factors on the one hand, but on the other have considerable impacts on environment and health (www.alpsmobility.net). Within tourism, the mobility component is the one that has the greatest environmental impact. Tourism mobility leads to more ecological deterioration than for example the waste problem, water problem and the deforestation of mountains. The transport of tourists accounts for between 50% and 75% of the total impact of tourism on the environment. Meanwhile, the general trend in tourism towards more frequent, further-away trips, for shorter periods of time is increasing the problem (Peeters et al. 2004).

2 Sustainability in tourism

Sustainable tourism development meets the needs of present tourists and the tourism sector without comprising the ability of future generations of tourists and the tourism sector to meet their needs (Peeters et al. 2004). Therefore, sustainable tourism development is a perspective that can positively enhance tourism. In the tourism industry sustainability is a known topic. Much research has been done on sustainable tourism (e.g.: Bargeman et al. 2002, Dobbinga et al. 2003, Duim van der 2005, Giessen van der et al. 2006, Gössling et al. 2005, Hoyer 2000, Peeters et al. 2004, RMNO 2006, Sharpley 2000). Among other things, the focus has been on an actor-network perspective on sustainable tourism development, on making an inventory of sustainable tourism initiatives, on the impact of transport in tourism, on sustainable tourism and transport policies, and on prevailing questions in the field of sustainable tourism development. All in all, they have been useful contributions to sustainable tourism research. However, when taken together, the field of research shows two weaknesses. It is either aimed at providers of the tourism industry, or at individual consumers’ attitudes, lifestyles and preferences. Next to that, up till now, the focus is more on the sustainability of tourism as a generic reality, instead of on the sustainability component of specific tourism practices (Verbeek et al. forthcoming).

As far as the first is concerned it can be said that tourism research is more or less captured in a dualistic approach to sustainability. Either it is focused on structure, concentrating on modes of provision, or on individual actors, concentrating on generic attitudes, lifestyles and routine behaviour. However, it can be argued that, in terms of strategies, both approaches are reaching their limits. Structural methods, such as the production of cleaner vehicles or even price mechanisms, don't seem to
be able to effectively change the travelling behaviour of tourists. On the other hand, it has become clear that policies directed at changing individuals’ attitudes neither affect their mobility behaviour as well (European Commission 2004, European Environment Agency 2005). In terms of the structuration theory of Giddens’s (Giddens’s 1984) we can speak of a dualistic situation which should be overcome by placing social practices, instead of structures or human action as such central in social research.

The second deficiency is that most of the times research aimed at the sustainability of tourism is not taking the specificity and contextuality of tourism practices into account. Implicitly or explicitly, researchers take tourism as a whole for granted. They do not bother too much about the contextuality or specificity of the tourism practices they study. Because different types of holidays concern diverging consumers and providers and the holidays are taking place in diverging contexts, it seems more appropriate to pay attention to the possibility of incorporating different sustainability strategies for different holiday practices.

All in all, different actors and structures exert their influence on holiday practices and therefore on tourism mobility behaviour. Socio-technical innovations need to be in a situation of fit with specific contexts, they should be embedded in users’ and producers’ contexts and routines in order for them to work and to be helpful in a transition to more sustainable tourism mobility and in mitigating climate change. A method of approach is needed that analyses the demand- and supply-side of the tourism industry in concrete or situated interaction. This will lead to innovative insights in sustainable consumption behaviour.

3 The Social Practices Approach

3.1 Origin of Social Practices Approach

Existing models of research do not fit to the study of social practices very well. On the one hand, “social-psychological models are strong in stressing the importance of the values and beliefs human agents adhere to. They are however weak in connecting individual motives for action with the wider society” (Spaargaren et al. 2000: 52). On the other hand, technological and/or economic models pay no attention to individuals’ motives or reasons. When taken together, they act like passing ships in the night. Because of that, they are becoming less effective in suggesting effective sustainability strategies in today’s globalised, post-modern reality.

The Social Practices Model developed by Spaargaren has its roots in Giddens’ structuration theory. The value of Giddens’ structuration theory is that it provides a means of bridging the structure-agency gap. The core notion of the theory is the concept of the ‘duality of structure’. Human agency and structure are not considered as two separate concepts, but are reciprocally influencing each other. On the one hand structures are ‘media’ in the sense that they enable a human actor to act,
on the other hand these structures are in turn confirmed and reinforced by the actors' actions. Therefore, they argue, in line with Giddens's structuration theory, that in order to study consumer behaviour, the social practices in which actors are involved when pursuing their daily routines should be the start of analysis. Therefore, individual behaviour and its underlying reasons, interests and motives are studied in the context of social practices situated in time and space and shared with others. Beliefs, norms and values are analysed as the rules which belong to a specific social practice. Rules and resources together constitute the structures that are involved in the reproduction of social practices.

3.2 Introduction
The Social Practices Approach is a contextual model of consumption that combines an actor-oriented approach with a system of provision perspective on consumer behaviour. The Social Practices Approach combines the notion of human agents as knowledgeable and capable actors in sustainable transitions, with an equal emphasis on the influence of the social and technological context on human behaviour.

Its focus is on the social practice itself in which actors with their lifestyles and routines on the one hand, and structure of rules and resources, norms and values, provisioners and infrastructure on the other hand are analysed in interaction.

In figure 1 the Social Practices Approach is visualised. In the following sections attention is given to social practices, to actors and modes of access, and finally to structures and modes of provision.

3.3 Social Practices
Social practices are to replace individual norms and behaviours as the basic unit of (policy) analyses. Social practices are shared routines which are structured in time and space. By focusing on the level of social practices an analysis can be made of the interaction between the provisioning of green socio-technological innovations by the suppliers, and the travellers’ lifestyles, tourism mobility potential (‘motility’; Kaufmann 2002) and expressed tourism mobility patterns of groups of citizen-consumers.

Recent work in the area of technology and consumption can be used as an example. It is focused on the interrelation between practices, technological and behavioural devices, and large technical infrastructures (Shove 2003). The work of Shove cleverly integrates user-technology interaction, transition management and the sociology of consumption, on the level of everyday life activities. She discusses the notion of slots (blockages) as they can be identified both at the modes of provisioning, as well as at the modes of access and consumption in production-consumption chains. This work highlights the importance of thinking about technologies in use, in practice and in context.

In the social practices concerned, there is a place and time at which the consumer makes choices between competing technologies, products, or services. This place
is called the consumption junction. In the consumption junction the relationship between inside factors such as the internal time-space organisation and the cultural style of the household, and outside factors such as the external systems of provisions like the mobility infrastructure in tourism is important (Spaargaren and van Vliet 2000).

3.4 Actor – Modes of Access

In this research the role of citizen-consumers is very important. We do not claim that only consumers are change agents, innovative enterprises and NGOs are of course important change agents as well. However, our focus is on citizen-consumers because of the fact that structural policy measures and restrictions and processes of technological innovations already receive much attention in research. The citizen-consumer however remains underexposed. Furthermore, there is a vast recognition of the fact that accomplished advantages for the environment are most of the time counteracted by a growth of consumption. The European Commission (European Commission 2004: 5) states in this respect: “Technological development and innovation have increased resource efficiency and enabled environmental gains. These gains are however often outweighed by increased consumption and changes in lifestyles”. In my view however, citizen-consumers are not only to be seen as the cause of problems. The key to sustainable development of tourism mobility is also in the hands of citizen-consumers as they have the power of choice. Citizen-Consumers can be change agents. Citizen-consumers have an important role in shaping and reproducing core institutions of production and consumption. At the present time, the opinions and behaviours of citizen-consumers matter increasingly for companies, policy-makers and social movements. Therefore, the ability for citizen-consumers to express themselves politically through consumer choices has increased dramatically, making it possible to influence the provisioning of green socio-technical innovations (see Micheletti 2003 for more detail on political consumerism).

The actor-side of the model refers among other things to the lifestyles and routines of citizen-consumers. Giddens defines ‘lifestyle’ as “a more or less integrated set of practices which an individual embraces, not only because such practices fulfill utilitarian needs, but because they give material form to a particular narrative of self-identity” (Spaargaren and van Vliet 2000: 55). The ‘narrative of self-identity’ refers to the fact that people have their own storyline(s), linking their consumption choices. However, an analytical separation needs to be made between people’s general way of life and their practice-specific lifestyle. This can be compared to what Giddens states: “A lifestyle sector is a time-space slice of an individual’s overall activities” (Spaargaren and van Vliet 2000: 55). In addition to people’s general lifestyle, practice-specific lifestyles exist that are only manifested in specific time-space configurations, in specific social practices.

For example, people have a generic lifestyle, based on generic attitudes, education level, income level et cetera. Furthermore, people have sub-lifestyles, or in Giddens's
words ‘lifestyle sectors’ for different holiday practices. In these terms, people’s beach holiday ‘lifestyle sector’ can differ significantly from the city trip ‘lifestyle sector’ and winter sport ‘lifestyle sector’.

The reason why the concept of lifestyle is so important in the Social Practices Approach is that citizen-consumers might realise environmental improvement by changing their behaviour in accordance with specific lifestyle characteristics. Reconsidering their holiday activities from a sustainability perspective, people might be motivated to develop more sustainable holiday practices, in line with the specific lifestyles motivating them. They can for example consider to go on a city trip by train, or take part in a climate compensation programme when going on a beach holiday to Turkey, or look for sustainable holidays on internet platforms on which sustainable holidays are gathered, not as something contrary to their lifestyle, but as something motivated by their lifestyle as such, e.g. by an affinity with convenience, comfort, safety, status: people’s more specific ‘lifestyle sector’ as a source for sustainability.

The Social Practices Approach is however not a model that predicts the direction of changes, nor is it a model that assumes a transition to sustainable development. it is an ontological framework that needs empirical analyses. However, because the research aims for sustainable development of tourism mobility, we use the Social Practices Approach to get insights in aspects that are of relevance in a transition towards sustainable tourism mobility, such as lifestyle and routines.

Routine behaviour is another important aspect of the human agent’s behaviour. The vast bulk of activities of life are habitual, taken for granted, and not directly motivated. The concept of routinization is vital to the theory of structuration and the Social Practices Approach. “Routine is integral both to the continuity of the personality of the agent as he or she moves along the paths of daily activities, and to the institutions of society, which are such only through their continued reproduction” (Spaargaren and van Vliet 2000: 60). Although tourism behaviour may not be a day-to-day experience, it certainly is characterized by routinized behavioural patterns. Most people have a routinized way of booking their holiday; they will first browse web pages of companies A and B and then go to travel agency C. For most families it is not questioned which transport means they will use and in what accommodation they will stay; they always go by car and stay on a campsite. Because they are characterized by this routine behaviour the behavioural patterns of tourists and the negative consequences of tourism are hard to change. Giddens (Giddens 1984) states about changing routines that they first need to undergo a process of disembedding. Disembedding refers to taking things out of their historical context and structure. When tourism behaviour can be disembedded, new behavioural patterns that enhance sustainability might be developed, by re-embedding this behaviour in a new (lifestyle) context. To re-embed behaviour means putting things together in a new context, in a new culture-structure (Giddens 1984). The result is a change in behaviour that could be more sustainable.
The actor side of the model can be described as the system-of-access dimension of consumer behaviour. The actor side of the model is referred to as the modes of access, because it incorporates the multiple modes in which consumers have access to supply. In the social practice modes of access and modes of provision are confronted with each other.

3.5 Structure – Modes of Provision

The structure-side of the Social Practices model is comprised of rules, resources, shared norms and values. Structure refers to the rules and resources that are needed in everyday life to be able to ‘go around’. Such rules and resources can be infrastructures, objects, conventions, uses and practices (Shove, in: Spaargaren and van Vliet 2000). For example, when going on winter sports in Italy, the infrastructure of railways and trains, the electricity networks, the road system, the gas stations, the presence of campsites, hotel accommodations, ski lifts et cetera are the rules and resources that make up the structure of this holiday practice ‘winter sports’. Or when going on a cycling holiday, the infrastructure of good cycling paths, the route ways, the availability of accommodation and restaurants et cetera are the rules and resources that make up the structure of the social practice ‘active holiday’. With these examples it is also apparent that structure is, as lifestyle, practice-specific. Different social practices are involved with different rules and resources.

The structure side of the model can be described as the system-of-provision dimension of consumer behaviour. System of provision refers to the mode in which product are provided to consumers in the consumption junction. It unites a particular pattern of production by suppliers with a particular pattern of consumption in the social practice (Figure 1). Therefore, changes in consumer culture and consumer behaviour are to an important extent connected with major changes in the organization of different sections of industrial production (Spaargaren and van Vliet 2000). The ‘modes of provision’, the way in which sustainable socio-technical innovations are being presented, can have an important influence on the so-called ‘modes of access’ and use of these socio-technical innovations. In short, the consumption behaviour in the social practice is not only influenced by the lifestyles and routines of consumers, but by the structuring properties of systems of provision as well.

To summarize, the Social Practices Approach displays the interaction between all actors involved in tourism, and thereby between demand and supply, between modes of access and modes of provision. The approach takes the social practice – holiday practice - its central unit of analysis. The model is about actor-structure dynamics that are contextually embedded in social practices. In that way it leads to the insight that producers and consumers each shape each other and that sociotechnical innovations need to fit to travellers’ routines and lifestyles as well as providers’ routines and structure of supply in order to be successful.
4  Social Practices Approach applied to Tourism

Having chosen the Social Practices Approach as the primary theoretical perspective, the next step is to demarcate in more detail the primary unit of analysis. Although from a sustainability perspective, this would imply choosing various mobility types, on second view, this is not appropriate. It might be the case that tourism mobility is not recognizable by consumers or tour operators as a meaningful practice by itself. Therefore the holiday practice will be the central unit of analysis, and sub-practices of holidays need to be distinguished. In these holiday practices, of course the tourism mobility component will receive most attention.

Holiday practices can be identified along several criteria. They need to refer to actual consumption behaviour; the travel and tourism behavioural patterns of consumers. They need to refer to different modes of provision; the different holidays tour operators and other tourism businesses provide. Additionally, they need to be meaningful and recognisable as separate holiday practices to groups of tourists and tourism businesses. Following from our focus on sustainability, the travel and tourism practices also need to be of relevance to the environment; the opportunity for climate change mitigation is a prerequisite. Finally, the travel and tourism practices need to have a mobility component in them, because of our focus on the mobility component of tourism behaviour.

In order to get an impression of holiday practices recognisable and meaningful to tourists as well as businesses in the tourism industry, a preliminary analysis has been conducted. The insights of providers on holiday practices have been collected through an analysis of websites of fourteen of the biggest players in the tourism industry. Tour operators as well as transport companies’ websites, were analysed to observe the way they structure their supply of holidays. Holiday practices that are often mentioned are: city trips (n=10), winter sports (n=10), beach holidays (n=8), active holidays (n=7), car (n=7), plane tickets (n=5), camping holidays (n=5), and family holidays (n=2). As opposed to the supply side of the tourism industry little is known about how consumers typify holidays. Therefore an open question was posed to friends, colleagues and family-members: “If you would have to identify multiple types of holidays, what holiday types would you mention?” Respondents were free to answer in their own words without predetermined categories. Out of the answers (N=21), the following holiday practices are frequently mentioned: active holiday (n=17), city trip (n=15), beach holiday (n=14), winter sports (n=12), camping (n=9), car (n=5), plane tickets (n=4), and family holiday (n=4). Combining results from supply- and demand-side, and avoiding overlap between different holiday practices it appears that the typology of holiday practices as mentioned in Figure 1 is appropriate for now. Comparing for example beach holidays with winter sports,

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2 ANWB, Baobab, D-reizen, Elmar, FOX vakanties, Kras, Neckermann, OAD Reizen, Pharos reizen, Shoestring, SNP reizen, Thomas Cook and TUI.
3 Translated from: “Als je verschillende soorten/typen vakanties zou moeten noemen, wat zou je noemen?”
city trips, family holidays and active holidays different travellers are involved, with different lifestyles, in a different surrounding, undertaking different activities and causing different impacts on the environment. Because of the fact that these preliminary analyses were only to get a first impression, methods and results are not showed here in the proper way. In future research we will further elaborate on this typology and data gathering and processing will take place in a proper way.

Figure 1: Social Practices Approach.

The typology of holiday practices, however, is not an aim at is own. The identified holiday practices are specific contexts socio-technical innovations need to be embedded in. The typology is a means to analyse if socio-technical innovations fit to holiday practices and how the practice-specificness of socio-technical innovations plays a role in sustainable development of tourism mobility.

5 Social Practices Approach and Labelling

The case of labelling will be used in analysing the importance of practice-specificity of sustainable socio-technical innovations. Eco-labels are currently a general measure, leaving contextual differences of holiday practices unexposed. Labels are to be
found in the consumption junction where consumers meet producers such as travel agencies, and the internet. Labels can influence behaviour by providing information and opportunities to consumers at places where they look for information and book their holiday. And by labelling their supply, providers can differentiate themselves from other providers, can attract more consumers, or they can supply them as a corporate responsibility strategy.


Analysing tourism eco-labelling using the Social Practice perspective, can lead to new insights. Eco-labels are socio-technical innovations that influence the holiday practice and give consumers the opportunity to change their consumption behaviour. Analysis is directed at how labels intervene or get involved in the holiday practice. Analysis will focus on the opportunities these labels and their provision give consumers for greening their holiday practice.

Different modes of provision of labels by providers need to be confronted with different modes of access to labels for travellers. Networks of actors providing labels need to be confronted with user preferences of whom they would like to get innovations and information on sustainability labels. Probably trust is an important factor in this respect. Travellers could trust governmental labels more than labels out of the profit sector. Next to labelling networks, the type of label could be important as well. It might be the case that travellers prefer appealing brands more than certified labels. Finally, different ways of providing the label in a consumer context are important. For example, eco-labelling in food can take place on product-level, on shelve-level, or on supermarket level. The same counts for tourism labels. They can be provided at product level (some holidays are labelled as sustainable, others not), at a digital platform (all holidays placed on this platform are sustainable), or on the level of tour operators (if you choose to travel with this tour operator, your holiday is guaranteed sustainable). This needs to be confronted with consumers’ information seeking practices. If consumers first go for a tour operator, eco-labelled tour operators are a window of opportunity. If it appears that consumers look for accom-

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modations first, then eco-certified accommodations are the best strategy.

The idea is to analyse labelling in the consumer context and confront access and provisioning to be able to explore situations of fit and misfit. Special attention is hereby given to the practice-specificity of labels. Are some labels more suited to winter sports (e.g.: Alpine Pearls), while others fit in the context of beach holidays (e.g.: Blue Flag)? Are consumer preferences and the way travellers look for information different for city trips than for active holidays, and what does this implicate for the mode in which suppliers need to provide their labels?

All in all, labelling is one strategy to find out about practice-specific interaction mechanisms between actors and structures, between modes of access and modes of provision.

6 Conclusion

We want to conclude this paper by stating that in our view mitigation of climate change caused by tourism mobility is only possible when the current dualistic approach in tourism research is overcome and practice-specificness is taken into account. Because the Social Practices Approach does precisely that, we expect by using this approach we can make a contribution to climate change mitigation studies in the domain of tourism.

Future research will be directed at how ‘consumer directed environmental information’ and ‘sustainable socio-technical innovations’ interfere in holiday practices, and give roles to citizen-consumers to act as active change agents in a transition towards sustainable development of tourism mobility.

References


Section II: Reducing greenhouse gas emissions

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Bart Boon, Arno Schrotten & Bettina Kampman

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COMPENSATION SCHEMES FOR AIR TRANSPORT

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Abstract - Tour operators and other organisations currently offer their clients the possibility to compensate for the climate impact of air travel by joining (voluntary) programs such as Trees for Travel, Greenseat and Atmosfair. This paper discusses the effectiveness of compensation through these organisations. We discuss inter alia whether the full climate change impact of flying is addressed and whether projects can indeed guarantee compensation. It is also discussed how compensating for flights compares from an environmental perspective to the option of flying and not compensating and the option of not flying. It is argued that voluntary compensation schemes should not be considered an alternative to public policy to limit the climate effects of air travel.

Keywords: Air transport, CO₂ compensating schemes

1 Introduction

Air travel contributes substantially to society’s total emissions of greenhouse gases. For 1992 the contribution of international aviation to climate change by human activities is estimated at 3.5% (IPCC 1999). Although significant improvements to aircraft technology have been realized, absolute emission levels continue to grow strongly due to a persistent growth of air travel. Emissions of CO₂ are expected to double in the coming decades (Eyers et al. 2004). Leisure tourism composes about 50 to 65% of all international air travel in 2000 (Peeters & Dings 2003). For 2020 an increase is expected to 55 to 75%.

In spite of the substantial impact of air travel on climate change, few policies aiming at reducing the climate impact of aviation have been implemented. Bunker fuels used in international aviation are not covered under the Kyoto Protocol. One of the reasons is that Parties have not been able to agree on who is responsible for emissions on flights between countries. This may be one of the reasons for limited governmental policies. Fuel taxes in the aviation sector are very rare, as are emission charges. In cases where such policies do exist, their aim is generally not directly related to the climate impact of aviation, but to improve local air quality or financ-

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ing air transport infrastructure.

In recent years there have been some developments. The Kyoto protocol states that emissions from international aviation should be addressed working through the International Civil Aviation Organization (ICAO). Progress within ICAO, however, is generally regarded as slow, because international agreement on measures is often difficult. ICAO’s Committee on Aviation Environmental Protection did agree on voluntary measures to reduce emissions by aircraft (Hart et al. 2004). More importantly, the European Commission aims to put forward a legislative proposal to include the aviation sector under the EU’s emissions trading scheme before the end of 2006 (European Commission 2005). Also, a group of thirteen countries recently agreed to introduce a tax on air tickets, with the proceeds going to development aid. The primary aim of this initiative appears however to increase funding for development aid and not to reduce the impact of aviation on climate change.

In the absence of effective governmental policies dealing with the impact of air travel on climate, several companies started offering air travellers the possibility to voluntarily compensate for the climate impact of their trip. Air travellers pay a certain amount of money, based on estimates of the climate impact of their flight, to the company, which in turn invests (part of) the money into compensation schemes. Originally, these schemes were mainly directed at planting trees that sequester CO₂. Nowadays, schemes have been extended to other sectors and include investments in solar energy, wind power and insulation programs. Instead of sequestering carbon dioxide (CO₂) by planting and growing trees, these new variants focus on a reduction of emissions compared to business as usual emission levels. These compensating schemes are not restricted to air travel, schemes for road travel and the consumption of electricity and natural gas have also been raised. Additionally, Visa has introduced the GreenCard. The CO₂ emissions related to the production and use of products or services bought with this credit card are automatically compensated.

In this paper we will discuss compensation schemes for air travel and focus in particular on compensation schemes related to planting trees. In section 2 we start with a short overview of the organisations involved in compensation schemes for air travel. In addition, we provide an indication of the size of the market for compensation for air travel. In section 3 we focus on the compensation schemes related to planting trees. We discuss the requirements posed to forestry schemes and their potential for storage of CO₂. Next we confront the total emissions from air transport with the potential for storage in section 4. We also compare emissions from air transport in Europe with the numbers found earlier on the amount of CO₂ compensated by companies. Subsequently, in section 5 we compare the environmental impact of flying and compensating with the option of flying and not compensating and the option of not flying. Finally, the conclusions of this paper are presented in section 6.
2 Compensation schemes

A number of organisations offer air travellers the possibility to offset the carbon emissions of their flights. These organisations are generally web-based and follow similar procedures. Air travellers can use an online calculator to compute the greenhouse gas emissions related to a specific flight and they can invest in projects that will offset that amount of greenhouse gas emissions. Almost all organisations express the amount of these emissions in terms of CO$_2$-equivalents, which are computed by multiplying the CO$_2$ emissions by some factor to include the non-CO$_2$ climate change impacts. Relatively few organisations also take account of the potential impact of cirrus clouds, which is still subject to considerable scientific uncertainty. Apart from the direct online supply of credits to air travellers, several organisations have started cooperating with tour operators, which either compensate all the flights of their clients (Robinson Club) or offer them the possibility to do so. At least one airline offers clients the option of compensation. Several firms and governmental bodies make use of the compensation schemes for all their official and business air travel.

In Table 1 an overview of the required CO$_2$-equivalents compensation and the corresponding costs for specific return flights are presented for a selection of organisations. The estimated number of required CO$_2$-equivalents and the costs of compensation vary substantially between organisations. There are several reasons why the estimated CO$_2$-equivalents differ. First, although most organisations assessed take account of non-CO$_2$ effects of flying, they use different multiplying factors (ranging from 1.9 to 3) to compute the full climate impact of flights based on the computed CO$_2$-emissions. Second, some organisations use more refined methods to calculate the CO$_2$ emissions of a specific flight than others. More specifically, some organisations use standardized figures of CO$_2$ emissions for a few classes of flights (depending on the distance travelled) while other organisations make use of complex models. Third, organisations differ with respect to the assumptions underlying the computations, e.g. computing CO$_2$ emissions per passenger versus CO$_2$ emissions per seat, assuming one standard type of aircraft for all flights versus differentiating the types of aircrafts used for various flights, etc. To what extent these factors can explain the variance in costs (see table below) has not been studied.

Apart from the calculation methodology for CO$_2$-equivalents, the costs of compensation depend on the overhead costs and more importantly, on the type of projects the organisations invest in. As can be seen in Table 1, the organisations invest in different types of compensation projects. First, some organisations choose to offset the greenhouse gases by projects for planting new forests or restoring

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1 Exceptions are The CarbonNeutral Company that compensates only the greenhouse gases and the British Airways scheme operated by Climate Care. Greenseat offer their clients the choice between compensating for the CO$_2$ emissions alone and compensating for the full climate change impact of flying.
existing forests. These projects are often executed in developing countries, in order to strengthen the local economies in these countries and tackle climate change at the same time. Moreover, trees planted in a tropical environment will sequester more CO\textsubscript{2} per annum than trees growing in more temperate environments. Also the costs are lower in these countries, primarily caused by the relatively low land prices. An additional reason for offsetting in developing countries is that these countries currently do not have emission reduction commitments under the Kyoto protocol. Reductions are thus indeed additional to business as usual developments. If offsetting would take place in the UK for example, the UK government would need to do less to reach its international commitments. Second, CO\textsubscript{2} emissions or climate change impacts from flying may be offset by investments in projects directed at renewable energy. These projects lead to direct reduction of greenhouse gases by replacing fossil fuels by renewable fuels, like solar energy and wind power. Also these projects are mostly placed in developing countries for much the same

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Means of compensation</th>
<th>Amsterdam - Barcelona - Amsterdam</th>
<th>Amsterdam - New York - Amsterdam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmosfair</td>
<td>Renewable energy, energy efficiency</td>
<td>0.6  12.00</td>
<td>3.98  80.00</td>
</tr>
<tr>
<td>Carbon Neutral Forestry</td>
<td>Forestry</td>
<td>1.82  18.07\textsuperscript{a}</td>
<td>5.26  41.07</td>
</tr>
<tr>
<td>Climate Care, Forestry</td>
<td>Forestry, renewable energy, energy efficiency</td>
<td>0.29  3.13</td>
<td>1.64  17.61</td>
</tr>
<tr>
<td>Climate Care, British Airways scheme\textsuperscript{b}</td>
<td>Sustainable energy products</td>
<td>0.30  7.49</td>
<td>1.33  14.90</td>
</tr>
<tr>
<td>Greenseat\textsuperscript{c}</td>
<td>Forestry</td>
<td>0.87  12.82</td>
<td>3.16  42.54</td>
</tr>
<tr>
<td>MyClimatethe Carbon Neutral Company</td>
<td>Renewable energy, energy efficiency</td>
<td>0.74  17.08</td>
<td>2.3  53.16</td>
</tr>
<tr>
<td>Trees for travel</td>
<td>Forestry</td>
<td>0.4  5.71</td>
<td>1.3  17.20</td>
</tr>
</tbody>
</table>

\textsuperscript{a} Carbon Neutral use a minimum price of 30 Australian dollars (about 18.07).
\textsuperscript{b} Only CO\textsubscript{2} emissions are compensated.
\textsuperscript{c} Greenseat offer their clients the choice between compensating for the CO\textsubscript{2} emissions alone and compensating for the full climate change impact of flying. The numbers presented refer to the latter case.
reasons as mentioned above (with the exception of better growing conditions for trees). Third, some organisations invest in projects related to energy efficiency, e.g. replacing 'normal' light bulbs with low-energy light bulbs in households, insulation projects etc.

There is currently no set of standards that projects of compensation organisations have to meet. Our general impression is however that most organisations take their responsibility very serious and try to adhere to standards that do exist, e.g. for the clean development mechanism projects under the Kyoto Protocol. Projects are overlooked by independent organisations which are in some cases controlled by the Société Générale de Surveillance (SGS). Also, at first sight, the criteria of additionality appears to be taken seriously by most organisations. Two sets of standards are currently under development, by the Climate Group and Gold Standard. Results are expected to become available in the course of 2006.

It is hard to estimate the number of air travellers participating and the size of the market for offsetting the climate impact of air travel. We have not been able to find any aggregate statistics. To provide an indication nonetheless, we will present incidental numbers based on personal correspondence and a public annual report (of Climate Care). The annual amount of compensated tonnes of CO\textsubscript{2} differs heavily between the various companies, ranging from 750,000 tonnes of CO\textsubscript{2} by the CarbonNeutral company to 10,000 tonnes by MyClimate. It should be noted that these numbers in general include the total amount of CO\textsubscript{2} compensated by these companies. They relate not necessarily just to air travel, but may include the general emissions of companies. Furthermore, compensated emissions of air travel do not only relate to all air travel and not only to tourism. Trees for Travel compensated only for air travel in 2005 35,000 tonnes of CO\textsubscript{2} of which about 15% for individuals and the bulk share for companies and organisations.

To get an idea of the share of holidaymakers compensating we turn to alternative sources. In a report by First Choice (2005) results from a UK questionnaire among air travellers are quoted. 28% of the holidaymakers stated that they would be willing to pay a small supplement, which would be invested to offset environmental damage caused by the flight. In contrast, less than 1 in 200 passengers participated in the first month of operation of a scheme initiated by British Airways in September 2005 (Times 2005).

We furthermore contacted various Dutch tour operators who cooperate with the Dutch compensation organisations Greenseat and Trees for Travel. We found that most tour operators do not record information on the number of passengers that

\footnotesize
2 It must be mentioned though that some organisations do carry out projects in Annex I countries. In these cases, the governments of these countries can count reductions towards their emission limitation commitment.
3 The Gold Standard being developed by the Renewable Energy and Energy Efficiency Partnership (REEEP) does not include forestry, in part because REEEP applies an energy methodology and does not include 'end-of-pipe' solutions.
4 Against 14% of the holidaymakers stating that they would be willing to reduce the number of holiday flights taken.

compensate. Information on compensating passengers which is available shows that only a small fraction (usually 5-10%, but up to 25% for some specific operators) of the travellers compensate for the climate impact of their flights. In addition, the tour operators cooperating with compensating organisations specialize in offering trips ‘off the beaten track’ and thus aim at a very special segment of the travel market. These agencies only cover a small share of the holiday market and we therefore expect that the share of all holidaymakers compensating for the climate impact of their flight lies substantially below the numbers mentioned by these specialised operators.

From the analysis above we conclude that currently a small share of holidaymakers compensate for their flight. It appears compensation by tourists is increasing though, due to travel agencies confronting more and more potential air travellers with the choice of compensating. Nonetheless, compensation of air travel by tourists is expected to remain small compared to the total amount of emissions that can be related to air travel by tourists.

3 Compensation by planting trees

Originally, compensation of CO$_2$ was organised by planting trees. Nowadays, this method of compensation is still used by a large part of the organisations, particularly since costs of this way of compensation are low compared to alternative measures (Kauppi & Sedjo 2001). For this reason we will focus in this section on offsetting CO$_2$ by planting trees.

Trees remove CO$_2$ from the atmosphere by photosynthesis, releasing oxygen and part of the CO$_2$ through respiration, and retaining a reservoir of carbon dioxide in organic form. In addition to capturing CO$_2$ by photosynthesis, trees also support the creation of humus in the soil, which will also sequester CO$_2$. At the moment trees are mature they are assumed to be carbon neutral, which means that the CO$_2$ gain from photosynthesis equals the loss of CO$_2$ by respiration (Matthews & Robertson 2001). The rate at which trees can sequestrate CO$_2$ depends on age and other factors such as climate, topography, soil characteristics, species, etc.

Through the capacity of growing trees to sequester CO$_2$, young forests can act as carbon sinks. Mature forests can be stocks of carbon formerly taken from the atmosphere. Thus, afforestation, reforestation and reducing deforestation can contribute to reduce climate change. Only afforestation and reforestation are in compliance with the Clean Development Mechanism (CDM), a mechanism under the Kyoto Protocol that provides industrialised countries the opportunity to meet their emission reduction commitments by implementing mitigating projects in developing countries (Waterloo et al. 2001). Although organisations that offer compensation schemes are not obliged to meet these requirements, most of them refer to similar

\*This appears to be corroborated by the data in Table 1. The organisations that have forestry in their portfolio are able to offer compensation at a relatively low price.\*
requirements in their own guidelines for forestry projects.
One crucial aspect of sequestration of CO\textsubscript{2} by trees is that it is always temporary. In case of a forest fire or a pest the stored CO\textsubscript{2} is released. This will also be the case if the tree ‘dies a natural death’ and decomposes over time. If the trees are used to produce timber, after time the timber wood will start to decompose or be burned and the CO\textsubscript{2} is eventually released. In all these cases the net effect of temporary storage will be negligible\textsuperscript{6}. An alternative would be to purchase land and to reserve this land infinitely for forest. Also in this case in time the trees grown will decay. However, new trees will replace them, and this process will repeat itself forever. Thus, an everlasting storage capacity can be ensured. At a certain point in time, the storage capacity of the newly dedicated area for forest will reach its saturation point, where the net removals of carbon by the forest will drop to zero. It is thus not so much the rate of storage of a tree that matters, but much more the storage capacity of the area dedicated for forest.

Clearly, it is hard to guarantee the dedication of a specific area for forest indefinitely. This is acknowledged in the CDM forestry projects under the Kyoto protocol. Parties involved are expected to report on how they will account for the non-permanence of the storage. Instead of the certified emission reductions (CERs) Parties normally receive for emission reductions by CDM, CDM forestry projects deliver temporary and long term CERs, coined tCERs and lCERs respectively. In contrast to general CERs, tCERs and lCERs expire over time. When they expire, these credits can no longer be used and emission reductions need to be obtained by other means.

The forestry projects under the voluntary compensation schemes appear not to take full account of the temporary nature of forestry projects. Generally, they require a minimum lifetime of the forest of 99 years. This is the longest period possible from a legal perspective. An exception is Carbon Neutral, which uses a project lifetime of 30 years. Climate Care which in 2002 compensated over 90% of its clients’ emissions by reforestation, has changed its position with regard to reforestation. ClimateCare no longer feels planting trees can be seen as a solution to climate change when taken in isolation. Nonetheless, it expects that ‘20% of its project mix will remain in forest restoration because approximately 20% of global emissions each year are from deforestation and forest fires’ (Climate Care 2004). The CarbonNeutral Company also strives to reduce the share of forestry projects in its portfolio to 20%. Trees for Travel notes on its website that the climate problem is not solved by planting trees, but that it can gain time (website Trees for Travel).

How much CO\textsubscript{2} can be stored by forestry projects? As was mentioned above, a lot of factors do influence the amount of CO\textsubscript{2} that can be stored in trees. Most organisations assessed apply their own specific computation method to calculate the

\textsuperscript{6} There may be some potential second-order climate effects, resulting from the different timing in the release of CO\textsubscript{2} and the potential background concentrations in different periods. We do not pursue this further, the effects are however likely to be small.
amount of CO₂ that can be stored by their forestry projects, taking into account the local circumstances and specificities of the trees planted. The literature\(^7\) provides a wide range of sequestration rates of forests, varying from 1.2 to 35 tons of CO₂ per hectare annually for a new forest.

Clearly, the extent to which forestry can be used as compensation measure depends also on the amount of land available for this purpose. Estimation of total land area available is complicated by complex socio-economic and political factors that lead to high uncertainties (Read & May 2001). IPCC (1996) estimates, based on a number of studies, that about 700 Mha of forestland might be available for carbon conservation globally (345 Mha for plantations and forestry, 138 Mha for slowed tropical deforestation, and 217 Mha for natural and assisted regeneration). At that time, forests were estimated to cover about 3.4 Gha worldwide. The 700 Mha could provide a cumulative mitigation impact of 220 to 319 Gt CO₂ by 2050\(^8\). These figures are confirmed by Kauppi & Sedjo (2001).

It has been argued that afforestation can have a significantly negative impact on biodiversity if poorly designed (Totten & Pandya 2003). The policies of the current organisations offering compensation schemes are generally directed at conserving the local biodiversity. So, they prefer planting local native species above fast-growing exotic species. Afforestation may also offer other ancillary (environmental) benefits and costs to society, e.g. negative impacts on water budgets (Jackson et al. 2005), changing property rights into a direction harmful for local people (Brown & Corbera 2003) etc. It goes too far to discuss all potential impacts here, see Kauppi & Sedjo (2001) for a good overview.

### 4 Emissions from air transport

In general, fuel efficiency of aircraft has improved substantially over the last 40 years. Annual improvements have been in the order of 1 to 2%. Despite the fuel efficiency improvements, CO₂ emissions levels from air transport have grown considerably over the last decades and are expected to continue doing so. For example, IPCC (1999) estimates global passenger air traffic to grow at 5% annually between 1990 and 2015. In this period, global fuel use and CO₂ emissions were expected to grow 3% annually, the difference due to improved fuel efficiency. For the long run, estimates for global CO₂ emissions levels are quite uncertain, ranging from 719 to 7,242 Mton annually in 2050 (IPCC 1999).

For illustrative purposes, we will now confront projected emission levels with the land available for compensation. Clearly, given the large uncertainties in emission


\(^8\) The source indicates 60 to 87 Gt of C. This has to be multiplied by 44/12 to obtain the weight in tonnes of CO₂. This figure can be compared to 1210 Gt CO₂ (530 Gt C) that was estimated to be stored in live and dead above and below ground vegetation in 1996.
levels, future policies and available land this section is highly speculative. Recalling from section 3, the 700 Mha of available forestland could provide storage of about 220 to 319 Gt of CO$_2$ by 2050. If we assume annual emissions growing steadily from 0.6 Gt CO$_2$ in 2005 to 1.6 Gt in 2055, and use a climate factor of 2, about 110 Gt of CO$_2$ storage would be required to compensate for the climate impact of aviation over the next 50 years. That means about fifty percent of all potential land available for compensation would be required to compensate for the full climate impact of air transport over the next 50 years alone. Compensation of the climate impact from air transport by forestry projects alone appears to run into land use limitations within not too long. This holds even stronger when taking into account the fact that a substantial share of the land may have to be used for other purposes.

Emissions from all flights departing from EU airports in 2004 equalled about 130 Mtons of CO$_2$ (CE Delft et al. 2005). This number relates not only to tourists but also to air travel for business and other purposes. Compensation in CO$_2$-equivalents should be about twice as high to compensate for the full climate impact of aviation. Recalling the numbers from section 2, The CarbonNeutral Company compensated the most emissions, amounting to about 0.75 Mton last year, much more than any other company. This number does not only refer to compensation of air travel, but the total amount of emissions compensated. It appears we can conclude it is likely that the voluntary compensation schemes capture less than 1% of the climate impact of air travel.

5 Effects of compensation schemes

In this section we discuss in more detail the effects compensation schemes may have on the total emissions from air transport and on public policy. We will distinguish between the direct (first-order) and indirect (second-order) effects. For the assessment of forestry projects, we make the assumption that an infinite dedication of the land to forest can be guaranteed.

5.1 First-order

The direct effect of compensation of the emitted CO$_2$ is the prevention of environmental deterioration by climate change. Flying with compensation will be better than flying without compensation. A more interesting question is how flying with compensation compares from an environmental perspective to the option of not flying? To answer this question, the first thing we should know is whether flying with compensation is really climate neutral.

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9 Here we only consider the effect on climate change. Large-scale forestry projects for compensation may cause other sustainability problems to society, such as the availability of land.
The climate impact of aviation is 2 to 4 times greater than the impact of CO₂ emissions alone. Organisations offering compensation schemes do take account of the non-CO₂ climate impact of aviation, with some exceptions. Air travel is also suspected of enhancing formation of cirrus clouds, which could also add to the overall global warming process. However, this effect is taken into account by just a few organisations. We conclude that travellers compensating at a random compensation organisation cannot be assured that their flight is climate neutral. How flying with compensation compares to the option of not flying will therefore depend on the particular compensation organisation.

5.2 Second-order
Apart from the direct effects of compensation schemes on climate change, there are also several second-order effects that need to be understood. These second-order effects will be small and probably negligible at the current levels of compensation. However, if popularity increases, these second-order impacts may become more important.

First of all, compensation schemes may compete with entities that have emission reduction obligations for emission reduction projects. The additional demand can have two effects. It can drive prices of credits up and may in time limit the political support for stringent emission reduction targets in other sectors. Alternatively, the additional demand may provide support for new technologies that can now be applied at a larger scale, making them cheaper and more cost-effective by advantages of scale. This effect could encourage more widespread application of these techniques.

In the second place, increased frequencies and new destinations may make it more attractive for other passengers to fly. Suppose there are many people that would otherwise not have flown, but decide to fly because of the possibility to compensate for the impacts of their flight. In that case, the increased demand for air travel by these compensating passengers may lead to increased frequencies and new destinations. There is some evidence that the frequency of services grows with the square root of the increase in demand (see Mohring 1976, quoted in Rietveld et al. 2002). A study by Koens (2004) provides some evidence that the possibility to compensate the climate impacts of aviation will lead to an increase in the demand of air travel. The increased demand may thus lead to higher frequencies and new destinations, attracting new passengers that do not compensate. In that case, the decision to fly of the compensating passengers does have a negative impact on climate change (ceteris paribus) because it makes air travel more attractive to other people, increasing the number of trips that are not compensated.

A third potential second-order effect relates to awareness. Voluntary compensation schemes may raise awareness of the climate impacts of air travel. This may affect both compensators and non-compensators in their decision on future flights. Raised awareness may make people behave more environmentally friendly. Potentially they reduce their air travel, but it is also possible that they take climate change more into account in their daily life decisions. Alternatively, the raised
awareness may also have a negative environmental effect. People may be surprised by low prices to compensate for a flight. They may conclude that climate change is therefore not a serious problem after all.

A fourth potential effect relates to public policy. Voluntary compensation may be used as an argument against public policies to limit the climate impact of air travel. It may be argued that by voluntary compensation, there is no longer a need for stringent public policy. It appears there is some support for this line of reasoning from the sustainable tourism sector; see e.g. Becken (2004) and Becken et al. (2003). Although some lobbyists may use this argument, we do not expect it to be taken very seriously by policy makers. Especially the European Commission is determined to do something about the climate impact of aviation (see European Commission 2005) and this argument has not come up so far in discussions. Moreover, it appears most compensation organizations agree that reduction of emissions at source is most effective.

Apart from the first-order and second-order effects, there is one thing more that should be taken account of. The effectiveness of compensation depends on the alternative scenario. Whether something is good or bad can only be judged when taken full account of the alternative. If people would decide against flying, they will spend their money otherwise. These alternative (economic) activities will most likely also involve emissions of greenhouse gases. If these emissions do not fall under an emissions regulating scheme (such as the Kyoto Protocol or the EU ETS) and if they are not compensated, it might have been a preferable option, from an environmental point of view, to have seen this money spend on air travel with compensation10.

6 Conclusions and further topics

When confronted with the climate impact of his trip, a potential traveller has three options. First, he can decide not to fly. Second, he can decide to fly and join a compensation scheme. Third, he can decide to fly and not join a compensation scheme.

Of these three options, from an environmental perspective, the third option is undoubtedly the worst. In this paper we also compared the option of flying and compensating with the option of not flying.

The result of this comparison depends in part on the specifications of the compensation scheme. First of all, not all organisations compensate for the non-CO₂ impacts of flights on which there is sufficient scientific knowledge to do so. Very few organisations try to take account of the potential impacts of aviation on the

10 It should be noted, though, that the eco-efficiency of flying in particular, and tourism in general is less than in other sectors of the economy (see e.g. Gosling et al. 2005). If there is an option between compensated air travel and an alternative spending that would fall under a regulating scheme, there may well be reasons why from a social perspective the alternative spending is to be preferred.
formation of cirrus clouds. Given the scientific uncertainty regarding these effects, this may be understandable.

In the second place, some organisations are involved in forestry projects. Despite all the efforts of these organisations to guarantee long-term existence of these forests, a specific tree can only temporarily store CO\(_2\). Dedication of the land to forest use to infinity cannot be guaranteed. Moreover, forestry projects pose significant land use requirements. To compensate for the emissions over the next 50 years, about half of all the available land for forestry would be required. For these reasons forestry projects are in our opinion not suited for compensation purposes. This is corroborated by the regulations for CDM forestry under the Kyoto Protocol, for which CERs are awarded that expire after a certain time.

Third, some of the organisations carry out projects within Annex I countries. These countries have emission reduction or emission limitation commitments under the Kyoto protocol. Any emission reductions by voluntary compensation may reduce the governments’ efforts to achieve these commitments. Voluntary compensation cannot be regarded as additional to other efforts in these situations.

The best a traveller that is dedicated to fly can do, is compensate his emissions with an organisation that invests in non-forestry projects outside Annex I countries and that compensates for the full climate impact of a flight. In this case, the first-order environmental impact of flying may be effectively neutralized or compensated. Flying and compensation can be compared to the option of not flying from an environmental perspective.

However, there may be some second-order effects. These effects are small and may be negligible at the current level of use of compensation schemes. If more and more passengers make use of compensation, these effects may increase and should be further studied.

Although the number of travellers that make use of the voluntary compensation offered is increasing, the total amount of emissions compensated is still very small. Therefore, and because of the voluntary nature, compensating emissions should not be seen as an alternative to public policy to limit the climate impact of air travel.

With respect to the subject of this paper, we feel there are several interesting topics to be further discussed and studied. In the first place, it would be interesting to study the potential size of the second-order effects discussed in this paper. To what extent does the option of compensation induce more non-compensated air travel? How does increased awareness affect people’s behaviour?

Second, it may be interesting to speculate more broadly about the moral issue involved when compensating emissions from air travel by forestry projects. To compensate for a one-off benefit, one lays a claim on scarce land forever. Such behaviour is by definition unsustainable in the long run.

And how about initiatives by compensation organisations to reduce the share of forestry in their portfolio to 20%? Does this solve the problems with the non-permanence of forestry projects?
References


**Websites**

MITIGATION OF CLIMATE IMPACTS WITH INNOVATIVE AIR TRANSPORT MANAGEMENT TOOLS

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Abstract - This paper explores the scope for applying emerging innovative air transport management concepts and tools to the mitigation of a wide range of climate impacts from aviation, including emissions of oxides of nitrogen (NOx), which affect ozone (O3) and methane (CH4) and contrail-cirrus formation. The impacts of commercially driven introduction of air traffic management (ATM) innovations and the potential for incorporating environmental issues in their design and implementation in order to address carbon dioxide (CO2) and non-CO2 impacts are discussed. The technological, scientific and political issues that would need to be addressed to achieve an integrated approach to the application of new ATM technologies to the mitigation of climate impacts are outlined. These issues highlight the need for improved understanding of the comparison and prioritisation of the different emissions and effects of aviation in order to successfully mitigate impacts.

Keywords: Air Traffic Management, Navigation Technology, Climate Change

I Introduction

As demand for air travel continues to grow rapidly, new technologies and operational procedures for air traffic management are sought to manage the increased traffic in a way that improves existing high levels of safety and minimises delays both en route and on the ground. By reducing delays and diversions from direct routes, these innovative approaches to air traffic management have the potential to cut fuel consumption and hence reduce emissions of carbon dioxide (CO2). However, the climate impact of aviation is not confined to CO2 and existing attempts to compare CO2 and non-CO2 impacts in scientific assessments and policy debates have failed to fully represent the very different characteristics of the different mechanisms (Forster et al. 2006, see also paper by Peeters et al., page 29).

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This paper provides a broad, qualitative discussion of the potential climate implications and applications of a range of potential future ATM measures and tools. While previous studies such as the report, ‘Environmental benefits associated with CNS/ATM initiatives’ (International Civil Aviation Organisation 2000) have considered specific airspace changes, this paper considers the transition towards new technologies in more general terms allowing a broader range of climate impacts to be considered. The paper focuses on examples drawn from innovations under development for European airspace, which is both highly congested and politically the most likely forum for early implementation of international approaches to mitigate climate impacts of aviation. The technologies and concepts, or variants of them, are also under consideration outside Europe, particularly for airspace which is congested or where significant infrastructure changes will be required to meet expected growth.

2 Air Traffic Management

Air Traffic Control (ATC) systems currently in use are a second-generation application of radar technologies, with the aircraft location data augmented to provide aircraft identification, altitude and other information. In the 1980s, the International Civil Aviation Organisation (ICAO) recommended development of a satellite-based system concept to meet the future civil aviation requirements for communication, navigation and surveillance/air traffic management (CNS/ATM). This could remove the need for relatively expensive and inflexible ground-based equipment, and lead to an integrated global system with benefits for efficiency, economy and safety. However, development and implementation of such a scheme is a long-term and expensive task, particularly in an internationally operating industry with divergent stakeholder demands.

The congested airspace of Europe presents particular challenges for existing approaches to air traffic control. One problem is the complex routing network due to ATC sector boundaries aligned to national borders. This fragmentation remains a significant inefficiency, contributing to the higher cost of ATC in Europe than in the US (Helios Economics and Policy Services 2006). Rapid traffic growth has placed pressure on the infrastructure, giving rise to potentially costly delays. There are also serious concerns that the system may not be able to meet forecast demand. The air traffic controller's workload has reached saturation in many sectors (Majumdar et al. 2001).

The Single European Sky initiative of the European Commission has given the improved harmonisation and integration of European airspace major political impetus (European Commission 2003). The Single European Sky ATM Research programme (SESAR) brings together key air transport stakeholders to define a shared vision for European ATM and to develop and deploy the integrated tools
required to deliver it. The deployment phase will begin in 2014.

The changes to be implemented under SESAR have yet to be defined, but two key changes envisaged are the introduction of real time high accuracy and high integrity 4D navigation and the increasing delegation of responsibilities for control to the flight crew. The latter is linked to the use of airborne separation assurance between aircraft, leading eventually to ‘free flight’ in en-route airspace, which will allow operations that are more autonomous and will enable greater flexibility.

In addition to these broad concepts for European airspace, innovative approaches and tools for specific elements of air traffic management have been explored. Some are interim steps, designed to deliver increased capacity through alternative management of traffic using existing systems. Others seek to reduce workload or increase capacity and system efficiency by addressing limitations of existing interfaces between pilots and controllers and improving the display and exchange of data.

Growth in CO$_2$ emissions from aviation has been slower than growth in passenger-km, due to improvements in aircraft and engine technology driven by the commercial pressures to lower fuel cost and a past trend towards larger passenger aircraft. Without successful efforts to reduce congestion and airborne delay as traffic increases, the rate of growth of CO$_2$ emissions is likely to increase. However, efficiency benefits due to increases in capacity may be countered by induced demand. In addition, growth in non-CO$_2$ radiative impacts may be larger than growth in CO$_2$ emissions. Measures to control CO$_2$ emissions could potentially increase impacts associated with NOx emissions and contrail and cirrus cloud formation.

Currently, routes flown differ significantly from the shortest (great circle) distance between the departure and arrival airports. A route diversion may optimise operations for the prevailing wind conditions, but generally increased route distance represents increased fuel consumption and increased emissions. The opportunities to reduce fuel use through operational changes have been explored in a recent circular by the International Civil Aviation Organisation (2004). This identified opportunities for reducing emissions by reducing fuel use. While many of these opportunities relate to the business practices of the airline (including aircraft selection, load factor, fuelling practices and maintenance procedures), the benefits offered by communication, navigation, surveillance and air traffic management (CNS/ATM) measures are identified as the most likely to deliver significant fuel savings. These savings would arise from more direct routing, reduction in in-flight delays and improved capabilities to plan and implement fuel-efficient routing, speeds and altitudes.

3 Climate impacts of aviation

As kerosene is a hydrocarbon fuel, combustion emits CO$_2$. This, as with CO$_2$ emissions from surface-based sources, enhances the greenhouse effect, trapping increased radiation in the atmosphere, which results in warming. Other impacts
are uniquely associated with operation at cruise altitudes. In the upper troposphere, nitrogen dioxide (NO$_2$) formed in the combustion process increases ozone (O$_3$), which also contributes to warming. This is partly offset by a cooling due to a reduction in methane (CH$_4$), also due to NO$_2$. The very cold ambient temperatures at cruise can cause the expanding exhaust gas to condense to ice crystals as it mixes with the surrounding air, forming a contrail. In the right conditions, contrails can persist for many hours and can spread to form extensive cirrus clouds, which are believed to have a further warming impact. Emissions of water vapour into the troposphere will rapidly precipitate out and the radiative impact is small, but emissions in the stratosphere are long lived and can have a significant warming effect (Penner et al. 1999).

For most of these mechanisms, effects can be (and have been) reduced through technological advances in aircraft and engine design. The scope for aircraft/engine technological measures to reduce contrail formation is limited. The radiative properties of the cirrus cloud formed could be manipulated (by increasing the number of condensation nuclei in the exhaust, to give more, smaller particles), but the radiative consequences are not yet well understood and the impact on climate may well be increased. One alternative is to divert aircraft to avoid atmospheric regions in which contrails form. This has been used to preserve the secrecy of military aircraft movements, but it may also have benefits for climate.

Previous studies have considered widespread altitude restrictions to reduce contrail formation, varying either monthly or 6-hourly (Williams et al. 2005, Williams et al. 2002). ATM constraints were found to be severe. Radiosonde data has shown that the average vertical extent of the layers in which contrails can form may be as small as 500 m (Spichtinger et al. 2003), suggesting scope for small in-flight adjustments to avoid contrail formation (Mannstein et al. 2005). This would target adjustments in cruise altitude for local atmospheric conditions, reducing both the disruption and the fuel penalty.

While flight adjustments to filed flight plans are not uncommon, for example to avoid convective weather systems, their use for contrail avoidance would place an additional planning and monitoring burden on both pilots and controllers. An incentive-based scheme would be required for contrail avoidance as it is likely to require diversion from the fuel-optimising preferred route. The costs to airlines would be larger if diversions significantly impacted journey time. If the onus were on the pilot to inform the controller of contrail formation conditions, then the cost of contrail formation must outweigh the fuel and time penalty of diversion. A charge based on the exact aircraft path and engine ratings could draw on data already recorded by aircraft. Due to atmospheric variability, any charge specifically for contrail would be likely to be dependent on aircraft-based monitoring to attribute contrail formation. This does not present a significant technological challenge, but better quantification of contrail and cirrus impacts would be needed to gain political and industrial support and to ensure that the price placed on contrail
formation were to reflect its contribution to climate forcing relative to other mechanisms. In theory, the decision to avoid a contrail fee could be balanced against the costs of a carbon fee, if the prices can be set to reflect the climate impact of each.

Increasing cruise altitudes to fly above the contrail formation layer may also offer some benefit but there are problems. Some aircraft would not be capable of achieving these altitudes; for those that are, additional fuel is required in the climb phase to achieve higher altitude and as cruise altitude is generally selected for optimum efficiency, being forced to higher altitudes may also increase the fuel burn rate at cruise. Contrail and cirrus could form from aircraft flying through ice-supersaturated layers during their climb to higher altitudes. Of greater significance for very high altitude flights is the long lifetime of water vapour in the lower stratosphere. Condensation will not occur, but there will be a radiative impact from the accumulation of water in its vapour form.

4 ATM concepts and tools

A range of ATM options that may be included in future ATM strategies are currently in development. These include ground-, aircraft- and satellite-based technologies. The opportunities for direct application of these options to climate impact mitigation and indirect climate benefits from operational efficiency improvements are summarised in Table 1 and discussed below.

4.1 Enhanced navigation and surveillance

Research programmes worldwide are considering on-board and satellite navigation and communication technologies to allow aircraft to be controlled accurately and with high integrity in four dimensions. This would enable each aircraft to negotiate and re-negotiate a 4D flight plan in real time. Satellite navigation systems already provide a useful service for aircraft, particularly in areas where the ground-based navigation infrastructure is limited. However, the position data obtained by the aircraft is not exchanged with other aircraft or with the controller. Increased precision in navigation and improved data communication could improve situational awareness of both pilots and controllers and could potentially allow reduced separation minima (subject to wake vortex limitations). The increase in capacity this would deliver could enable aircraft to adhere more closely to environmentally preferred flight profiles, although environmental benefits would be negated if the capacity increase were used to accommodate growth in air traffic movements.

4.2 Pilot based autonomous control: conflict detection and resolution

One method to reduce controller workload is to transfer functions, especially conflict detection and resolution tasks, to the pilot. The concept of free flight, proposing the greatest degree of autonomous operations, has emerged in the USA.
Free flight envisages each aircraft negotiating with ground controllers and other aircraft to establish conflict free flight paths. Most negotiation will be carried out semi-automatically using new data links. In line with the US, free flight is also an aim of EUROCONTROL’s ATM 2000+ programme (EUROCONTROL, 2003). Crucially, in free flight airspace responsibility for aircraft separation is transferred to the pilots. Accurate and reliable displays of the position and intent of each aircraft will be required for use by other pilots and controllers. Current technology consolidates navigation and safety information as part of an aircraft’s flight management system, and enables it to compute an accurate preferred trajectory to optimize the operating airlines’ preferred procedures. In future, the aim is to provide information on the aircraft’s current position and that of other aircraft potentially in conflict. This information must be delivered with high integrity and reliability and an indication of the level of uncertainty.

Table 1: Summary of tools/concepts and their direct and indirect applications for climate impact mitigation.

<table>
<thead>
<tr>
<th>Reduced unnecessary flight</th>
<th>Climate mitigation applications</th>
</tr>
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| Navigations/surveillance  | • Improved direct routing routes  
|                           | • Closer adherence to preferred routes  
| Autonomous control        | • Option to accurately fly optimised routes  
|                           | • Increase in capacity at optimum flight altitudes  
|                           | • Flexible flight planning to avoid contrail  
| Conflict detection and resolution | • Option to accurately fly optimised routes  
| Resolution manoeuvres     | • Increased capacity at optimum flight altitudes  
|                           | • Flexible flight planning to avoid contrail  
| Highways                  | • Reduced planned diversions from great circle route  
| Visualisation             | • Flexible flight planning to avoid contrail  
|                           | • Option to accurately fly optimised routes  

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Enhanced surveillance methods could provide additional safety measures required to operate in a more flexible airspace. These systems, together with automated communications, will have profound impacts on ATM functions and working methods. Traffic will not be constrained to a fixed route structure with predictable congestion points and controllers will need to adapt to the dynamic assignment of airspace to traffic, and to take account of the interface between 'uncontrolled' and 'controlled' airspace (Majumdar et al. 2004).

The transfer of responsibility for separation will depend on universal uptake of satellite navigation and surveillance technologies and will require safeguards for responding to system failures. It would be unlikely to occur in the short term. Currently, the initial intent of an aircraft is described through clearances based upon the agreed flight plan. Improved knowledge of intent would be expected to improve the safety and efficiency of today’s system, but the effect on capacity is difficult to predict.

Greater autonomy should increase flexibility of en-route operations and improve user-preferred trajectories, increasing capacity and allowing fuel and time efficient operations with the minimum ATC constraints. Initial studies at EUROCONTROL indicated a 33% reduction in conflicts in a free routes environment, primarily from the dispersion of tracks. This could allow a greater proportion of aircraft to receive their requested flight level and reduce controller intervention, and increase overall sector capacity.

Reductions in conflicts will reduce in-flight diversions and so can be expected to have an environmental benefit, by reducing CO$_2$ emissions. In addition, increased precision navigation will improve the accuracy of environmentally preferred routes, whether for noise avoidance or for optimisation of climate impacts. With increased pilot autonomy for route selection, however, pilots will respond to airline cost and time pressures and incentives for environmental best practice will be required, particularly for non-CO$_2$ climate impacts such as contrail-cirrus.

4.3 Controller based tools: Conflict detection and resolution
The ability to predict and avoid potential conflict situations at an earlier stage could play a key role in improving efficiency, even when controllers remain actively in control of the airspace with little pilot autonomy. Early detection can reduce diversions in-flight, and could be significant for any scheme to optimise flight trajectories to minimise environmental impacts. Such measures could increase congestion, particularly if contrail avoidance is included in the optimisation. Medium term conflict detection would allow planning controllers to identify potential conflicts. Conflict resolution advisories will assist controllers in providing efficient conflict resolution, reducing their workload. Enhanced capabilities for conflict detection and resolution by controllers are likely to form a key part of the SESAR strategy for future European ATM and are also being explored for other regions.
4.4 Alternative resolution manoeuvres

Measures such as lateral offsets and speed controls to resolve conflicts between aircraft also have the potential to change the environmental impact of flights. Lateral offsets resolve conflicts by shifting an aircraft to a track parallel to its flight plan. This allows conflict resolution or avoidance using only small diversions from the initial route. Fast-time simulations have shown that this technique could resolve the majority of conflicts associated with forecast traffic for the congested core European region for 2010 and 2025 (Ehrmanntraut 2005). The effectiveness of manoeuvres such as lateral offset would be further increased by improvements in the precision of aircraft navigation as described above. Further fast-time simulations can be used to determine the relative fuel and emissions impacts of these options compared to resolution manoeuvres currently in use.

Speed controls have the potential to resolve a large fraction of conflicts, but are rarely applied in en-route upper airspace in Europe. A first assessment of their associated emissions has been made, and concluded that when traffic increases to double the base case (1997) scenario, the application of speed restrictions to strategically resolve conflicts could also offer reductions in emissions. Further assessment of environmental impacts (particularly compared to other resolution methods) is required (Ehrmanntraut 2005).

Speed controls could also be used to impose fuel efficiency measures on airlines. Improved understanding, by controllers, pilots and airline dispatchers, of the optimum operating speeds for aircraft in order to minimise fuel consumption could provide significant emission reductions. This is among the emission reduction opportunities identified by the International Civil Aviation Organisation (International Civil Aviation Organisation 2004). Optimising speeds for minimum fuel burn would increase journey times. While the cost of fuel provides a strong market incentive for airlines to minimise their fuel costs, pressures to reduce journey time and the associated operating costs are also significant.

As these measures could be applied using existing navigation and control technologies, their application to conflict resolution could come much sooner than some of the other measures outlined in this paper.

4.5 Highways

One innovative approach currently being researched is the introduction of dedicated ‘highways’ for air traffic, which would contain several lanes of air traffic travelling along parallel defined routes that are clear from other traffic (Guibert et al. 2005). These highways offer one approach to address the fragmentation of European airspace by providing blocks of airspace allocation according to their function, rather than to the conventional national boundaries. The intention is to separate high altitude, long distance traffic from other traffic using continental-scale specified routes which link sections of airspace. These would be designed to reduce en-route delay on highly trafficked routes by having fixed access and departure points and
procedures and strict constraints on aircraft types. The exclusion of crossing traffic would reduce workload and en-route delays and diversions associated with conflict resolution. These highways would be dynamically designed to optimise performance based on fuel efficiency and/or journey time, but there is additional scope to reduce the environmental impact on these routes by including an assessment of contrail formation conditions in the selection of the highway route and varying these based on ambient atmospheric conditions.

4.6 Visualisation
New visualisation techniques are required for controllers managing increasing numbers of aircraft. Current research is ongoing to develop new approaches to human machine interaction for controllers (Bourgois et al. 2005). Virtual reality visualisation tools are also under development, allowing dramatic changes to the conventional control screens and more manipulation of the field of view and the display, even by voice recognition.

Innovative research into visualisation systems for controllers could be adapted to facilitate the selection of environmentally optimised routes. The visualisation opportunities offered include overlaying weather data, potentially incorporating contrail formation regions and/or data on NO\textsubscript{x} emissions and impacts to aid in an environmental optimisation process, whether for real time control or for pre-flight planning. The effectiveness would depend on the availability of accurate, high-resolution data in a timely manner. This could also facilitate the design and selection of routes for highways.

The introduction of such tools would require improved understanding of human factors issues, including the ability of the controller to retain situational awareness in the event of system failure.

5 Science, policy and technology: developments required

This paper has reviewed key future steps in air traffic management that could contribute to mitigation of climate impacts. While these may be technologically feasible in the near-term, new technologies and practices could change safety culture (Henderson et al. 2005) and there will be a delay in implementation to ensure existing high standards of safety continue. Applying new ATM technologies for environmental benefit may also require complementary technological advances. Mapping and forecasting contrail formation regions are considerable challenges, given the difficulties in obtaining accurate observations of upper tropospheric humidity. But systems could be based on available technology. Best results for contrail reduction would be achieved using accurate global satellite observations with high horizontal and vertical resolution of relative humidity and temperature, but (for humidity particularly) such data is not available. Radiosondes can provide very detailed local
profiles, but the spatial extent of contrail formation cells can not be accurately determined in this way. One approach would combine data from satellites, ground based observations and on-board instrumentation and observations. Real time satellite photography could also be used, when coupled with traffic data and pilot observations to identify the altitudes at which formation was occurring. In fact, the easiest approach might be for pilots to communicate their visual observations of current conditions, as contrail formation from neighbouring aircraft are usually visible, but without an effective regulatory structure, cooperation would be unlikely as contrail avoidance routes would incur additional costs. These approaches, or a combination of them, would not provide complete contrail avoidance, but would allow subsequent aircraft on the same route to avoid contrail formation, thereby reducing the total climate impact.

A key challenge is that current metrics to contrast contributions to climate change are inadequate for assessing the impacts of aviation which clouds the policy debate (Forster et al. 2006). The most widely used measure is radiative forcing, which reflects the additional energy trapped in the climate system relative to a past date. While this is to a first order proportional to the global average surface temperature increase associated with a particular mechanism, it is flawed. Radiative forcing can represent the cumulative impacts of past emissions, for example by comparing the impact in 2005 of emissions of long-lived carbon dioxide from aviation over previous decades with the impact of short lived contrails produced in 2005. However, comparison of the impacts occurring in one year does not fully represent the longevity of future impacts or help to target mitigation measures effectively, and expressing the impacts as a single, globally averaged measure cannot contrast their very different spatial and temporal properties.

In parallel with the scientific effort to clarify techniques to compare the climate impacts within aviation and with those of other transport modes and other industry sectors, further research is needed to prioritise environmental impacts. Some measures to reduce CO$_2$ emissions can increase both NO$_x$ emissions and contrails. There are further trade-offs between climate impacts and other environmental issues including noise. These are key issues to resolve, as measures to reduce one environmental impact will often be compromised by pressures to reduce another, and these environmental trade-offs will also interact with a wide range of economic, political and social issues and priorities.

Induced demand represents a further problem. Increasing capacity can improve efficiency and deliver environmental benefits by reducing diversions and delays, but will lower airline costs, improve reliability and reduce journey times, all of which are likely to contribute to an increase in demand. If this is served by an increase in air traffic movements (rather than transition to larger aircraft or increase in the load factor), congestion and demand will again increase and the total climate impact of aviation will grow further.
6 Conclusions and research recommendations

Many of the new and innovative approaches to managing air traffic that are currently being researched could reduce environmental impact by:

• improving the precision of navigation to allow environmentally preferred routes to be flown more accurately
• reducing the reliance on conventional navaid routes to allow more direct, efficient routing
• integrating weather and emissions data into the decision making process more fully to allow pilots and controllers to cooperate in the selection of minimum impact routes
• minimising delays and diversions associated with airspace and airport congestion (such as hold-stacks) to reduce unnecessary emissions.

These emerging technologies offer new opportunities for the optimisation of routes to minimise environmental impact. Economic measures such as innovative approaches to route charging also have the potential to encourage environmental best practice by enabling external environmental costs to be better included in route planning. This is likely to be particularly relevant as pilots gain more autonomy over routing decisions.

Many of the new technologies for ATM are intended to accommodate continuing future growth. While some of those outlined here could contribute to the reduction of impacts per flight, dramatic improvements in environmental performance would be required to ensure that future air transport has a reduced total footprint compared to the present day. The focus of this paper is on potential new technologies and concepts for air traffic management and their possible application for environmental impact mitigation, but a successful reduction of (or even control of the growth of) aviation’s environmental impacts would require a suite of technological, operational and political measures and considerable international cooperation.

This paper has provided a qualitative assessment of the nature of the potential climate benefits associated with proposed ATM changes. A framework for the quantitative analysis of the environmental impacts of ATM tools and concepts in development is urgently required. This is a key research priority. Its development is particularly urgent for the European context, as strategic research programmes intended to set the agenda for future European air traffic management are already underway. As well as requiring detailed research into proposed ATM changes and the decision processes determining their introduction, a comprehensive framework to evaluate these measures from an environmental perspective needs research advances in:

Comparison metrics between climate impacts from aviation and between avia-
tion and other transport modes and industries
How climate impacts compare with other environmental impacts of aviation, including (but not limited to) the development of new techniques to place meaningful economic values on impacts and mitigation options
Understanding of the social and economic role of aviation and the distribution of both benefits and impacts.

Acknowledgements

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References


LONG DISTANCE TRAVEL IN EUROPE: THE POTENTIAL OF THE TRAIN

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Abstract - The increasing propensity of tourists travelling long distances imposes an increasing pressure on sustainability. This could be relieved by encouraging a shift from car and airplane to the more energy-efficient train. Two key studies provide an understanding about factors that condition the attractiveness of trains in international long distance travel in Europe. One study examines train use between the Netherlands and Germany, the other assesses the impacts of introducing high-speed train services between the Netherlands and Paris. The studies clarify that the attractiveness of the train can be enhanced by reducing need for transfers, increasing operating speed, suspending the obligation for seat reservation, operating more train services with high 'status' and asking price sensitive fares. Current developments in European train supply partly enlarge and partly reduce attractiveness. High speed and high status services are increasing, but this is also true for the need to make transfers and seat reservations. Fare systems become more complicated, where some travelers pay low fares and other high fares.

Keywords: attractiveness of the train, international travel demand, tourism, sustainability, climate change

1 Introduction

Tourism is a fast growing industry and the desire to travel more imposes an increasing pressure on sustainability. The number of holiday journeys is growing, tourists select more distant destinations, and they travel to an increasing extent with energy-inefficient modes. This is illustrated in Tables 1 and 2. Table 1 demonstrates the increasing travel volume and the shift to less energy-efficient modes in Europe. The CO₂ emissions shown in the table are related to both travel distance and travel time. The rationale of the latter is the assumption that travel time is an important factor in holiday destination choice.

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The CO\textsubscript{2} emission figures regard tourist travel and so they mainly relate to travel on longer distances. Regarding car, coach and train, the figures have considerably lower values than the more commonly quoted figures that relate to short distance travel. There are two reasons. First, vehicle employment in long distance travel—with high maximum speeds and little stops—leads on a balance to lower emissions per seat km. Second, vehicle occupation is higher in long distance travel, so reducing emissions per person km.

Table 2 demonstrates the growing travel distances for Dutch residents. Rough estimates of the average distance between home and holiday address range from 1050 km in 1990 to 1400 km in 2001. The rapid increase of travel by airplane—a typical convenient mode for long distance trips—suggests an increase in travel distances for residents of other countries, too.

<table>
<thead>
<tr>
<th>distance from Dutch border (km)</th>
<th>annual growth 1990-2001</th>
<th>market share in 2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 500</td>
<td>0.6%</td>
<td>34%</td>
</tr>
<tr>
<td>500-1000</td>
<td>0.9%</td>
<td>32%</td>
</tr>
<tr>
<td>1000-1500</td>
<td>6.8%</td>
<td>10%</td>
</tr>
<tr>
<td>1500-2000</td>
<td>4.1%</td>
<td>9%</td>
</tr>
<tr>
<td>2000-3000</td>
<td>23.7%</td>
<td>4%</td>
</tr>
<tr>
<td>&gt; 3000</td>
<td>8.4%</td>
<td>10%</td>
</tr>
</tbody>
</table>

Source: CBS, Statline database
This paper addresses the question how attractiveness of the train mode could be enlarged in European long distance travel in order to bring about a modal shift from car or airplane to train. This question is in line with the EU-policy that aims for revitalizing European railways (European Commission 2001). The focus is on international travel. It should be noticed that travel choices made for international trips differ from those made for domestic trips. The data of the Dateline-project, a survey of long distance travel behaviour of EU-residents in 2001-2002, show that the market shares of the train are considerably higher in domestic travel compared to international travel for all purpose/distance class combinations.

In this paper, long distance travel includes trips on distances exceeding 100 km. This is in line with the Dateline-definition. The paper discusses all travel purposes on these distances, not only travel of tourists. The reason is a practical one: separation of tourist travel from other purposes was not possible in some of the studies underlying the analysis. However, tourists are responsible for the majority of long distance journeys. When using the UN-WTO definition of tourists: persons making a journey with at least one overnight stay, either for leisure or business, tourists are responsible for 81% of all journeys >100 km made by residents of the EU (Dateline databases). The share of tourists in international long distance journeys is still higher: 94%. The figures are a bit lower for train travellers: 78% for all long distance journeys and 91% for the international journeys. Therefore, it is unlikely that the general findings for all travellers will not be valid for tourists.

The analysis of factors that mainly define the attractiveness of the train in long distance travel is described in Section 2. It is principally based on two studies that both relate to international travel to and from the Netherlands. In Section 3 the findings regarding train attractiveness are compared with the actual developments in European train supply.

2 Factors defining the attractiveness of the train

Nearly all studies on attractiveness of public transport relate to short distance travel, mostly travel in urban areas. Studies in long distance travel, and particularly international travel, are sparse. In this chapter two studies are discussed that together provide a good understanding about train attractiveness in international long distance travel. The first study examines travel behaviour of train users between the Netherlands and Germany. Travel behaviour is described by a direct demand model. The model is calibrated on revealed preference data in the period before high-speed trains (ICE) were running between the Netherlands and Germany. Therefore, the study explains attractiveness of conventional express trains. The second study assesses the impact on train demand of introducing high-speed train services between the Netherlands and Paris (called Thalys). This study is primarily based on stated preference data, collected by a survey of users of the Thalys and alternative
train and air services. It gives information about the additional factors that influence attractiveness of high-speed train services and is therefore complementary to the first study. Both studies relate to distances where the train is a viable alternative (<1000 km). They will be discussed next.

2.1 Modelling Dutch–German travel by train
Van Goeverden (1986) built a model describing train demand between the Netherlands and Germany in the framework of a cost-benefit analysis of two rail connections between the two countries. Both connections were threatened with closure and the model was used to estimate the impact of closure on train demand, passenger revenues and consumer’s surplus. A detailed description of the model in English is given by van Goeverden (2006).

Short model description
The model calculates train demand between two regions—located in both countries—as a function of regional volume factors and quality/price attributes regarding train and alternative modes. The general specification of the model is:

\[ n_{RS} = \exp(f_1(c_{RS}^t) + f_2(c_{RS}, c_{RS}^{a1}, c_{RS}^{a2}, \ldots)) \times P_R \times A_S \]

where

- \( n_{RS} \) : annual train journeys from region \( R \) to region \( S \) by residents of \( R \)
- \( c_{RS}^t \) : generalised costs of travelling from \( R \) to \( S \) by train (weighed sum of relevant attributes, including both monetary costs and other factors, like travel time)
- \( c_{RS}^{ai} \) : generalised costs of travelling from \( R \) to \( S \) by alternative mode \( i \)
- \( P_R \) : population of region \( R \)
- \( A_S \) : attraction of region \( S \)

In this specification \( f_1 \) describes the direct influence of the train attributes and \( f_2 \) the additive influence of competition of alternative modes. Only train demand of travellers living in either \( R \) or \( S \) is calculated. Persons living elsewhere are excluded. We call them “third travellers”. Also travellers that use non-regular tickets, like inter rail passes, are excluded. Though the reason is a practical one in that data about journeys with non-regular tickets were not available; the exclusion is also preferred from a methodological point of view. Persons travelling with rail passes may exhibit untypical travel behaviour, having already decided to travel by train. With respect to the aim of this paper, inclusion would create noise in the outcomes regarding
attractiveness of the train. The data show that third travellers, as far as they buy regular tickets, travel mainly between the large cities. We expect that this is also true for persons travelling with rail passes, most of them also being third travellers.

Calibration of the model is based on the observed train ticket numbers sold at Dutch stations for stations in Germany in 1983. These data are rather dated, which can be considered as a disadvantage. However, it is a minor disadvantage, because the basic determinants of travel behaviour, described by the parameters in the model, are highly constant in time. A check of the model using some recent data indeed gave no rise to the suspect that the parameters would have changed since 1983. Additionally, the old data have the clear advantage that high-speed services were still not running in the Netherlands and Germany. Therefore, they give unblemished information about attractiveness of conventional train services.

**Main influencing factors**

Calibration of different specifications of the model gave insight into which factors influence long distance international train demand significantly and which factors do not. Let us start with the latter, factors that have no significant influence:

1) Train frequency is not significant. This result could partly be due to a negative correlation between frequency and transfer numbers. A weak influence of frequency is contrary to results for short distance travel (see for instance Balcombe et al. 2004). However, there are good arguments that the influence is considerably smaller in long distance travel. Wardman (2004), who estimates a strong decrease of the valuation of headways at increasing distance, states that “travellers would not regard low frequencies to be unreasonable on long distance journeys” and “longer distance journeys tend to be more planned and hence the convenience of high frequencies is less important” (p. 371). We would add a third argument: waiting time due to a certain interval time between services will cover a smaller part of total travel time when distance and in-vehicle-time increase, so reducing the relative impact of frequency.

2) The attributes of the airplane are not significant. After definite calibration of the model, leaving out the airplane as an alternative mode, the model still does not overestimate train demand in relation to good air connections (like Amsterdam-Frankfurt) nor does it underestimate demand in relation to poor air connections. A possible explanation is that the choice between air and train is not based on the defined attributes but on other factors, for instance, distance. An alternative explanation is that the markets for train and airplane are strictly separated, at least for the range of distances studied (<1000 km). In that case mode choice might precede destination choice. The latter is supported by outcomes of the Dateline-databases, presented in Figure 1. Looking at the international graph (at the right), the market share of the train is fairly constant for distances up to 900 km (as the crow flies), despite a sharp increase of the airplanes market share at increasing distance. The latter is at the cost of the car’s share. The course of the
curves in the domestic graph (left) is differently. The increase of the airplanes market share stagnates between 400 km and 700 km. This could be due to competitiveness of high-speed trains that mainly serve domestic travel in this range of distances. This implies that high-speed train services are a real substitute for the airplane, unlike conventional express train services. Substitution between high-speed trains and airplanes will be examined in the next section.

![Figure 1: Modal split by distance in domestic travel (left) and international travel (right).](image)

Then we come to factors that have a significant influence:
1) Travel time and travel costs by train have together a very significant influence. The separate impacts of these distance-related variables could not be assessed because they are highly correlated. When extending distance by 10 km, assuming corresponding average increases in time and costs, the joined impact of both variables is a decrease in train demand of 2.5-3%. This is the direct effect. If costs or time of the train journey increase while those of the main alternative, the car, remain constant, the increased competitiveness of the car creates an additional indirect effect that decreases train demand further. This is explained in the next point.

2) The generalized cost ratio between train and car has a strong influence, suggesting that train and car are highly competitive. An increase of 10% decreases demand by 10-40%. Interestingly, the impact on demand is substantially lower for residents in North-Germany than for those living elsewhere in Germany or in the Netherlands.

3) The number of transfers has a strong and very significant influence. Adding one transfer to all services between two regions will decrease demand by 30-60%. Again the impact is smaller for the North-Germans. The large influence of transfer numbers is illustrated by Figure 2. The figure shows the number of Dutch residents travelling to Düsseldorf compared to those travelling to Cologne, separately for connections with an equal number of transfers to the two German cities and connections with one additional transfer when travelling to Düsseldorf. In both cases the five Dutch cities with the largest number of tickets
sold to both German cities are selected. One should note that also other differences in attributes play a role; these are especially in favour of travellers between The Hague and Düsseldorf (compared to The Hague-Cologne) and between Eindhoven and Cologne (compared to Eindhoven-Düsseldorf).

Figure 2: Dutch residents travelling in 1983 to Düsseldorf and Cologne on connections with equal number of transfers (left) and one additional transfer to Düsseldorf (right).

2.2 Impact of introduction of the Thalys service

In 1996 a high-speed train service was introduced between Amsterdam and Paris, called Thalys. Thalys trains provided 4 daily services between both cities and a frequent additional service between Brussels and Paris. The conventional express train services running from the Netherlands and Belgium to Paris were abolished except for the night train. Between the Netherlands and Belgium, the conventional and frequent “Benelux”-train service continued to be operated as an alternative for the Thalys. Initially the Thalys trains could run at high speed only on French territory, limiting the gain in travel time to 30-60 minutes. A few years later, the whole section Brussels-Paris could be operated with high speed, and shortly the trains will run at high speed along the whole route.

In contrast with the conventional trains, Thalys services seat reservation is obligatory. Additionally, regular tickets are not valid in the Thalys trains. Thalys introduced its own, rather complicated fare system with low fares for early bookings of return tickets and high fares for single tickets and late bookings.

Impact on train demand

HCG (1997) studied the short-term impacts of replacing conventional trains by Thalys on demand. The study is reported in English by Ettema et al. (1998). The method is a survey of both Thalys users and users of alternative train and air services. They observed a growth in train demand between the Netherlands and Paris of 27%, mainly due to Thalys introduction. Selecting the trains at daytime, the night
service was not affected by Thalys introduction, Thalys induced a growth of 30%. However, a survey of Thalys passengers indicated that about half of the passengers would not have travelled by train if the Thalys service had not been introduced. So, the new market created by Thalys is substantially larger than the total growth in train demand. This means that the train also lost a substantial part of the old market (Figure 3). The calculated loss is one third of the old market, though the margins of this figure could be rather large.

![Figure 3: Train patronage at daytime between the Netherlands and Paris in 1996-1997 after continuation of conventional services (estimated by HCG) and after replacing them by Thalys (observed).](image)

A considerable part of the new passengers (45%) indicated that they would otherwise have travelled by airplane. Contrary to the findings mentioned before regarding conventional train services, high-speed trains seem to be competitive to the airplane. Also competitiveness with the car is high: 35% of the new Thalys passengers would otherwise have travelled by car. A smaller share of the new passengers would have travelled by bus (10%), the remaining 10% would not have made the journey.

Strong competitiveness of high-speed trains to the airplane is also found in studies relating to domestic travel (see for instance Bonnafous 1987 for the TGV Paris-Lyons and Pintidura 2003 for the AVE Madrid-Sevilla). Presumably potential air travellers consider high-speed train services as a serious alternative unlike conventional train services.

An interesting result is the small volume of induced travel (10% of the new market and only 5% of all trips made by Thalys). It should be noted that these figures reflect the short term effect of a modest speed increase. In the long term the share of generated trips could increase, in particular when a larger part of the route will be operated at high speed. Still we expect only a limited increase of the share of induced trips. The main argument is that for those travelling between the Netherlands and Paris, the Thalys is not essentially faster than the fastest alternative, the airplane.
Main influencing factors
The main reason for travelling with Thalys, mentioned by Thalys passengers, is shorter travel time (HCG 1997). Persons that continued travelling using conventional trains mentioned the need to make seat reservations, ‘timetable’, and price as important reasons for not travelling with Thalys. The ‘timetable’ argument might relate to the much higher frequency of the conventional Amsterdam-Brussels services (serving rather short distance connections where frequency plays a more important role) or the possibility to arrive early in the morning in Paris or Amsterdam using the conventional night train. Seat reservation obligation is by far most mentioned by frequent travelers, timetable is most mentioned by non-frequent travelers. Price is third in importance for both groups. Air travellers mentioned travel time by far the most important reason for not travelling by Thalys.

Reasons why former train passengers have been lost are not examined. We hypothesize that need for seat reservation is at least an important reason. Obligatory reservation reduces the number of travellers in two ways. First, travellers may dislike making reservations before and decide not to travel by train. Second, the train company may refuse train access because no unreserved seats are left. From the traveller’s point of view, the first reason could be indicated as active choice, the second as passive choice. Terabe and Ongprasert (2006) demonstrate that obligatory seat reservation combined with insufficient train capacity is applied worldwide and that in some cases a considerable number of seat reservation requests are rejected. Based on the author’s experience and what he learned from others, the latter might also be true for the Thalys.

Attempts to simulate the observed growth in train demand by the models described in Section 2.1 give rise to the supposition that there is an additional factor, not mentioned by the travellers, that makes the Thalys service more attractive. The growth computed by the models, based on travel time reduction, was always less than half of the observed growth. We hypothesize that high-speed services like the Thalys gain a special ‘status’ that attracts more passengers, apart from the real time reductions. Train status could be a factor that makes trains competitive to the airplane.

2.3 Conclusion regarding main factors influencing train attractiveness
In summary, the analyses demonstrate that demand for international long distance travel by train is very sensitive to a number of variables. The most important variables are number of transfers, travel time, obligation for seat reservation, train status, and price. Frequency of services is less important in long distance travel.
3 Developments in long distance train supply in Europe

International long distance train services in Europe are liable to continuous changes. During the last 20 years the changes have been accelerated. Comparing the timetables, the following major changes can be observed:

1. An increasing number of high-speed services are operated, mainly on domestic connections at medium distances (300-600 km). In most of the large European countries high-speed services are provided. The Thalys is the most striking example of international high-speed connections, connecting four countries.

2. Long distance train supply is becoming more fragmented. The rather homogeneous supply of express trains with a fairly transparent European fare system is being replaced by 'special' services that promote themselves as an outstanding product, thereby neglecting their role in the ‘whole’ railway system. These services have their own fare system and often seat reservation is required. Sometimes seat reservation is encouraged by offering considerable fare reductions if seats are reserved in advance.

3. Direct long distance services between countries are disappearing. The withdrawal of very long distance services started many years ago, due to the intense competition of the airplane. Recently, removal of through services has been accelerating. For instance, the Netherlands lost in a few years all direct train services to Denmark, Austria and Italy (Figure 4). Though it sounds contradictory, extension of high-speed services is one of the factors behind cutting long distance services. If a high-speed line is built, serving part of a long distance route, usually services are split up into different parts, one served by high-speed trains and the other served by conventional trains. Operating the whole route by high-speed trains is not cost-effective, because it needs expensive trains running at low speed over a considerable distance.

Figure 4: Daily long distance train services to the Netherlands in 1986 (left) and 2006 (right); thickness of the lines corresponds to frequency, dashed lines indicate seasonal services.
4. Services are being concentrated on certain corridors. This makes the timetable more transparent and raises frequency on these corridors. However, it also increases the need for making transfers. In the Netherlands, all international express train services have been concentrated on the routes to Amsterdam. As a consequence, large cities like Rotterdam and The Hague have lost their frequent direct services to Germany.

5. Train services are operated to an increasing extent with fixed headways ("Taktfahrplan"). This enlarges transparency of the timetable as well.

Comparing the described developments with the variables that define the overall attractiveness of the train, one can conclude that some developments affect attractiveness of long distance services positively and other negatively. Favourable developments are travel time reductions and increasing train status, both due to expansion of high-speed train services. Unfavourable are the increase of the need to make transfers due to cutting long distance services and concentration on corridors, as well as the increasing need to make seat reservations. Also the complication of fare systems may be considered as unfavourable.

4 Conclusion and recommendations for further research

The paper assesses the main factors that define the attractiveness of long distance train services. A large majority of travellers on long distances are tourists (as defined by UN-WTO). The main factors explaining attractiveness are travel time, number of transfers, obligation for seat reservation, train status, and price. Additionally, train demand is sensitive to attributes of the car as an alternative. In the case of high-status trains this is also true for the competing attributes of the airplane. No significant influence on long distance train demand could be assessed in relation to frequency of services and, as far as conventional train services are concerned, attributes of the airplane.

Current developments in long distance train supply both enhance and reduce the attractiveness of the train. Positive developments are faster journey times of train services and increasing provision of high status services. Negative developments are the increasing need to make transfers, extended obligation to make seat reservations, and complication of fare systems. In particular seat reservation obligation affects train attractiveness seriously: it creates uncertainty about the possibility to travel by train. European policy makers who aim to revitalize European railways should be aware of the negative developments and seek measures that reverse these, thus maintaining the positive developments.

It would be useful to give more attention to long distance travel in transport research. For the sake of efficiency it is advisable not to exclude the relatively small group of non tourists in the analysis. When a distinction between tourists and non
tourists is made, separate results for both groups will be produced. Additionally, it is advisable to distinguish between domestic and international journeys; both kinds of journeys seem to obey to different ‘travel laws’. Next we propose some train related issues that deserve further research.

Firstly, calibration of the model describing train demand between the Netherlands and Germany should be repeated, using recent data. The more regular train supply, due to fixed headways and concentration of services in corridors, will facilitate the assessment of weak influences like that of frequency, because it reduces the variation of train attributes on the separate connections. Model calibration should be extended to travel between other countries and to long distance travel within countries.

Secondly, research dedicated to the impact of both seat reservation obligation and train status is important. There is hardly any knowledge about these variables. The research of the impact of seat reservation obligation should include both active and passive choices. It should be done for several connections because capacity shortage, the direct cause of the passive choice, may vary substantially.

Thirdly, studies that investigate the impacts of replacing conventional train services by high speed services should pay attention to possible negative impacts on train demand. To what extent will former travellers be lost and which are the factors behind?

Finally, personal modal preferences should be investigated. There are indications that conventional train and airplane are separate markets which would imply that modal choice precedes destination choice. To what extent is mode choice in long distance travel based on personal preferences (or preferences of households) rather than on modal attributes?

The databases of the Dateline-project can be helpful in analysing the first and last research questions. For both questions, attribute data of all relevant modes have to be added to the trips and journeys that are recorded in the databases. Enrichment of the databases with these data will create a powerful tool for different kinds of analyses of European long distance travel.

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THE ROLE OF SCHEDULED BUSES IN REDUCING CAR JOURNEYS IN TOURIST AREAS

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Abstract - This paper examines the role of local bus services in reducing car use at tourist destinations. It concludes they are an essential element in cutting the local and global environmental impact of tourist and leisure travel, as most leisure trips are currently relatively short and car-based. Using data collected from nearly 3,000 bus passengers in 18 tourist areas of the UK and qualitative data collected through in-depth interviews in Northern England and Pembrokeshire, South Wales, the paper describes the characteristics of people who use these buses although they have a car available. It outlines how they use these buses, their choice sets if the bus had not been available and why they choose buses rather than cars for their trips. The research indicates a number of ways that bus services can attract more day visitors and holiday-makers, so reducing the environmental impact of tourist travel and enhancing the tourist experience.

Keywords: Scheduled bus, modal shift, tourist destination

1. Introduction

Mobility has long been recognised as a core element of the tourism system, yet it has rarely been the subject of detailed critical analysis (Hall 1999), despite over two decades of discussion as to how we might make tourism more sustainable. Recent work has focused on the journey to and from the tourist destination particularly the intensity of externalities associated with air travel (Janic 1999). However, most tourism and leisure trips involve surface transport and occur nearer to home (Department for Transport 2005, Peeters and Schouten 2006). The high levels of car use for leisure journeys are a compelling reason to investigate how to reduce the carbon footprint of the day and staying visitor while at the destination (Lumsdon et al. 2006).

There has been renewed interest in reducing car use in urban areas, both to reduce the environmental impact and to make cities more attractive to visitors

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and residents. For example, many European cities, such as Amsterdam, Budapest, Copenhagen, London and Rome use buses as part of an integrated transport network. Nevertheless, the use of the car for tourist travel is still largely overlooked by researchers, neither have they investigated the advantages of other means of transport, such as walking, cycling or the bus over car-borne tourism transport in any detail. At a destination level, bus travel offers, in many cases, the most readily available alternative to car travel and improving bus services to meet the travel needs of tourists and day-visitors can reduce local congestion and pollution, as well as contributing to the reduction of global climate-changing emissions (Black 2004).

This paper reports on research conducted in the summer of 2005 into the use of scheduled buses in tourist areas in the UK. It focuses on the minority of respondents who had a car available but chose to use local buses and presents the evidence gathered in a survey of buses in 18 tourist areas as well as in-depth interviews conducted with visitors using buses in three of these areas. It argues the case for designing bus travel as part of the tourism transport system at the destination (Page 2004) and sets out a research agenda to help achieve this.

According to Mintel (2003) the bus and coach sector remains a neglected area in tourism research. Accounting for 9% of all passenger-km in the wider European Union (EU25), it represents a higher proportion than rail or tram and metro systems (European Commission 2005). Although bus and coach travel are frequently bracketed together, this paper focuses solely on local, regular, scheduled buses operating between villages and towns and in major urban areas and does not investigate express coach services or coach excursions and holidays.

The role of the bus as an integral element of the urban transport network has encouraged modal switch in many EU countries, attracting increased and sustained patronage over the past 20 years as in Portugal, Spain, Austria and Denmark. This has not been the case in the Netherlands, Finland and the UK where the decline of bus patronage has mirrored the growth of car trips for short distances (European Commission 2006).

The provision of tourist transport at the destination is not well documented in the literature. Although experience in the UK suggests that it forms an important part of the business for most bus companies, the percentage of trips being made for tourism and leisure purposes at each locality is not known. The British 2005 National Travel Survey (Department for Transport 2006) found that leisure travel accounted for ‘just under a third (31 per cent) of all trips in 2004’ and 40% of the distance travelled in 2004. Car travel accounts for 70.2% of the trips and 82.1% of the distance travelled for leisure, while the corresponding figures for local buses are 4.6% of the trips and 2.0% of the distance (Department for Transport 2006). This illustrates the potential for reducing car travel if even a small percentage of car users transferred some of their leisure travel to public transport.

Generally transport and tourism providers have failed to understand the role of buses as an integrated element of visitors’ transport and tourism experience of
a destination (Lumsdon 2006) despite many examples of good practice such as the ‘hop on hop off’ city buses found in many large and some smaller historic cities. There have also been a number of EU projects which have attempted to demonstrate modal shift for all purposes, such as the MOST project (Mobility Management Strategies for the Next Decades) which included tourism projects in Bremen, Malaga, and Zug (Wilhelm 2003). Other examples include the MobiHarz project in Germany and the Sanfte Mobilitaet project for car-free tourism resorts in the Alps (Hoenninger 2003, Holding 2001). Each case study provides insights into the barriers and incentives associated with modal switch in tourist areas, for example, the need to build confidence in public transport through reliability and the range of provision. These projects clearly highlight the need for more detailed understanding of visitor expectations, particularly of those with a car available for their leisure trip. One of the objectives of this study of buses in tourist areas in the UK was to examine the expectations of different user segments, including those who had a car.

2. The Research

Tourism on Board is a research project co-ordinated by the University of Central Lancashire in association with a group of local authorities, national parks and the Youth Hostels Association. The research aimed to produce evidence of how bus services were being used in these tourist areas and whether the bus services were encouraging modal shift away from car travel. It is, as far as we know, the first attempt to measure these effects across different areas of the UK.

The bus services surveyed, selected by the collaborating authorities, were usually services subsidised by the authority and intended for leisure use, although most also carried local people travelling for utility purposes, such as shopping and work. They provided access to a range of mostly rural tourism destinations such as mountains, the coast, historic houses and monuments.

This paper reports on the respondents who were using the bus although they had a car available. As well as the quantitative findings, it analyses their open comments and qualitative data collected from in-depth interviews held with bus users both in conjunction with the Tourism on Board research and from an independent research project conducted by one of the authors, also in the summer of 2005, into bus users in the Pembrokeshire Coast National Park.

3. Methodology

The survey, designed by the University, was conducted on designated buses in each tourist area on three days in August 2005. The respondents were handed the
survey form on the bus by a surveyor, who also collected completed forms. Those unwilling to complete the survey during their bus journey could return the form in a pre-paid envelope, along with a second form asking them about their itinerary and expenditure for the day. In total, 2,997 survey forms were returned, a response rate of 45.7%.

The quantitative data for the 836 respondents (29.6%) with a car available were compared with those for the other respondents using Mann Whitney U and Chi tests in SPSS. In addition, the open comments made by respondents were analysed according to their themes such as fares, information, driving, using Excel.

The Tourism on Board research included 10 semi-structured telephone interviews conducted with respondents who had used buses in the Lake District and Hadrian’s Wall areas of Northern England. The in-depth interviews with holiday-makers using buses in Pembrokeshire, South Wales were conducted in person and by telephone after recruitment on buses and through a letter enclosed with requested timetables. This paper draws on the data provided by the 5 bus passengers from Northern England and 18 from Pembrokeshire who had a car available to them when they used the bus. All the interviews were recorded, transcribed and analysed using template analysis.

4. Results

Those with cars available are most likely to be aged between 35 and 64, while younger people and those aged over 74 are less likely to have a car available. A slightly higher proportion of men (32.2%) had a car available than women (24.4%) but this is also related to differences in the age profile. People travelling in larger groups are more likely to have a car available to them; only 17.9% of people travelling alone had a car available, but 30.2% of people travelling in pairs had a car available.

There is another group of 242 respondents (8.1% of all respondents) who did not have a car available because they were ‘on holiday without a car’. Over half of these (53.9%) were overseas visitors, 42 of whom were from continental Europe, predominantly Germany, and 35 were from North America. As Figure 1 demonstrates they have different age profiles, with the majority of overseas visitors being under 45 and the majority of the UK passengers being over 45 years old.

The main journey purpose for all passengers was (recreational) ‘walking’, but a greater proportion of those with a car available were using the bus primarily to get to or from a walk (Figure 2). Most of the tourist or leisure trips lasted several hours, involved stops for refreshment, changing mode and included spending an average of £16.18 per person (23.35 Euros).
The question, ‘Are you using a bus because...?’ focussed on the choice of mode. Here again, the main reason was for (recreational) walking, for all respondents, but a higher proportion (43.5%) of those with cars available gave this answer than those without a car available (32.5%). The next largest difference was for ‘better for the environment’. While only 7.3% of those with a car available gave this reason, 17.4% of the respondents without cars did, possibly because this group includes people who are ‘car-less’ for environmental reasons. Thus, it appears that personal benefits, rather than environmental concerns, generally motivate people with cars available to use buses in tourist areas.
Figures 4 and 5 show the different responses from people with and without cars available to the question ‘What would you have done if the bus had not been running today?’. People without a car available are much more likely not to travel at all if the bus is not available or to change their destination to one accessible by bus. People with cars are most likely to visit the same or another destination by car (41.8%), an indication of the importance of the bus service in reducing car use. 13.4% of those with cars available would go to another destination by car, suggesting that the bus influenced their choice of destination in addition to their mode.

**Advantages offered by Buses over Cars**

The clear advantage to recreational walkers of using a bus is that they do not need to return to the same point to collect their vehicle; this frees them to do a longer distance in one direction, without having to retrace their steps, find a suitable circular route or use two cars. This is particularly important when the chosen path is linear such as along a river, coast (as in Pembrokeshire Coast National Park) or Hadrian’s Wall, a Roman defence stretching across Northern England.
Our group would have had to have taken two vehicles out if the bus had not been available. It enabled us to spend the whole day walking in one direction and see a welcoming bus at the end of our walk.

The advantages of not having to drive included: being able to see the views, especially when using a double-decker or open-top bus, not having to drive along narrow or unfamiliar roads and, occasionally, avoiding congestion or difficult parking.

Figure 4: Alternatives for people without a car available.

Figure 5: Alternatives for people with a car available.
...at 70 years old we don't want to be driving all the time

For some of the respondents, who normally relied on cars, a bus journey was a novelty, particularly if they were young or were accompanying children. Open-top buses had a special excitement and many passengers appreciated the local knowledge from the driver or guide on the bus.

Although the survey found that car users were less likely to be using buses for environmental reasons than those without a car available, it is evident that some car users are happier not to use their car, especially in areas where they were aware of the problems caused by traffic.

_The bus service is reliable, clean and comfortable. I use it instead of my car for convenience and less pollution to the environment._

_It's not a very nice environment to have hundreds of thousands of cars charging round on a Bank Holiday in a prime tourist area so I don't particularly want to contribute to that…_

**How Buses might be made more attractive to Car Users**

People with cars available tended to give higher scores for the bus attributes than people without cars available, possibly because they had made a deliberate choice to use the bus while those without cars might consider themselves a ‘captive audience’.

‘Frequency of service’ received the poorest scores in all areas in a list of attributes in the survey, but had the greatest difference between those with and without cars available. The comments indicate that frequencies of over an hour cause frustration and inconvenience leading some bus passengers to return to their cars. Another problem for bus users was that the length of their day was dictated by the bus operations, often the first bus left too late and/or the last bus left too early to give them sufficient duration of stay at the destination. This is particularly frustrating in summer when the northern latitudes bring daylight until late evening. Unreliability and worries about unreliability create stress, particularly for people who are unfamiliar with the area or service, where it stops or who are using the bus for the first time.

Visitors and infrequent users required information about bus schedules, fares, days of operation and the location of bus stops. They became frustrated when they could not find that information, but exasperated when it was misleading. Many also commented that better information and marketing would encourage more people to use the service, making it more efficient and possibly reducing car use in sensitive areas. Getting information from outside the area could be a problem especially if you wanted the information to help you choose where to go.

Feelings about fares were mixed. Rover tickets and family tickets allowing unlimited travel in a set time period or reduced rates for larger parties were generally appreciated. The introduction of free bus travel for Welsh people over 60 was
welcomed by those who qualified. There was resentment where the host destination did not honour concessionary rates for visitors. Some respondents felt that fares should be set to make public transport more attractive than car travel, while others were more concerned that the service should be financially viable.

Most of the comments about staff attitudes were positive and emphasised how this had enhanced the journey, occasionally encouraging repeat journeys. However, some bus drivers seemed not to care about their passengers, either by their attitudes or driving and this detracted from the experience and might put off potential passengers.

There were complaints about the comfort and cleanliness of some buses and a few respondents made the point that seeing the countryside was part of their day out and could be spoilt by bad driving. Some respondents were concerned about the poor image that buses gave to prospective passengers.

_The driver drove much too fast over narrow winding roads so we did not enjoy the scenery. This bus does nothing to get people to use them into the National Park. It is old, uncomfortable, the driver is monosyllabic. If we want to get people out of their cars we need to sell these services to them by advertising smart buses and good service. Add a bit to the price if necessary, but sell it to the people, don't make it look like the poor man's substitute for a car._

People who had come on holiday without a car needed transport for all their needs, including reaching their accommodation. Several suggested that they had chosen that area for their holiday because they knew there were buses available.

_We love the bus service, we wouldn't come to the area without it._
(Visitor from USA)

### 5. Discussion and Conclusions

**The relevance of short leisure trips to Climate Change**

With leisure travel accounting for nearly a third of all trips and 41% of distance travelled in Great Britain, it clearly has a large and growing impact on both local and global environments. Given that mobility at a destination is an essential part of tourism and part of the appeal of day trips from home, their impact might be reduced if visitors could be encouraged to switch modes. Some of these car trips could be substituted by walking or cycling, many may be more suitable for public transport and local bus services will often be the most appropriate alternative. However it is only possible to reduce car use for leisure trips if the alternative is acceptable to at least some car users.
This paper investigated the motivations and characteristics of people who chose to use buses in tourist areas although they had a car available at the time. It is the starting point of understanding the potential of local public transport to help reduce the environmental impact of car-borne leisure trips, by encouraging modal shift.

From the results, it is clear that there are segments of the leisure trip market who will respond to different forms of incentives. For some car users, the ability to make linear walks is predominant, while, for others, the inducement may be the views from a double-decker or open-top bus or not having to drive in an unfamiliar area. Some car users are also open to environmental arguments for catching the bus, especially when they relate to the local environment.

Different barriers may be deterring different sub-segments of the potential market. Clearly information and marketing are critical factors in attracting car users, but worries about unreliability, a low frequency of service and a short duration at the destination are also deterrents. For another group, the relative costs of car and bus travel are important.

This research found 8.1% of respondents were on holiday without their car, half of them from overseas. This implies that the provision of local transport can actually reduce long distance trips to the holiday destination area, something that would need to be included in any environmental/economic impact assessment of these bus services. Of the people using the buses surveyed 29.6% had a car available and personal benefits, rather than environmental concerns, motivated most car users to use these buses in tourist areas. The research also found that provision of buses:

- reduced the number of car trips,
- meant that people without cars could access tourist areas and
- influenced where people chose to go for day trips and holidays.

The research also found that bus passengers brought spending to the local economy, some of which would be diverted if the bus service were not provided (University of Central Lancashire 2006). These benefits should make the provision of bus services for visitors and tourists an attractive option for destination areas, but more research is needed to determine optimum frequencies and windows of operation. Downward and Lumsdon (2004) suggest that one reason for bus passengers spending being less than car-borne visitors is that their duration of stay is restricted by the bus schedules, not allowing them to stay for a drink or evening meal after the day’s activity.

**Further Research**

Given the relatively modest expense and effort involved in providing and improving these bus services; it seems incomprehensible that they are largely ignored both by policy makers and researchers as a way of reducing the environmental impact of leisure travel. Possibly their role in reducing the scale of the problem has been
overlooked because they are not seen to provide a ‘total’ solution, although there is an absence of alternative policies.

‘The problems caused by car use in the countryside are colossal, and continue to increase. Huge problems such as congestion, pollution, energy use and CO₂ production will not be affected by modest public transport initiatives. (our emphasis)

(Red Kite Environment Ltd and Countryside Training Partnership 2004)

Several of these recreational bus services face threats to their funding, often decided on the ratio of subsidy to fares generated (Reeves 2006), rather than their effectiveness at reducing car use, their potential to do more, the spending generated in the area and their contribution to social inclusion, thus making it harder to make leisure trips without resorting to car travel. An alternative model for attracting visitors through greater spending on ‘public goods’ such as transport is offered by Switzerland (OECD 2000) where one third of passenger kilometres are travelled by public transport or non-motorised modes (Swiss Federal Statistical Office 2006). Research into the effects of ‘soft measures’ for utility travel estimates that they could reduce car travel by 11% (Cairns et al 2004). The possibilities for short leisure trips may be even greater, given the flexibility of destination and relative lack of time constraints, but it would need more data collection to verify this hypothesis.

One line of enquiry is investigation of the ‘pathways’ to using local bus services. The interviews undertaken in 2005 discovered several ‘pathways’ involving decisions at different stages, from the people who chose their destinations because of the bus services available, to others who spontaneously decided to use the bus on seeing it. Identifying different ‘pathways’ should help inform effective strategies for marketing intervention at important decision points. Although we only have anecdotal evidence from respondents’ comments, it seems that some people, once they have experienced a good public transport network in a destination area, will consider using public transport to reach that area on a return visit, meanwhile, others who experimented using buses for day trips reported that they would travel by car for future visits. This suggests that the quality of the initial experience may influence travel decisions for a long time.

Future research also needs to investigate the attitudes and requirements of car users not currently using public transport for leisure trips. It is quite possible that distinct markets exist for walking/cycling trips, for scenic trips or to places where it is difficult to drive or park cars. Several respondents said they tried to use their car as little as possible once they reached their holiday destination, future research should address the barriers they perceive in using public transport to reach that destination area. The potential for mode shift for long distance trips to holiday destination areas, already achieved by 8.1% of the respondents, needs further research: it may well be that removal of a few barriers in service or information
could achieve a disproportionally high reduction in car miles. The research also highlights the specialised market for visitors from overseas, many of whom may prefer not to bring or hire a car while they are in the UK because of driving on the left and unfamiliar traffic regulations. They may require information about public transport availability before they arrive, as well as reassurance that they can reach their accommodation and destinations using public transport. Tourists who rely on public transport generally require a denser, more frequent network of services than people who use public transport only when it offers advantages over car travel. They also need pre-knowledge that they can get around once they arrive as well as making the utility trip from rail/coach head to their accommodation. While there are obviously many people who are wedded to the convenience and flexibility of car travel for leisure trips, the research shows that there are segments of the leisure-travel market who perceive advantages in using public transport for day trips and once at their holiday destination. A quality transport product, with a reliable service and good marketing and information can attract some of these people from their cars and may in time encourage some of them to use public transport to reach their holiday destination, whilst providing leisure opportunities for those without cars and generating local spending.

In conclusion, a high proportion of leisure travel is short car journeys. If the environmental impact of this is to be reduced, alternatives including local bus services, have to be made attractive to car users. This research found that local bus services in tourist areas already carry car users, most of whom are using the services to access recreational walking. It identified the advantages that bus travel offers over car travel and several barriers to its use. More detailed research is needed to understand better the behavioural patterns which underpin modal switch within the leisure context.

References


MITIGATION OPPORTUNITIES IN PORTUGUESE HOTELS UNDER A WARMING CLIMATIC TRENDS

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Abstract - Portuguese hotels typically spend nearly one third of their energy consumption on space conditioning. Mitigation of greenhouse gas emissions is necessary, but has to be balanced against the tourist’s comfort levels. Meanwhile, the nature of this challenge is being altered under a warming climatic trend, mostly through the impact of changes in temperature and average levels of solar radiation. These effects were analysed using a numerical simulation model representative of a Portuguese 4-star hotel. Simulations were done for the two most popular tourist locations taking into account their different climate conditions. Results show that, by the end of the century, climate change will increase the energy demand for space conditioning, because the increase of cooling energy demand will outweigh the decrease of heating energy demand even when more efficient technological scenarios are considered. Retrofitting of existing facilities and stricter building regulations might be required, in order to achieve actual mitigation of space conditioning related emissions from Portuguese hotels.

Keywords: Energy demand, HVAC systems, Hotels, Climate Change, Portugal

Introduction

As large energy consumers hotels are viewed as a primary target for greenhouse gas (GHG) emission mitigation schemes. This can be achieved through (1) the use of renewable energies (e.g. for swimming-pool and water heating), (2) the use of more efficient equipment, for lighting and heating, ventilation and air conditioning (HVAC) systems and (3) upgrading the thermal performance of the buildings themselves. All this has to be carried out under the constraint of retaining the high comfort standards of tourist facilities.

Currently, about 21% of the energy spent in hotels is on space heating, while only 5% is spent on space cooling (see Figure 1). So, under a warming environment in order to reach the same indoor thermal comfort level one would expect to use
less heating and thus minimise their greenhouse gas emissions.

However, the final energy consumption balance depends on many factors. The timing and magnitude of changes in temperature and solar radiation are key factors that could increase the annual energy consumption for HVAC. Furthermore, considering the time scales (i.e. 25 to 100 years) at which climate change may occur, other factors like hotel occupation levels and technological advances could also have a significant role.

![Figure 1: Final uses of energy at 4-star Portuguese hotels.](image)

Within the SIAM Project – Climate Change in Portugal: Scenarios, Impacts and Adaptation Measures – the effects of climate change on the thermal performance of various types of buildings were reported (Santos et al. 2002). SIAM collected data for climate change and socio-economic scenarios for Portugal. It also provided integrated information on the vulnerability of ecological systems, human health, water resources, coastal zones, forests and biodiversity, agriculture, fisheries and energy production/consumption. The study analysed and proposed adaptation options for each sector and was connected to the official Portuguese action plan on climate change (PNAC 2002).

The SIAM impact and adaptation studies for the energy sector included responses of both residential and service sector buildings. More recently we also investigated the impacts on hotels. The latter results and their implications for mitigation are presented in this communication. The study approach was to numerically simulate the energy consumption of a representative hotel under different climatic and socio-economic scenarios. Simulations were conducted for hotels located in the two most popular tourist areas in Portugal, namely: the Algarve which is the southernmost region of continental Portugal and the Atlantic central West coast, near Lisbon.

The Algarve has a Mediterranean climate while the Atlantic central West coast, is a somewhat colder and less sunny region, but still with a mild temperate climate even during the winter.
2 Representative model of a Portuguese hotel

Portuguese hotels are major consumers of energy and one of the building classes with the highest specific energy consumption: typically between 220-290 kWh/m² and 42-89 kWh per tourist night. Although these values can vary, they reflect the need to achieve high comfort standards for hotel guests, particularly through the use of HVAC systems which, as indicated in figure 1 represent 31% to 33% of the overall energy consumption of hotels in Portugal (Gonçalves 1999, INE 1999).

In absolute terms, these buildings are also major energy consumers. Four-star hotels use between 500 and 7500 MWh/year with most using between 1000 and 3000 MWh/year. Five-star hotels use about 3 to 11 GWh/year with most using between 3 and 6 GWh/year. Furthermore, all scenarios assessed in previous studies point to increased tourism activity and consequently an increase in the number of hotels and higher hotel occupation levels in Portugal.

The Portuguese building regulation (RCCTE 1990, RCCTE 2006) divides the country geographically by climate characteristics into 3 winter regions (I1, I2, I3) and 3 summer regions (V1, V2, V3). Most hotels and tourist areas are located near the coastline and fall into climatic regions 1 (I1 and V1) and 2 (I2 and V2).

Figure 2 shows the distribution of 4 and 5-star hotels by climatic region and indicates the main tourist destinations in each region (Gonçalves 1999). The I1 V1 (continental Portugal only) and I1 V2 climatic regions were selected for the study, representing the Algarve and Atlantic central West coast.

![Figure 2: Distribution of 4- and 5-star hotels examined, per climatic region of the 1990 Portuguese building code, and indication of main tourist destinations.](image)

Figure 3 presents the assembled hotel model conceived based on surveys by Gonçalves (1999) and it was used here to be representative of a typical 4-star hotel.
floor. This model consists of 12 rooms with exterior facades oriented to N, S, E, and W, separated by corridors. All rooms have a floor area of 24 m\(^2\) and window panes of 2 m\(^2\). The social area (e.g. hotel lobby, dinning rooms and conference rooms) occupies 100 m\(^2\) and has window panes facing all orientations, totalling 12 m\(^2\). The total hotel floor area simulated was 436 m\(^2\) of which 288 m\(^2\) were bedrooms, 100 m\(^2\) social areas, and 48 m\(^2\) corridors.

![Diagram of the simulated hotel.](image)

The operation characteristics of the hotel are shown in Table 1. These correspond to typical features and constructive characteristics of current hotels in Portugal. A detailed description of these parameters can be obtained from Santos et al. (2006). These were slightly adjusted to obtain an energy demand for space heating compatible with survey results.

**Table 1: Operational characteristics of the simulated hotel.**

<table>
<thead>
<tr>
<th>Internal gains</th>
<th>Rooms</th>
<th>Corridors</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupation</td>
<td>2 person</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 PM - 8 AM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lighting</td>
<td>10 W/m(^2)</td>
<td>1 W/m(^2)</td>
<td>10.6 kWh/m(^2) pa.</td>
</tr>
<tr>
<td></td>
<td>10-12 PM and 7-8 AM</td>
<td>24 hours/day</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Air conditioning</th>
<th>Rooms</th>
<th>Corridors</th>
<th>Occupation rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer</td>
<td>Tcomfort: 22°C</td>
<td>Tcomfort: 22°C</td>
<td>75%</td>
</tr>
<tr>
<td>Winter</td>
<td>Tcomfort: 20°C</td>
<td>Tcomfort: 20°C</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>10 PM - 8 AM</td>
<td>24 hours/day</td>
<td></td>
</tr>
</tbody>
</table>

**Ventilation**

0.8 air renovations/hour
The hotel model was implemented and simulated with ESP-r software (Clarke et al. 1993).

3 Climate and socio-economic scenarios

Climate change scenarios for Portugal are similar in all climate models examined by the authors. Long term monthly data obtained from the MAGICS/SCENGEN tool was used. In addition, monthly and daily time series from the HadCM3 and HadRM3 models, provided by the Climate Impacts LINK Project (DETR Contract EPG 1/1/68) were also used. However, upon further investigation, HadRM3 data were found to be unsuitable because of its large bias when compared with observed data. Thus only monthly data from the HadCM3 model was used.

In building thermal behaviour assessments, the most relevant parameters are temperature and solar radiation, followed by humidity and wind. HadCM3 temperature data was used directly without correction, as the bias of the control run with respect to 1961-1990 climate data was negligible. On the other hand, solar radiation data had to be corrected using the European Solar Radiation Atlas (Scharmer 1998).

Accurate numeric simulation of building thermal behaviour requires hourly data. This is a very calculation intensive process, which can be impractical when long (i.e. 30 year) data time series are used. To overcome this impracticality synthetic meteorological Test Reference Years (TRY) were used. TRY were assembled using statistical and stochastic models that cross-correlate average daily temperature and thermal amplitude with solar radiation. This was done for both the baseline (BASE) and the SRES scenarios (discussed below) and tuned for the regions of interest (Aguiar et al. 1999, Aguiar et al. 2002). During the TRY assembly process, a cascade of algorithms that evolve from monthly mean values to daily time series, and then to hourly time series are produced.

Hence, many stochastic samples can be generated with low computational cost. By selecting the samples with statistical characteristics similar to those in the long term climate model data we ensure that no bias is introduced in the monthly mean and variance values.

The more subtle effects such as auto- and cross-correlations changes under climate change are not well represented by these TRY techniques. However, for the purpose of simulation of buildings with moderately large thermal masses this should not be a problem since small sequential details are “smoothed out” by the mean behaviour. The TRY data also includes diffuse solar radiation estimates, a key factor when converting the horizontal data provided by the models to tilted planes (e.g. walls and windows).

Socio-economic scenarios from the Intergovernmental Panel on Climate Change Special Report on Emission Scenarios (SRES) were used in this study (Nakicenovic...
et al. 2000). These scenarios depict future changes in economic, technological, demographic trends and energy use as major drivers for emissions and hence global climate change. For example, in the case of residential buildings, this can be reflected on the number of dwellings, family size, and occupation periods and even in the desired comfort levels. There are four SRES scenario ‘families’ each containing a specific story line.

The A1 scenario describes a fast-growing economic and technological world with global population reaching a maximum in mid-XXI century. This scenario is further sub-divided into three scenarios based on fossil fuel usage. Scenario A2 is a very heterogeneous world, with fragmented socio-economic and technological development, and where population continues to grow throughout the century. The B1 scenario presents a converging world that privileges sustainable development and global solutions for social and economic problems, with population growth similar to A1 but not always for the same reasons. Finally, the B2 scenario describes a world centred on local solutions for social, economic and environmental problems, with populations growing to the end of the century but at a slower rate than in A2. All four scenarios were used in this study. In the case of the A1 scenario, the sub-scenario A1F1, which is the most fossil fuel intensive, was used.

Despite all the information contained in these scenarios, there is no indication that comfort levels requirements in tourism facilities will change much. In addition, tourist behaviour regarding, for example, time spent inside hotel bedrooms, is not likely to change significantly. In our study, technology advancements, particularly in HVAC systems were the only building operational characteristic changes considered. The coefficient of performance (COP) of HVAC systems used for each future scenario is listed in Table 2.

Table 2: Specification of HVAC system’s COP for all SRES scenarios.

<table>
<thead>
<tr>
<th></th>
<th>BASE</th>
<th>A1</th>
<th>A2</th>
<th>B1</th>
<th>B2</th>
</tr>
</thead>
<tbody>
<tr>
<td>COP heating</td>
<td>2.0</td>
<td>2.5</td>
<td>2.3</td>
<td>2.5</td>
<td>2.3</td>
</tr>
<tr>
<td>COP cooling</td>
<td>1.4</td>
<td>1.9</td>
<td>1.7</td>
<td>1.9</td>
<td>1.7</td>
</tr>
</tbody>
</table>

4 Results

Hotel simulation results for the end of the century (2070-2099) are summarized in Tables 3 to 5, and graphically depicted in Figures 4 and 5. These results are combinations of the climatic and socio-economic scenarios data described above. The difference between energy needs and energy demand (compare Table 3 with 4) is mediated by the HVAC system’s COP. The effect of using different technological processes (i.e. different COP values) reduces the building energy requirements for space conditioning between scenarios. This difference is most noticeable between scenarios A1 and A2.
The most important result relevant for mitigation purposes is that, for all scenarios the reduction in energy demand for space heating is less than the increase in energy demand for space cooling. Hence climate change is likely to increase the annual energy demand for space conditioning in Portuguese hotels. This impact will be more pronounced in the southern regions of Portugal (i.e. Algarve) than in the Atlantic central West coast.

In all future scenarios assessed, the specific energy demand may increase from the current 19-20 kWh/m² per year. Our results indicate additional annual increases...
of about 1-3 kWh/m$^2$ and 4-7 kWh/m$^2$ for scenarios B1 and B2 respectively and about 8-10 kWh/m$^2$ for both the A1 and A2 scenarios.

![Energy demand for the Center West Coast hotels](image1.png)

![Energy demand for the hotels in the South (Algarve)](image2.png)

Figure 4: Absolute impacts (2070-2099) on energy demand for space heating (dark gray) and cooling (light gray): 4-star hotels for the Center West Coast (left) and the South (Algarve, right).

In relative terms (i.e. anomalies in respect to the reference case) the changes in energy demands in 4-star hotels for the B1 scenario is a modest increase of 7% to 15%. A somewhat higher increase (21% to 31%) is expected for scenario B2, while a rather substantial increase of 38% to 57% is possible for both A2 and A1 scenarios (see Figure 5).

![Energy demand change with respect to Base for Centre West Coast hotels](image3.png)

![Energy demand change with respect to Base for hotels in the South (Algarve)](image4.png)

Figure 5: Relative impacts (2070-2099) on energy demand for space conditioning: 4-star hotels at the Center West Coast (left) and the South (Algarve, right).

5 Conclusions and Discussion

Following the recent transposition of the European Directive on the Energy Performance of Buildings (Directive 2002/91/EC 2002) into Portuguese law (RCCCTE 2006), there is a great deal of debate as to the positive effect it will have on the mitigation of national GHG emissions from the building sector. In this legislation an energy certification scheme is mandatory and there are limits on energy consumption of new buildings, such as hotels. Such measures could, in theory,
reverse or at least slow the persistent increasing trend in tourism facilities related emissions, which reflect the growing activity of this sector.

However, the present study revealed that climate change may make it difficult to meet the proposed energy consumption limits in Portuguese hotels. All future scenarios assessed indicate that reductions in energy demand for space heating are always outweighed by increases in energy demand for space cooling and hence the net impacts of climate change will probably amplify Portugal’s annual energy consumption in hotels. This is true even when more efficient technology is considered.

It is important to note that many uncertainties were incorporated in the assessment. Regional climate variability, as well as potential variations of tourist behaviour and the small sample of building types and locations modelled, give room for further research into the subject. For example, conducting a similar study in locations where space cooling is currently unnecessary may yield different net benefit for energy demand results.

In conclusion, when the next generation of energy related building codes are developed, it is important that these take into account the potential climate change impacts on the lifetime usage of the buildings. If climate change is not taken into account we might fall under the error of systematically overestimating the potential of many energy efficiency measures.

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GREENHOUSE GAS EMISSIONS REDUCTION BY TARGET-GROUP TAILORED HOLIDAY OFFERS

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Abstract — Holiday offers are only successful on the market when they fulfill the expectations, desires and needs of holidaymakers. This applies also to environmentally friendly holidays that contribute to the reduction of greenhouse gas emissions. Within the project INVENT a “Target Group Model of Holiday and Travel Styles” was developed on the basis of a representative survey for the German travel market. Target group specific marketing strategies and exemplary offers for the mass market addressed by tour-operators were developed to rise the share of soft mobility in the mass market and to contribute to the reduction of greenhouse gases. Only two out of seven identified target groups respond to environmental arguments. To make soft mobility more attractive also to the other groups it is more promising to address their prior motives. Strategies aim at including soft O/D and local mobility into holiday packages and tailoring offers for nearby destinations taking into account different customer orientations.

Keywords: target-group model, mass market, marketing, soft mobility, customer orientation, GHG emissions reduction

1 Introduction

The greenhouse gas (GHG) emissions generated by tourism are to be attributed by the most part to transport; in Germany for example two thirds of tourism-related GHG emissions are related to origin-destination transport and local mobility (Schmied et al. 2002). Nearly three out of ten citizens of the EU-25 fly to their holiday destinations, which means that about 55% of all tourism transport (measured in passenger-kilometers, pkm) is air transport. Tourism transport on the ground is dominated by private car use. On the ground car transport accounts for some 80% of all pkm, while environmentally sound transport modes are playing a marginal role – only about 5% of all tourism trips in Europe are made by rail, only 7% by coach (Peeters 2004). And the basic trends for the future in tourism travel are: more

What tour operators can do to counterbalance these trends and to attract holidaymakers to more ecological transport modes and to more sustainable travel patterns, has been explored for the German travel market in a 3-year project. Researchers and practitioners have looked for ways to develop more ecological and socially compatible holidays offers. To be successful not only in the “ecological market niche” (Villinger et al. 2000) of holidaymakers particularly interested in and committed to ecological and social issues, but also in the broad mass market, the study specifically addressed the market of holiday packages marketed by tour operators.

2 Methods

Starting points were the analysis of the German travel market, an analysis of tourism trends and the definition of a set of indicators to assess the economic, social and ecological performance of holiday-trips. The main emphasis of the project was a detailed analysis of the expectations and needs of German holidaymakers as well as of the lifestyles and holiday habits of different target groups. The results of four focus groups and 60 in-depth interviews with holidaymakers were used to create a questionnaire. The survey carried out in 2003 included face-to-face interviews of about an hour to 2,021 persons with a minimum age of 14 years who had undertaken a holiday-trip of at least one over-night stay during the preceding 12 months. The sample was representative for the German holidaymakers. Business trips and trips with the sole purpose of visiting family or friends were excluded. Short trips of one to three overnight stays were distinguished from holiday trips with four or more overnight stays. Information gathered included socio demographic data, data on holiday destinations, number and duration of trips, type of accommodation, choice and perception of transport means, lifestyle and holiday orientation, perception of environmental questions, internet use, ways of decision-making and booking, as well as perception of holiday-components and intentions for the future.

By means of factor and cluster analysis a model of seven travel types was created providing detailed information on different patterns, motives and wishes. In a first step the factor analysis helped reducing the complex information gathered by the survey. The large number of variables were condensed into a manageable number
of factors summarizing connected background motives which have a latent, not
directly visible influence on given answers.

There are no univocal statistic rules how many factors should be defined; as an
acknowledged approach the present study used the criterion of eigenvalue (Kaiser
criterion) to carry out factor analysis on two different batteries of statements,
namely holiday orientations and lifestyle orientations.

On holiday orientations three different solutions have been tested before decid-
ing for a solution of 11 factors being the one easy to interpretate as well as meaning-
ful and accounting for 58.5% of the over-all variance.

Factors of holiday orientations:
• U1: sport, action, adventure
• U2: price and bargain orientation
• U3: openness to different countries and cultures
• U4: ecological and social justice
• U5: summer, sun and beach
• U6: child- and family friendly
• U7: safety and cleanliness
• U8: social contacts
• U9: service and comfort
• U10: familiar and habitual destinations
• U11: travel agency/package holiday

For the description of the the main dimensions of lifestyle orientations a 7-factor
solution (testing beforehand also 5- and 6-factor solutions), accounting for 58.1%
of the overall variance, was favoured.

Factors of lifestyle orientations:
• L1: egocentrism and strong stimulus
• L2: modesty and distance to modern techniques
• L3: tradition and family orientation
• L4: stress and feeling overburdened
• L5: styling and body
• L6: hedonism and fun
• L7: culture and social engagement

Cluster analysis allows to group respondents according to variables representing the
theoretic frame. Base of the present analysis are the concepts of lifestyle research
which assume that orientations referring to a certain field of activity (in this case
holiday and travel orientations) express lifestyles and determine actual consumption
behaviour. The present study combines for the first time variables of holiday and
travel orientation (in the form of the factors described above) with socio-demo-
graphic items. To counteract arbitrariness the clustering was carried out in a step-by-step approach: starting from the results of the focus-groups and the in-depth-interviews as well as from the analysis of the motivational variables of existing travel market studies, criteria were identified which in all probability would be part of the typology. On this basis different cluster solutions (cluster center analysis as well as two-step-cluster analysis with SPSS) were tested before deciding for a stable 7-cluster solution.

Based on the resulting holiday and travel styles the INVENT partners developed strategic marketing concepts for a shift towards more sustainable offers and derived exemplary offers tailored to the specific target groups. These offers were tested in 4 group discussions with representatives of specific target groups before actually integrating them into the range of offers of the practitioner partners.

3 Results

3.1 Target Group Model of Holiday and Travel Styles

The “Target Group Model of Holiday and Travel Styles” resulted in a typology of seven target groups with characteristic lifestyles and holiday habits. The project gathered rather substantial and detailed information and data on the groups. In the following only a brief characterisation of the single target groups is given and some of the findings with regard to mobility are addressed. More complete information is available through the project publications (Schmied et al. 2007, Götz 2005a, see also www.invent-tourismus.de).

Traditional habitual holidaymakers (16%) are not drawn to faraway places; they prefer to enjoy their holidays where they know their way around and feel safe; preferably at the same destination year after year, often within Germany.

To be preferred by family-orientated holidaymakers (14%) destinations obviously must provide children- and family-friendly offers. This includes not only acceptable pricing, but also special services and activities for children.

Sun and beach package holidaymakers (20%) are looking for summer, sunshine and relaxation at the beach when they go on holiday. They are also highly price-sensitive bargain hunters. Another important aspect for them is not to have to bother with anything, but simply being able to relax.

Rather than seeking relaxation, young fun and action holidaymakers (11%) want action and adventure when they go on holiday. During the day, the engage in trendy sports, at night-time they look for action in the disco. They also regard holidays as a good opportunity to get to know new people.

Unconventional discoverers (10%) are particularly interested in other countries and cultures. They are independent-minded and want to immerse themselves in the cultures of the destination region. To achieve the desired authentic experience,
they avoid the hubbub of mass tourism centres and are prepared to accept a certain loss of comfort.

**Sophisticated cultural holidaymakers** (15%) also enjoy cultural diversity and seek to experience it as authentically as possible when they go on holiday. For them, this includes typical food, but also encounters with local people. Empathy and a high level of education makes this type responsive to issues of ecology and social justice.

**Nature and outdoor holidaymakers** (14%) are environmentally conscious and orientated towards the family and experience. On holiday they look for authentic experiences in unspoilt natural surroundings, even if this costs more. This group has the highest unexploited potential for new types of ecologically oriented holidays.

### 3.2 Choice of transport mode

With regard to transport mode in tourism the choice is limited by the fact, that tourism service packages mostly prescribe the transport mode: most of them simply cannot be had without air travel.

One reason why rail transport has continuously lost market share over the last few decades (Lohmann et al. 2004) is the rise of long-distance destinations where only air transport provides convenient access in acceptable time. Most holiday-makers will prefer air transport for distances above a certain threshold. This varies individually between 500km and 1,500km (Götz 2005b). Air transport preference thus correlates strongly with the choice of destination.

![Figure 1: Transport mode shares by target groups.](image-url)
Young fun and action holidaymakers and sun and beach package holidaymakers are the two groups with the highest share of long-distance and Mediterranean trips and consequently, the highest air transport share (63 % and 58 %, respectively). Moreover, both groups are above-average buyers of package holidays which frequently include air travel. Consequently they are the group producing the highest amount of greenhouse gases per capita.

The opposite is true for the traditional habitual holidaymakers and the sophisticated cultural holidaymakers. (Air transport shares 14% and 26%). Most traditional habitual holidaymakers spend their holidays in Germany or neighbouring German-speaking regions. Many of them feel also anxious about air travel. They are the group with the lowest rate of greenhouse gas emission.

Sophisticated cultural holidaymakers obviously seek out destinations that promise cultural highlights, and they often find them also in closer destinations. Moreover, travelling in comfort is a higher priority for this target group than speed. The higher age holidaymaker groups generally do not use less air transport. It can be expected that future generations of higher age and good income will be more familiar with air travel and that the share of air transport will further rise (Schmied et al. 2007, Lohman et al. 2004, Schmied et al. 2002).

With respect to destinations that can be comfortably reached without air transport, travel patterns are similar across all groups. A broad majority uses private cars, citing better local mobility at the destination, higher flexibility of travel schedule, luggage transport and unbroken journeys as the main arguments.

Surprising at first sight is the high share of coach transport in sun and beach package holidaymakers and traditional habitual holidaymakers, sophisticated cultural holidaymakers and unconventional discoverers, yet this merely reflects the fact that these target groups like to travel with professional guides and / or in pleasant company (Lohmann et al. 2004). Besides, coach transport is often part of all-inclusive packages in the sun and beach package holidaymakers group. For the traditionalists, the door-to-door service provided by coach transport is a significant benefit over other transport modes, given that 15 % of this group are subject to some constraints when it comes to physical mobility.

### 3.3 Price

While the total cost of a holiday plays a role in the transport mode preferences of all groups, the weight attached to cost considerations varies widely across the groups (Figure 2). Bargain hunting and a focus on inexpensive last minute offers are particularly prominent among the young fun and action group and the sun and beach package holidaymakers.

Both types of holidaymakers may accept long and inconvenient O/D transport in return for low cost. Family-orientated holidaymakers are also highly price-sensitive, as holidays with children may be quite an expensive undertaking. The increasingly popular all-inclusive offers of tour operators are therefore attractive for them.
Bargain hunting is not a prominent feature of the traditional group, but price is a significant factor for them, as they have the lowest incomes of all groups. Price is a less important consideration among the sophisticated cultural and nature and outdoor holidaymakers. Although having the highest incomes of all groups, they do not use the – supposedly more expensive – environmentally sound transport modes any more than other holidaymakers.

The situation is rather difficult for soft mobility offers – coach, but especially rail transport – given the high price sensitivity of many holidaymaker groups. Holidaymakers from all groups agree that rail transport is too expensive (Schmied et al. 2007). Moreover, existing rail offers are unknown to many holidaymakers who use rail transport only rarely or not at all. Statements with respect to price are therefore often based on hearsay, rather than on first-hand experience. This becomes evident in comparison to regular rail customers: 19 % say that the low price was their main motive in deciding to go by train. The corresponding results for coach and private car are 15 % and 9 %, respectively (Schmied et al. 2007).

3.4 Local mobility
Another important factor in transport mode preference is the demand for a maximum of local flexibility at the destination, which can be met often only by private car use, in particular for trips to rural areas or during the off-season, where no public transport is provided.
Figure 3 shows how German holidaymakers perceive the attractiveness of various offers designed to improve their local mobility at destinations without having to use a private car. Generally, even car owners are interested in such offers.

Nowadays all bigger German railway stations offer rental car service and more and more also rental bicycle service, but in rural areas this is still exceptional. Key to success, however, is not service provision pure and simple, but also the pricing and marketing of such offers to holidaymakers. Such local mobility services have to be promoted in the offer phase and appropriately included in the package.

3.5 Holidaymakers' mobility orientation and attitudes
Contrary to what is happening in everyday transport, general mobility orientation is not directly decisive for holidaymakers’ choice of transport mode. It is evident that even persons who have a marked preference for private car use readily accept another (public!) transport mode when they go on holiday – the airplane (Schmied et al. 2007). What is seen as negative in other forms of public transport (lack of independence as to travel time, lack of local flexibility etc.) is not associated with air travel, or may be compensated by the speed and prestige of this transport mode.

The picture is different if the destination can be reached by car. Car aficionados and everyday drivers also use the car for O/D transport in that case. Routine, everyday car use and O/D transport decisions are clearly linked. 83% of all persons who use the car on one to seven days per week in everyday life, also drive to holiday
destinations within Germany (average of all holidaymakers: 70%).

It could be assumed that holidaymakers’ ecological awareness has an impact on
their travel decisions and the choice of transport mode. However, 70% of German
holidaymakers do not want to consider environmental protection and sustainability
when planning their next holiday. Only two target groups are responsive to ecoโล-
cal and social arguments: the sophisticated cultural holidaymakers and the nature
and outdoor holidaymakers – but their responsiveness depends on holiday offers
that are specifically tailored to their demands of high quality.

Holidaymakers who choose their transport mode on the basis of ecological
arguments are a minority: only 2% of German rail travellers say that their most
important reason for going by train is that it is an environmentally sound option
(Schmied et al. 2007). It may be safely concluded that ecological advantages will
not be a useful argument to attract mass tourism consumers to rail and coach
transport.

Moreover, if price is an important factor when booking a holiday, holidaymakers
are less likely to be interested in environmental considerations; this is especially true
for young fun and action holidaymakers and sun and beach package holidaymak-
ers. Soft mobility is thought to cause unnecessary expenses, and such offers are not
booked. It is therefore counterproductive to use ecological arguments in marketing
soft mobility offers to these target groups. Other arguments should be put in evi-
dence, such as safety and comfort for sun and beach package holidaymakers or fun
and entertainment for the young fun and action holidaymakers.

3.6 Strategies to promote soft mobility offers in tourism

Soft mobility tourism offers that include rail and coach transport can be marketed
successfully to broader target groups only if the main advantages of car and air
travel are identified and confronted and specific advantages of public transport are
tailored according to the different needs and desires of the target groups.

Air travel will remain the number one transport mode for destinations beyond
a certain distance – no rail or coach offers, however attractive, will change that.
Changes are possible, however, where the choice of destination is concerned. If holi-
daymakers develop more interest in nearby destinations that are accessible by rail
and coach, the soft mobility options stand to benefit. A strategy to promote nearby
destinations can be realized only over the medium to long term, however.

3.7 Consistent costumer orientation

Consistent customer orientation means that specific offers have to be developed
that are tailored to the needs and requirements of each target group. The paragraphs
below outline some examples for the German tourism market.

Where families are concerned, solutions for the transport of luggage and local
mobility at the destination are crucial. Soft mobility offers have to be attractively
priced for adults and children travelling together. Options would be all-inclusive
packages comprising holidays at a family hotel, rail transport, transfer from and to the train station (including luggage transport), availability of bicycles with children’s seats or trailers and coach excursions to get to know the vicinity, all without extra cost. Marketing should focus on the family oriented services.

When addressing these target groups relatively insensitive to ecological arguments, environment-friendly transport should be only featured “underhand”, putting arguments as safety or low-cost more into evidence. Car-free destinations for example can be marketed as an enhancement of the children’s holiday quality and their safety.

For young fun and action holidaymakers and sun and beach package holidaymakers, soft mobility offers also have to be included in inexpensive packages that can be marketed as all-inclusive offers and sold by travel agencies. Success hinges on whether the package as a whole is attractive for the target group members. One week’s fun at the beaches of the Adriatic, including night-time entertainment at the coolest local clubs and day-time offers of trendy sports, may motivate young fun and action holidaymakers to shift to rail transport – provided that the price is right. Product tests have shown that, the price threshold for a trip from Germany to Venice is now about €100. Most holidaymakers in this group regarded €200 as too expensive (Schmied et al. 2007). This group has responded warmly to the introduction of night-time party trains – a way not to miss a single minute of partying! Package offers for sun and beach package holidaymakers have to take into account that this group opts for all-inclusive holidays to ensure a safe trip free of worries. Coach trips already meet this need, other soft mobility options will have to focus more on it.

The traditional habitual holidaymakers and sophisticated cultural holidaymakers are above all looking for convenient and comfortable travel options – both groups are on average older, and some of these holidaymakers are not fully mobile physically.

Soft mobility offers therefore have to ensure an unbroken door-to-door service chain, including in particular luggage transport. This is a special challenge with regard to the traditionalists whose lower incomes do not permit the use of expensive extra services. For this reason this group represents a potential also for coach trips. Culture enthusiasts, on the other hand, tend to be more affluent, which may mean that first class rail travel may be a viable option for them. Local soft mobility offers at the destination may have great potential with traditionalists if such offers are included in visitor passes or bonus cards. Such items have to be marketed specifically to the target group (e. g., afternoon concerts, not admission to a “tropical fun” indoor swimming pool), and English designations such as “TouristCard” should be avoided.

Local mobility at the destination is a central aspect for nature and outdoor holidaymakers. Soft mobility offers therefore have to ensure that the holidaymakers are able to pursue their favourite holiday activities, such as “experiencing nature” and “outdoor activities in natural surroundings”. Also, this target group includes many
families. Unless local public transport ensures sufficient mobility, rail transport offers for these holidaymakers may be sold including car rental or rented bicycles at the destination. But the members of this group will not be satisfied with pedalling around on cheap department store bikes during holidays when they have machines worth €1,000 at home.

For unconventional discoverers rail transport already makes up an above-average share of all ground travel and surveys have shown lower-than-average interest in special service packages among this group. While these holidaymakers are generally responsive to soft mobility offers, their marked individualism makes any generalized conclusions difficult.

3.8 Promotion of nearby destinations
The objectives in promoting nearby destinations are twofold: on the one hand, shorter travel distances mean a reduction in the emission of pollutants and greenhouse gases; on the other, shorter travel distances are required for holidaymakers to consider environmentally sound transport as an option at all.

For the German tourism market the most promising target group are the nature and outdoor holidaymakers – who travel to remote destinations more frequently than others and thus are above-average air transport users – to consider destinations in Germany, Poland, Austria or Italy instead. This strategy will be successful, however, only if attractive, customized offers are developed. Holiday packages would have to provide variety and options to choose between leisure (wellness & health) and activity (e.g., outdoor activities). Hotels have to meet the required quality standards. If the product package as a whole appeals to this type of holidaymaker, rail transport may well be attractive – provided that local mobility is also ensured. Nature and outdoor holidaymakers seek pristine, attractive scenery – destinations which cannot provide it will not be accepted.

The young fun and action holidaymakers and the sun and beach package holidaymakers prefer sea coasts with plenty of sunshine – for them, destinations in Germany will hardly be an attractive alternative, but they may be drawn to southern France, Northern Italy or Croatia. Germany and neighbouring countries are possible alternatives for families. Sophisticated cultural holidaymakers and traditional holidaymakers already travel to nearby destinations more than the other groups – the strategy will therefore have little impact on these groups. The unconventional discoverers are the group most difficult to attract to nearby destinations. They prefer to spend their holidays apart from the main tourism regions, nearby destinations have only limited appeal to them and they are not appalled by packaged offers.

Even though not all target groups can be equally addressed, the strategy offers significant potential for soft mobility offers in the future.
4 Conclusions and discussion

Most soft mobility offers in tourism today are niche products for consumers with strong ecological and social commitment. But these offers do not reach the vast majority of holidaymakers.

The development and marketing of soft mobility offers therefore have to be better adjusted to holidaymakers’ needs and wishes. Environmental benefits will generally not play a key-role in marketing holiday offers, instead appropriate “motivational alliances” have to be adopted.

Air transport is frequently an inevitable consequence of the choice of destination. Over the medium to long term, attractive offers may help to win back more holidaymakers for nearby destinations and to raise shares of environment-friendly transport modes.

Customer-oriented strategies are faced with constraints, however, if prevailing conditions put soft mobility offers at an economic disadvantage (e. g. hidden subsidies for low cost air carriers). Even the most customer-friendly offers can be only partially effective in shifting transport preferences towards environment-friendly transport modes, where price considerations are too important a factor in decision making.

Consequently further research is recommended which provides basis and hold to policy and economy stakeholders for the shaping of political conditions and economic windows of opportunity to uncouple tourism growth from growing greenhouse gas emissions.

This includes on the one side ongoing socio-ecological research approaches considering societal mega trends as well as individual needs and wishes of consumers to identify potentials for more sustainable consumption patterns. If also mass market shall be (at least relatively) optimised, it should be accepted that ecology is decisive only for minorities and that decision relevant motives have to be found to encourage successful motivational alliances with ecological behaviour. This should be enhanced by corresponding socio-economic research to concretise fiscal conditions which allow soft mobility to be price-competitive and to put this into relation to follow-up (avoidance) costs of climate change. Further steps would include an extension to cross-European exploration of travel-styles as well as more in-depth investigation of customers price-sensitivities.

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Section III: Policies for mitigation

‘Not my main priority’: Tourism entrepreneur attitudes and behaviours with respect to climate change adaptation and mitigation
Michael Hall

Can domestic tourism growth and reduced car dependency be achieved simultaneously in the UK?
Derek Robbins & Janet Dickinson

How heavy will the burden be? Using scenario analysis to assess future tourism greenhouse gas emissions
Ghislain Dubois and Jean-Paul Ceron
NOT MY MAIN PRIORITY': TOURISM ENTREPRENEUR ATTITUDES AND BEHAVIOURS WITH RESPECT TO CLIMATE CHANGE ADAPTATION AND MITIGATION

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Abstract - Although there is increased interest in the attitudes of tourism firms with respect to climate change the majority of research has been undertaken on larger businesses and not the small SMEs that constitute the bulk of the tourism industry. This study reported on the findings of a longitudinal series of qualitative research on 43 rural tourism businesses and entrepreneurs in New Zealand that was undertaken from 2002 to 2005 as part of a broader study of attitudes and behaviours with respect to global environmental change. The study found that respondents rated climate change as a low-level concern compared with the day-to-day operation of the business even though it was recognised as a potential future issue. Respondents were also far more likely to have taken climate change adaptation or mitigation measures if they had experienced a high-impact low-frequency weather event therefore suggesting the possibility of an issue-attention cycle in business behaviour.

Keywords: tourism SME, adaptation, risk, business concern

1 Business & Climate Change

Business clearly has a major role to play with respect to adaptation and mitigation in tourism and climate change. However, when the term ‘tourism industry’ is used in studies of the relationship between tourism and climate change it is generally used in reference to a supposedly readily identified collection of firms and organisations which share a common industrial and organisational goal rather than the stated preferences of specific actors. The distribution of tourists in space and time and their associated consumption patterns should not be confused with the location of firms and organizations that may choose to classify themselves as part of the tourism industry – or not. As numerous studies have indicated not only is the technical definition of tourism as an industry for statistical purposes highly debatable but so

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is the potential for disagreement between diverse stakeholders in tourism in policy and regulatory terms (Hall 2005).

Just as significantly the primary focus of research in relation to business and climate change tends to be with respect to larger tourism enterprises, such as resorts and airlines as well as umbrella organizations, rather than the many small businesses that make up the bulk of the tourism industry (e.g. Elsasser & Messerli 2001, Elsasser & Buerki 2002, Hall & Higham 2005, Saarinen & Tervo 2007). In addition, it may be important not to confuse the statements of tourism industry associations and other umbrella groups with respect to climate change with that of individual tourism firms and organizations given not only the issue of how representative such bodies are but also the different scales at which firms are operating (Hall & Kearsley 2001, Becken & Hart 2004, Belle & Bramwell 2005).

2 Focus

This study focuses on small tourism SMEs that particularly important for tourism in the New Zealand context. Small business is usually regarded as the cornerstone of employment and wealth generation in the New Zealand economy. SMEs account for 35% of New Zealand’s economic output and account for a greater amount of employment than in other international economies. According to the New Zealand Ministry of Economic Development (2001) 84.9% of New Zealand businesses are small enterprises, defined as one that employs 5 or less FTEs (Full Time Equivalent Employees) and 11.6% are medium-sized enterprises (businesses that employ 6-19 FTEs).

The New Zealand tourism industry is also dominated by SMEs although estimates vary on the exact number (Hall & Rusher 2004). According to the New Zealand Tourism Industry Association (TIA) (2002) the tourism industry has ten publicly listed companies and about 16,500 small to medium enterprises (interestingly, these figures also indicate that approximately only 20% of tourism businesses are members of TIA). The 2000 New Zealand Tourism Strategy estimates that the tourism industry has ‘between 13,500 and 18,000 SMEs, approximately 80% of which employ less than 5 people’ (Tourism Strategy Group 2000: 7), of which, approximately 34% are accommodation providers. The New Zealand Tourism Strategy 2010 recognised that SMEs lie at the heart of tourism even though they ‘have limited ability to invest in its development’ (2000: foreword), with the Strategy Group observing that, amongst other factors, ‘capability building of sector participants, particularly small and medium sized businesses’ was ‘critical to the success’ of the New Zealand Tourism Strategy 2010.

As with small business in New Zealand generally, the understanding of actual business behaviour of tourism SMEs in New Zealand is extremely limited (Page et al., 1999), particularly when it is claimed that the strategies of some tourism SMEs may well be aimed as much towards maintaining the desired lifestyles of the own-
ers as they are towards profit maximisation or growth oriented strategies (Ateljevic & Doorne 2000, Hall & Kearsley 2001). For example, as Hall and Rusher (2004) observed that little is known of the risk tolerance and uncertainty management behaviour of tourism SMEs that are associated with business decision-making and activities, even though it is a major theme within the wider small business and entrepreneurship literature.

Previous research on climate change in New Zealand has recognised the concerns of public and private organisational stakeholders (Becken & Hart 2004) but there is a dearth of material on the perceptions of small tourism businesses. One of the exceptions is a masters thesis by Orchistron (2004) on marine tourism in New Zealand found. It found that operator perception of the potential impact of global warming on marine tourism was the lowest ranked of 15 potential environmental and regulatory issues in terms of future significance. The majority of respondents (n=230) disagreed that global warming and higher sea levels will impact on the industry. Forty percent either disagree or strongly disagree with the statement, and 39% chose a neutral position.

3 Outline

This study presents some results from longitudinal research of 43 rural tourism businesses and entrepreneurs in the Bay of Plenty (North Island) (32) and Otago/Southland (South Island) (11) regions of New Zealand that was undertaken from 2002 to 2005 as part of a broader study of attitudes and behaviours with respect to global environmental change (GEC). All business had an accommodation dimension although other tourism activities were also available including hunting, fishing, garden tours, wine and food; all were rural land properties some of which were also diversified commercial farms with others being best described as lifestyle properties. Most businesses did not retain detailed information of their customer base although estimates were provided. Nearly all overnight visitors to the respondents were from out of region with approximately 80% being international visitors and 20% domestic. Businesses which offered garden tours, or wine and food tourism products had a significant proportion of local day visitors, estimated to be approximately 50% of day visitors for garden tours, 40% for food tourism activities and 20% for wine. Domestic overnight visitors were primarily travelling by car as part of short break holidays or weekends from major urban centres (Auckland and Hamilton in the North Island and Christchurch and Dunedin in the South Island). International overnight visitors were typically engaged in two to three week self-drive holidays with Europeans being identified as the most common source market.

Respondents were selected through a convenience snowball sampling developed through personal contact. Some respondents had participated in other accommodation provider research (Hall & Rusher 2004) and had indicated an interest in being
involved in future projects. In order to be included in the sample respondents has to either self-identify or be identified by others as demonstrating high stewardship values with respect to the environment as demonstrated through management practices and/or organisational membership.

Respondents participated in an annual interview regarding business and environment issues that was conducted either face to face or by phone. Ten respondents dropped out over the study period leading to a final number of respondents of 43. The main reason for drop out being selling of the business or no longer offering visitor products. Interviews were conducted because of participant preference for interviews over paper based surveys, with the comment of being ‘fed up with forms’ being noted by a number of respondents. Anonymity was guaranteed to respondents with all initial interview notes that might identify operators being destroyed. One of the main reasons for this was that much of the income gained from tourism was ‘cash-in-hand’ and was not declared, unlike other income from property such as farm income.

In terms of the profile of the businesses the accommodation component tended to be quite seasonal and was managed by respondents usually with the help of other family members. This also meant that there was a relatively low level of employment of non-family staff. There was substantial variation in length of time of family ownership, ranging from one to 90 years, with a median of eight years and a mean of 14 years.

Respondents tended to have a low level of formal engagement in the tourism industry, e.g. through association memberships at a regional or national level, although otherwise they did tend to hold a high degree of social capital in their communities through membership of a range of national and local organizations such as chambers of commerce and service clubs. The profile of respondents is consistent with that identified in a previous survey of small accommodation providers in New Zealand (Hall & Rusher 2004).

Issues discussed with respondents included:

- perception of GEC and its significance at various scales
- its significance at a personal and business level
- how might the various dimensions of GEC affect their business practice
- the respective role and responsibilities of government and industry with respect to GEC
- individual actions with respect to climate change and other aspects of GEC and adaptation and mitigation strategies

4 Results

The majority of interviewees did identify climate change as a potential issue that may affect their business and personal well-being, but importantly climate change
ranked well below other more immediate business concerns in terms of changes to business behaviour. Many respondents noted that although they were interested in climate change concerns it was not an immediate or even main priority as they have more day-to-day concerns with running a business. The five most important issues for respondents being:

- costs of operating a business
- regulation by government - in terms of costs and time taken to meet regulatory requirements;
- competition – in terms of too many operators;
- quality – concern over the entrance of other operators that provided a poor standard of service and
- inappropriate rural development and pollution and its impact on the landscape and personal and visitor amenity

Such results are not to suggest that climate change was seen as unimportant. But in comparison with more immediate issues that were identified as more important (see above) climate was recognised as a possible medium to long term issue (5+ years). Familiarity with climate change issues was gained through general media, although interestingly other GEC issues (biosecurity, water security) were understood through more technical media such as that available through government agencies at the national and regional level as well as through agricultural field days operated in part through agricultural and farming associations.

Innovation and adaptation measures were being developed by some respondents in relation to environmental change issues with respect to biosecurity and water security but not necessarily climate change per se. A number of respondents had started to restrict visitor access to parts of their property as a result of biosecurity concerns while water conservation was becoming a major focus of respondents in terms of making existing use more efficient as well as developing new storage strategies. Concern over water security was also leading to consideration of new property management strategies and plantings.

Where changes to behaviour occurred it was often associated with perceived immediate impacts on the business, for example severe storm and flooding events or extended dry periods in relation to farms which are also used for homestays. Indeed, it was noticeable that the greatest expressions of concern over climate change and its potential affects at both a personal and national level were from those respondents who had been directly affected by extreme weather events or lived near to a location that had been affected. Although the number of respondents is not large enough to undertake meaningful statistical analysis the extent of a spatial relationship between changes in behaviour in order to respond to extreme weather events and level of concern over climate change was such that it clearly indicates the importance of ‘concrete’ events in influencing risk perceptions and behaviours.
Despite the recognition of a number of respondents of the potential longer-term effects of climate change and the need for ‘government to do something’ increased regulation or taxes were opposed if it added to business costs. This reflected the prime focus on respondents on managing day-to-day immediate business risk rather than what was seen as something in the future. Responses of businesses whether at the personal or a national level therefore focussed on adaptation rather than mitigation. Indeed, concerns were expressed over the potential of ‘green’ or ‘carbon taxes’ to increase the cost of aviation or car travel and therefore affect the travel market to the regions in which respondents were located which are away from the main tourist flows in New Zealand (Hall & Kearsley 2001).

Few respondents ever offered comments about increasing costs of insurance as a result of weather events or long term climatic change. Instead, insurance and liability issues were far more focussed on immediate occupational health and safety concerns. Again this situation reflects a concern with perceived immediate business risk versus longer term or the impact of what are regarded as infrequent risk events. To an extent the existence of already set-aside public funds in New Zealand in the event of natural disasters and previous government assistance packages to areas hit by natural disasters may influence perceptions of insurance and other financial risk. However, there was no evidence from respondents that this affected overall business risk with respect to climate change.

Finally, interviews suggested some potential differences in attitudes and behaviours towards climate change adaptation and mitigation between different activity based businesses with those that were most natural resource dependent for their core business activities, e.g. farm sales as a compliment to accommodation provision, being the most concerned about climate change. Interestingly, there also appeared to be a relationship between resource ownership and concern over climate change, with businesses that utilised public tourism assets, such as lakes, rivers and the conservation estate (national parks and reserves) indicating less concern than those with significant private holdings in terms of farms or forest plantations.

5 Conclusions and Implications

This study reported on the findings of a longitudinal series of interviews undertaken with 43 small tourism businesses in regional New Zealand from 2002 to 2005. In general climate change was a minor consideration of respondents in terms of daily management activities and business planning although it was considered a potentially significant mid to longer term issue. However, the focus of small businesses in terms of the issue ecology of running a business was that attracting customers, delivering good service and keeping costs down were far more important. Although the sample size is limited the longitudinal nature of the study provides a rare occurrence to judge business reaction to events affecting business viability and
risk perception. More comparative work is required to judge the extent to which such results are representative of small tourism SMEs in rural areas in developed countries. Yet the findings of a recent Finnish study of tourism SMEs (Saarinen & Tervo 2007) do suggest that the results of the present study with respect to small tourism business behaviour and risk perception in relation to climate change may have substantial applicability elsewhere.

Ranking of climate change in relation to other business issues; and even with other GEC concerns was therefore low. Water security and biosecurity were far more immediate concerns with respect to both adaptation and mitigation than was climate change, unless respondents had been affected directly or indirectly by an extreme weather event in which case climate change was regarded as a much more immediate and pressing issue. Nevertheless, even with respect to respondents who did perceive climate change as a significant immediate issue there was opposition to regulation and increase costs unless there was a perceived direct benefit to the firm.

International and domestic consumers of the products offered by the respondents do have opportunities to purchase similar products in markets closer to their place of permanent residence. However, because of the relatively peripheral nature of the regions in which respondents are located, their businesses do not have such ease of opportunity to adapt. In discussion several respondents noted that in terms of the overnight visitor market that they did not perceive there to be a capacity to substitute the domestic market for the international market. Similarly, the majority of operators who offered products catering to their local market felt that there was relatively little capacity to expand this market because of the limited population of regional centres and the extent of competition for the same day-trip market. The comments of respondents may well provide an accurate perception of their capacity to adapt to reductions or changes in visitor flows as a result of adaptation or mitigation strategies that substantially increase the cost of car travel to regional New Zealand. Such areas are presently poorly served by public transport systems that connect them either internally or to major gateways and urban centres. Car transport remains the key means by which they access international or domestic overnight markets while the small population size of local markets means that the potential to increase visitation from this market is extremely limited. Those businesses for whom tourism is adjunct to other farming activities may have some capacity to adapt so long as export opportunities exist. However, businesses, often described as lifestyle businesses, for which tourism represents the primary income apart from any secondary employment of superannuation or pension income (Hall & Rusher 2004), would appear to have few opportunities to diversify.

Respondents were clear that they did not wish to directly bear the costs of climate change adaptation or mitigation schemes that may be brought in by government. They felt that regulatory and compliance costs on small businesses were already too high. This attitude was consistent even with the substantial proportion of
respondents who had not registered a business for tax purposes and who were in effect operating in a grey economy by taking much of their income in cash and not declaring it. Nearly all respondents felt that they could have little direct influence on government policies through business or tourism associations although they felt far more positive with respect to influencing local decision-making. Should regulatory and compliance costs, for whatever reason, be perceived as unacceptable then the primary means for response was seen as the ballot box.

The direct experience of high-impact low-frequency weather events had the greatest impact on respondent attitudes towards climate change adaptation and mitigation and even as to whether climate change even existed. In reviewing the range of participant responses over time it appears highly likely that an issue-attention cycle exists with respect to respondent attitudes and behaviours which is strongly related to crisis and natural hazard literature (Mitchell 1989, Blaikie et al. 1994, McEntire 1999, Hall 2002). Just as significantly it appears that adaptive behaviour and to a much lesser extent mitigative behaviour tends to follow concrete events and the provision of technical information through what are perceived as legitimate sources rather than media stories of climate change. However, in the case of the tourism dimensions of climate change respondents could not readily identify any legitimate source of such information.

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CAN DOMESTIC TOURISM GROWTH AND REDUCED CAR DEPENDENCY BE ACHIEVED SIMULTANEOUSLY IN THE UK?

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a School of Services Management, Bournemouth University, United Kingdom

Abstract - ‘Tomorrow’s Tourism’ sets out a strategy for the development of the UK tourism industry incorporating growth targets for international and domestic tourism. Transport policy as outlined in the 1998 White Paper (DETR 1998a) advocates integrated transport solutions leading to reduced car dependency and road traffic growth. This paper contrasts the differing objectives of the two policies and explores whether they are compatible. This paper evaluates to what degree the policy conflicts have been acknowledged, policies developed to simultaneously reduce car dependency for domestic tourism trips whilst promoting tourism growth, and barriers to implementation.

Keywords: Car dependency, sustainable tourism growth, policy.

1 Introduction

Transport policy and tourism policy are the responsibility of different government departments in the UK. Transport has its own department, the Department for Transport (DfT) whilst tourism policy is the responsibility of the Department for Culture, Media and Sport (DCMS). This division of responsibilities does not in itself create a problem. When first elected in 1997 the Labour Government stressed the concept of ‘joined up’ government, acknowledging how the actions of one Government Department impacts upon others, and set the ambitious objective of avoiding conflicting policy agendas. “We are committed to ensuring better coordination across all Government Departments in Whitehall and the Regions”. (DCMS 1999: 13). The Transport White Paper (DETR 1998a) highlighted how other Government Departments impact on transport. For instance, the concentration of health and education services, to produce economies of scale through the closure of smaller facilities, has implications for:

• average distances travelled by users and staff
• personal travel costs

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The link between transport and land use planning extends beyond traffic generation to the creation of a more ‘car dependent’ lifestyle. The continued development of ‘out of town’ retail and leisure developments with free parking and poor public transport links illustrates how planning has increased car dependency and generated a Government response (DfT 2004). For a short period the importance placed on integrating transport and land use planning influenced the structuring of Government Departments. From 1997 the Department of the Environment (DoE) was merged with the Department of Transport (DoT) to create the Department of the Environment, Transport and the Regions (DETR), but it proved too large and unmanageable and by June 2002 transport was restored as a single department. The objective of an integrated policy remains, although one Government advisory body, the Commission for Integrated Transport (CfIT), has criticised “the breaking of the link between transport and land use planning” (CfIT 2003: 19).

Data from the International Passenger Survey reveals only 6.7% of overseas visitors to the UK arrived by private car in 2005 (ONS 2006). This paper therefore focuses on the relationship between domestic tourism and transport policy. Tourism is traditionally defined as “the activities of persons travelling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business and other purposes” (WTO and UNSTAT 1994) with a minimum length of stay of one night. This definition has been refined for planning and statistical purposes in the UK to non-regular journeys away from home for more than 3 hours (The Countryside Agency 2006), as day visitors display most of the characteristics of tourism. Tourism travel rarely features in urban or regional transport planning models and differs from leisure travel, which includes activities local to the area of residence. UK planners exclude travel ‘in the course of business’, as the motivation for the journey is unrelated to the tourism characteristics of the destination, but include travel to conferences, exhibitions, conventions and corporate meetings, which have regard to the tourism characteristics of the destination (Quarmby 2006).

2 Road Traffic Growth & Tourism

Transport serves two separate yet inter-dependent functions for tourism. In the first instance it provides the link between the tourist’s home and the destination area referred to in this paper as O/D-transport. It also provides local mobility in the destination area referred to as destination transport. The implications of a dominant car share are different for these two functions. For O/D-transport the high car share contributes to congestion on main roads (motorways and A roads) and to accidents but the most significant environmental impact is its contribution to greenhouse gas
(GHG) emissions. On the other hand, destination transport is much shorter, and contributes marginally to GHG emissions. The more significant environmental impacts are noise, visual intrusion, local air quality (suspended particles), congestion in the destination area, and increased demand for land for an expanded local road network and parking.

The two functions are related. Policies targeted at reducing the car dominance of O/D-transport will impact on the transport used for destination transport. Tourists arriving in the destination area by car will have that car available for local trips (Table 1) whereas those arriving by public transport are largely dependent on public transport, walk and possibly cycle. However as the paper will demonstrate, much policy is designed to reduce car trips within the destination where the impact is less clear cut. Whilst policies may reduce local car trips will they impact on the choice of mode for O/D-transport?

Table 1: Advantages of the car for tourism travel (Source: Author).

<table>
<thead>
<tr>
<th>Advantage of car</th>
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<tbody>
<tr>
<td>Price</td>
</tr>
<tr>
<td>Flexibility of time of travel</td>
</tr>
<tr>
<td>Door to door</td>
</tr>
<tr>
<td>Accessibility</td>
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<tr>
<td>Luggage capacity</td>
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<tr>
<td>Flexible route with intermediate stops</td>
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<tr>
<td>Availability of the car at the destination</td>
</tr>
<tr>
<td>Impulse trips</td>
</tr>
<tr>
<td>Carriage of family/children</td>
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</tbody>
</table>

2.1 The car in UK transport
Car traffic in the UK accounted for 85% of all passenger kilometres in 2005. Growth rates have slowed with passenger kms being virtually stagnant since 2002 (DfT 2006b) and the number of trips has actually fallen, by 4% between 1995/7 and 2005 (DfT 2006a). This mirrors trends elsewhere in Western Europe (Belgium and The Netherlands) where the number of car trips and car kms have stagnated or fallen (CBS 2003, INS 2006).

Car ownership has risen to 26.21 million cars in 2005 (DfT 2006b) although 25% of UK households consisting of 19% of the population (approximately 12 million) do not have access to a car (DfT 2006a). In rural areas, where public transport is at its poorest, only 11% of households do not have access but this rises in urban areas reaching 39% for London with its comprehensive public transport network (DfT 2006a). Not surprisingly, improved supply of public transport also increases the percentage of tourist arrivals by public transport in urban destinations.
2.2 Tourism transport

The National Travel Survey (NTS) shows that leisure accounts for 31% of all trips and 40% of kms travelled in the UK which is car dominated (see also paper by Guiver et al., page ....). With an average trip length of 11.6 kms leisure clearly includes local journeys (see Table 2) so a more appropriate measure of domestic tourism is holiday trips (average length 71.1 kms) and day visits (23 kms) which account for 12.5% of all UK passenger kilometres, but only 3.7% of all trips (DfT 2006a). This has remained virtually unchanged since 1985/86 indicating growth for tourism in line with road traffic growth for other journey purposes. Interestingly improvements to the road network are acknowledged by the Standing Advisory Committee on Trunk Road Assessment (SACTRA) to have induced traffic growth (DoT 1994), and, as tourism trips are clearly discretionary and day visits also impulsive, one may have expected them to be more susceptible to high levels of induced traffic growth.

Table 2: Notes and definitions by the national travel survey (DfT 2006a: Appendix A).

<table>
<thead>
<tr>
<th>Definition</th>
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<tbody>
<tr>
<td>Leisure Travel travel for a leisure purpose. Trips which are themselves a</td>
</tr>
<tr>
<td>form of recreation, eg yachting or gliding, are excluded.</td>
</tr>
<tr>
<td>Holiday trips trips (within GB) to or from any holiday (including stays of</td>
</tr>
<tr>
<td>4 or more nights with friends and relatives</td>
</tr>
<tr>
<td>Day trips trips for pleasure (not otherwise classified as social or</td>
</tr>
<tr>
<td>entertainment within a single day)</td>
</tr>
<tr>
<td>Social or entertainment visits to meet friends, relatives and acquaintances</td>
</tr>
<tr>
<td>both at someone’s home, or at a pub restaurant etc.; all types of</td>
</tr>
<tr>
<td>entertainment or sport, clubs and voluntary work, non vocational evening</td>
</tr>
<tr>
<td>classes, political meetings etc.</td>
</tr>
<tr>
<td>Business personal trips in the course of work</td>
</tr>
<tr>
<td>Trips a one way course of travel having a single main purpose. Outward and</td>
</tr>
<tr>
<td>return halves of a trip are treated as two separate trips</td>
</tr>
<tr>
<td>Distance travelled the length of any trip stage is the distance actually</td>
</tr>
<tr>
<td>covered, as reported by the traveller, and not the distance as the crow</td>
</tr>
<tr>
<td>flies.</td>
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</table>

Peeters et. al. (2007) estimate that tourism accounts for between 15 – 20% of passenger kms travelled within Europe by surface modes of transport. There has been a fall in domestic tourism trips by car (Dubois et al. 2006) demonstrated by Germany where both the number of trips and the distances travelled (vehicle kms) have declined (BMVBW 2003, Gstalter 2003).

Analysis of tourism statistics shows the car dominates domestic tourism travel accounting for around 71% of all trips to and from holiday destinations (UKTS 2004). This is similar to the leisure travel share identified (see also paper by Guiver.
et al. page ....), but is less dominant than the car share of all travel due to a number of reasons including the popularity of organised coach tours (7% of all UK domestic holidays) and the decline in car use for trips of over 400 kms mainly for the benefit of rail (DfT 2006a). The domestic air share for longer trips is also rising, driven by the growth of low cost carriers (DfT 2006a). The car share rises for shorter trips, shorter stays and for rural destinations reaching its highest share with day visits to rural areas (82%) and National Parks (91%) (The Countryside Agency 2006).

3 Transport and tourism strategies

The objectives of Government transport policy were initially set out in the publication of a White Paper ‘A New Deal for Transport: Better for Everyone’ (DETR 1998a), and expanded and developed by the publication of 11 subsidiary documents. The ‘Transport Ten Year Plan 2000’ (DLTR 2000), added policy detail and set targets, although policy has continued to be developed and adapted culminating in a new White Paper in 2004 (DfT 2004). The overall direction remains unchanged, to develop a sustainable transport policy with reduced car dependency.

Initially it was not entirely clear whether the aim was to reduce road traffic from its current levels, hold it at current levels or even accommodate traffic growth but at a slower rate. The 10 year plan was more specific, “to reduce congestion on the inter-urban trunk road network and in large urban areas in England below 2000 levels by 2010 by promoting integrated transport solutions” (CfIT 2003 p23: DLTR 2000 Appendix B). However this reveals a subtle change in emphasis and differs from a target to reduce road traffic. Traffic growth and reduced congestion do not have to be incompatible and the 10 year plan included a targeted £21 billion programme of construction and widening to the strategic road network (DLTR 2000) involving 100 completed schemes by 2004 (DfT 2004). Whilst this does not represent a return to the ‘predict and provide’ policies of the late 1980s (DoT 1989), it is more pro road than initially proposed in 1998 and questions the relative importance attached to reducing GHG emissions. The Government acknowledges that the scope for the main road network to carry more traffic and simultaneously reduce congestion will quickly be lost to induced traffic unless road improvements are accompanied by an integrated approach to ‘lock in’ these gains (DfT 2004). It is more difficult to see how congestion in local environments, where there is less scope to increase road capacity, can be reduced unless traffic itself is also reduced. Other targets, such as the growth of rail traffic by 50% and increased use of local public transport by 12% demonstrate the policy direction is predominantly to promote modal shift away from car (DLTR 2000).

The Government’s strategy for the development of the UK tourism industry outlined in ‘Tomorrow’s Tourism’ sets a target to “exceed the rate of global growth in the industry by the end of 2010” (DCMS 1999: 3). Whilst the document advocates
a ‘wise’ growth strategy for tourism, “one which integrates the economic, social and environmental implications of tourism” (DCMS 1999: 48) it is less specific on how and the ‘wise growth’ section on the DCMS website is currently unobtainable. The follow-up document ‘Tomorrow’s Tourism - Today’ (DCMS 2004) sets a target for a 100 billion industry by 2010 which represents a growth rate of around 4% per annum (Purnell 2005).

4 Integrating the Transport and Tourism Strategies.

4.1 The conflict
The potential for conflict between the transport strategy and the tourism strategy is clear. In essence the key aim of transport policy is to suppress future road traffic growth whereas the tourism strategy is to encourage growth. Whilst sustainable transport policies may well be targeted primarily at the most problematic journey purposes, such as commuting to work and the accompanied journey to school, policies will impact on a wide range of journeys including tourism. Furthermore, tourism is a significant contributor to road traffic and as a derived demand creates significant spatial and temporal peaks such as car travel to popular tourist destinations on peak summer Saturdays. A tourism contribution to transport reduction targets is appropriate and the White Paper targets discretionary trips. “It doesn’t take much to make a difference - if we all left the car at home just once out of the ten or so shopping and leisure trips we make each month, we would deal with most of the projected increase in traffic this year” (DETR 1998a: 19).

The Tourism objective “to make it easier for people to make more informed decisions about their travel choices” (DCMS 1999: 56), assumes “a switch away from car to less polluting forms of transport” (DCMS 1999: 57). Here lies the crux of the issue. Tourism growth and reduced traffic levels are only seen as compatible by the policy documents if the tourism growth is accompanied by a significant modal shift away from car use. The consultation which preceded publication of ‘Tomorrow’s Tourism’ sought detailed proposals for “ways in which visitors can be encouraged to use more environmentally friendly transport options to (a) reach their destination (b) to travel around once they are there” (DCMS 1998: 7). Whilst modal shift is an appropriate objective, a more sophisticated analysis would realise that some tourism trips have a greater environmental impact than others, and that the greatest benefits would be achieved by targeting those trips that produce the greatest impacts. This is discussed in more detail in §6.

4.2 Transport policies
There is insufficient space in this paper to describe the transport policies for reducing car dependency outlined in the 1998 White paper in great detail. Table 3 summarises the main proposals. A key proposal was charging motorists to use
certain roads. Although it was assumed that “take-up of new charging powers will, at least initially, be in urban centres, where the problems of congestion and pollution are worst” (DETR 1998b: 16), a wider application was also acknowledged. “In rural areas, road user charging is most likely to be used where there are significant problems caused by very high levels of seasonal traffic, for example, in tourist areas such as National Parks” (DETR 1998b: 115). Historic cities also have significant seasonal tourism congestion.

Table: Transport white paper (DETR 1998a).

<table>
<thead>
<tr>
<th>Measures</th>
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<tr>
<td>“To allow local authorities to charge road users so as to reduce congestion” (p. 115)</td>
</tr>
<tr>
<td>Road user charging on motorways</td>
</tr>
<tr>
<td>Stricter parking controls / traffic management</td>
</tr>
<tr>
<td>Park and ride</td>
</tr>
<tr>
<td>Reduce the amount of free workplace car parking available (DETR 1998b: 30)</td>
</tr>
<tr>
<td>Improve public transport alternatives through quality partnerships between Local Authorities and operators</td>
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</table>

Two of the first four proposals for road charging schemes targeted domestic tourist traffic (DETR 1999):

- Durham: A flat-rate charge to the historic core of the city, a World Heritage site.
- Derbyshire, Peak District National Park: A scheme alongside the Derwent Reservoir involving charges on Saturdays, Sundays and Bank Holidays funding improved Public Transport links including a Park and Ride service.

To date only one of the four proposals, Durham, has progressed to implementation where monitoring shows vehicular traffic was reduced by 85%, albeit in a very small central area, with increased pedestrian activity and bus use. This initial piecemeal approach of local charging schemes has since been developed into a proposal for a co-ordinated national ‘electronic’ road pricing system, replacing fuel tax and vehicle excise duty, although this is technically at least 10 years away (DfT 2004). In the meantime any extension of charging for road use will be through more local schemes which charge for entry to a designated area (zone) and a further nine areas (including Durham) have been selected in November 2006 to share £7.5 million from the Transport Innovation Fund (TIF) to develop pilot road pricing projects (DfT 2006c). Local schemes predominantly target ‘destination travel’, keeping cars away from fragile or vulnerable areas, rather than impacting over modal choice for the whole journey. Progression to a national scheme with charges more closely related to distances travelled has much greater potential to impact on ‘O/D-trans-
port’ and on tourism’s contribution to GHG emissions.

Parking has been an important planning mechanism to control traffic levels in congested areas incorporating a combination of controls on both the supply and costs of parking spaces. Government has sought additional powers for Local Authorities to reduce the amount of parking as a means of reducing car journeys, although the focus has been on workplace car parking (DETR 1998b: 30).

4.3 Integrated tourism policies for transport

There is a marked difference in the emphasis given to an integrated policy for transport and tourism between the two principal strategy documents. Despite its focus on integration the 1998 White Paper barely mentions tourism. A word search analysis reveals that ‘tourism’ is mentioned twice and tourist a mere five times (DETR 1998a). In contrast the tourism strategy devotes a specific section to the transport issues associated with tourism (DCMS 1999: 56-58). It sets out ‘six’ specific measures in support of the objectives contained in the Transport White Paper of which one is in reality dissemination rather than policy (Table 4). The English Tourism Council (now replaced by Visit Britain) has taken lead responsibility for developing and monitoring the strategy (ETC 2001).

Table 4: Tomorrow’s tourism proposals for integrating policy (DCMS 1999: 56)

<table>
<thead>
<tr>
<th>Proposals</th>
</tr>
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<tbody>
<tr>
<td>Improve the quality and accessibility of information available to tourists by developing a national, integrated public transport information service by 2000</td>
</tr>
<tr>
<td>Examine the potential for delivering integrated public transport and tourist information in a user friendly way, including electronic means</td>
</tr>
<tr>
<td>Encourage tourist and leisure site managers to produce green transport plans to reduce congestion and pollution from employee and visitor car traffic</td>
</tr>
<tr>
<td>Encourage the upgrading of public transport infrastructure such as facilities for bicycle carriage</td>
</tr>
<tr>
<td>Identify and publicise schemes which utilise transport or visitor management techniques to good effect</td>
</tr>
<tr>
<td>Encourage the creation of new tourism products which integrate walking with cycling or travel by bus and rail as part of the experience</td>
</tr>
</tbody>
</table>

5 Evaluation of the DCMS strategy to achieve modal shift for tourism trips

The first two transport measures proposed by the tourism strategy are improved quality and delivery of public transport information (see Table 4). Complex journeys to tourist attractions which require an interchange between modes of transport are difficult to plan and a potential barrier to making these journeys by public trans-
port. This was shown by a video that used a number of scenarios to demonstrate the difficulties of finding out details of local transport services (routes and departure times) in advance of a journey in an unfamiliar location (ETC 1999). A National Integrated Transport Information service, Transport Direct, available on-line since December 2004 has addressed this (www.transportdirect.com) although the effect on modal choice is difficult to determine (ONS 2001).

The third measure is the development of green transport plans, to achieve a modal shift away from car use. The main approaches to divert visitor traffic have been:

- Combined transport and admission tickets offering discounted admission for arrival by public transport
- Special bus services between attractions and the closest railway station.

Results from such schemes have proved disappointing. The combined rail and entrance ticket at Legoland Windsor with a shuttle bus to and from Windsor station attracted a mere 3% of arrivals (Oswin, 1999). Combined transport and admission tickets can be undermined by the many alternative promotions for reduced entry including supermarket loyalty card vouchers and promotions in newspapers and magazines. The National Trust’s (NT) green transport plan aims to reduce the car share of arrivals to its properties from the current 90% to 60% by 2020 (Dickenson et al. 2004). Approaches include opening visitor attractions without car parking (Prior Park in Bath), dedicated coach services from rail stations to certain properties (Derbyshire House) and support for bus services to NT properties, often in partnership with Local Authorities (National Trust 2005), but the car share continues to rise. NT attractions have the added disadvantage that members receive free admission and parking, removing financial levers to influence this group of visitors.

Interviews with tourism attraction managers in Purbeck reveal conflicting objectives for public transport initiatives between stakeholders. The link ran from the small town of Wool to the nearest railhead (Wool) had the principal aim to increase visitor numbers by making the attraction accessible to non car owning households rather than to shift visitors from car. Although this meets policy objectives of social inclusion it becomes a promotional tool rather than environmental policy but will achieve growth without an increase in GHG emissions.

There are successful green transport plans for employee mobility, including dedicated buses and coaches and car sharing.

Two of the DCMS proposals specify infrastructure improvement and the development of new products to integrate walking and cycling as part of the tourist experience. The Government’s National Cycling strategy (DOT 1996) and the 10 year plan include a target to triple the number of cycling trips from a 2000 base.

The potential for cycling is under appreciated when one considers levels of
cycling in Holland, Denmark and Germany compared to the UK. A study of the Danish Island of Bornholm, an important tourism destination, showed that 34% of peak season visitors used a bicycle during their holiday (Simonsen et al. 1998) and Dickinson et al. (2007) show it is seen as a leisure experience. In reality there is much greater scope for cycle use for day trips and for destination transport than there is for O/D-transport, which will only appeal to a hard core of enthusiasts and therefore limit cycling’s impact on GHG emissions. Furthermore cycle carriage by public transport operators remains patchy with variable provision by rail operators further limiting its impact on O/D-transport. Sustran’s ‘Cycle Mark’ campaign has set future targets for rail operators both for the carriage of cycles and for the provision of secure cycle parking at rail terminals. Dedicated bus routes in tourism areas equipped with cycle racks or trailers are rare. Whilst cycling has the capacity to reduce dependency on the car for destination transport, there is also the potential to generate car journeys to appropriate cycle venues, with cycles carried on racks.

There are positive developments including a much enhanced national network of safe segregated cycling routes implemented and promoted by Sustrans and improving provision of secure cycle parking facilities including provision at visitor attractions. Can cycling reverse its decline in the UK of the last 50 years? European research suggests a strong link between cycle training at school and levels of cycling as an adult (Russell 2003). The monitoring of 27 Local Authorities in the UK by the CTC shows few examples of large increases in cycling (Russell 2003) and current trends do not suggest a significant contribution over the next 10 years.

The measures in Table 4 are not comprehensive when compared to the White Paper (DETR 1998a). They are predominately soft measures to encourage use of public transport by various incentives such as reduced admission (often termed ‘carrots’ in the literature). A genuine integrated tourism and transport policy needs to incorporate the car restraint measures (the sticks) included in the 1998 paper (Table 3). Currently the majority of schemes at tourist destination, around 70%, focus on the ‘carrot’ (Dickinson et al. 2006), but improvements to public transport services on their own are not sufficiently attractive to encourage modal shift (Holding et al. 1998).

The development of a national road pricing scheme will directly impact on the cost of the O/D trip by car and ‘discretionary’ tourism journeys by road will show some sensitivity to price. Current policy documents do not address or model how road pricing will impact on the targets for 4% tourism growth.

Park and ride schemes are the most widespread and long running policy in the UK. They acknowledge the need to separate the two elements of tourism travel and facilitate O/D-transport by car but accept there are significant benefits from keeping these cars out of sensitive environments such historic towns or fragile rural areas of scientific importance. Monitoring of the Oxford park and ride scheme has witnessed stable city centre traffic levels for 25 years, and increased bus patronage of 80% (Williams 1999) although P&R has negligible impact on GHG emissions.
Assessment of their effectiveness is difficult in the absence of clear objectives and targets but are predominately related to congestion, noise and air quality.

6 Discussion

6.1 Objectives of the DCMS Proposals
A shortcoming of the DCMS paper (DCMS 1999: 56-58) is the lack of any discussion of clear targets and objectives. There is a broad assumption that any shift from car to alternative modes is desirable but the impacts of modal shift are not analysed.

One key target, and the focus of this volume, is the reduction of GHG emissions. The emphasis placed on GHG reduction by the UK Government continues to grow as reflected by the Stern Report (Stern 2007) and O/D-transport is dominant to tourism’s environmental contribution. It accounts for around between 50% and 75% of the total environmental impact of tourism (DG Enterprise European Commission 2004) of which the impact of destination transport is small (Peeters et al. 2005).

Unlike the consultation document (DCMS 1998) the proposals in ‘Tomorrow’s Tourism’ (DCMS 1999) do not address whether they target O/D-transport or destination transport and whether different policies for these two elements are required. The policies to improve public transport information could be seen to apply to both, although the greatest improvements are experienced when planning the last chain of a multi chain trip to a destination. Green transport plans also apply to both elements. For staying visitors they may reduce the use of the car for destination transport but are unlikely to significantly effect modal choice for O/D-transport but they are directly aimed at the O/D element of day trips. There are an estimated 1.1 billion daytrips (The Countryside Agency 2004) compared to 75.5 million domestic holiday trips (UKTS 2004) and it is estimated that 20% of the longest daytrips cause 80% of domestic tourism’s GHG emissions. Increased cycling and walking have much greater potential to influence destination transport but again could be incorporated into a planned daytrip using public transport as an alternative to the car. An integrated tourism and transport policy must set clearer, less ambiguous and measurable transport objectives in addition to the tourism growth target.

6.2 Inherent Advantages of the Car
Neither paper (DCMS 1999, DETR 1998a) directly addresses the inherent advantages of car for leisure and tourism travel summarised in Table 1. Perhaps the greatest barrier for public transport operators to attract a modal shift from car is price. Fares for public transport continue to rise in real terms (DfT 2006a) and in this era of mass car ownership the costs of taking tourism journeys by car is low. Although the full cost of car use is estimated by the Automobile Association at around 44p
per vehicle mile (AA 2004) or 24p per passenger mile (DfT 2005) around 60% of these costs are fixed costs, incurred on an annual basis and unrelated to mileage. A discretionary tourism journey does not generate additional fixed costs, therefore the escapable costs of such journeys are the cost of the trip as opposed to leaving the car parked at home. This is low compared to public transport alternatives (Table 5).

<table>
<thead>
<tr>
<th>Transport mode</th>
<th>Cost (pence per mile)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rail</td>
<td>17</td>
</tr>
<tr>
<td>Bus</td>
<td>22</td>
</tr>
<tr>
<td>Motoring fuel costs</td>
<td>06</td>
</tr>
<tr>
<td>All motoring costs</td>
<td>24</td>
</tr>
</tbody>
</table>

Table 5: Average cost per passenger mile by mode (DfT 2005: 89).

In addition, the cost of carrying additional passengers by car is virtually zero and the average occupancy of cars for leisure and tourism trips is higher than for other journey purposes. The NTS shows an average occupancy of 2.2 people per trip (DfT 2005) whilst the occupancy for day trips is even higher at 3.9 (The Countryside Agency 2004). Some public transport operators have attempted to react with targeted products such as Family Railcards, but the car remains an ideal option for such groupings.

The price differential between motoring costs and public transport costs continues to widen. Although petrol costs have risen above the rate of inflation, overall motoring costs have risen almost directly in line with inflation increasing by a mere 4% in real terms since 1990. In contrast the cost of public transport has continued to rise, over 20% since 1990 (DfT 2005), which does not generate optimism for a significant modal shift. A national road pricing scheme will narrow the pricing gap internalising the costs car users impose on others creating a more level playing field for public transport, although the impact of such a change on the domestic tourism industry is more unpredictable. It could encourage modal shift, but alternatively it could also deflate domestic tourism growth.

6.3 Development of an Integrated Policy

On reflection UK policy has developed little over a thirty year period. Schemes that incorporate a two pronged policy of 'carrot' in the form of improved public transport services and 'stick' in the form of some sort of restriction on the car to produce a modal shift have been tried since the 1970s, for instance, the Goyt Valley in the Peak District National Park (Cullinane 1997). This approach has failed to produce an overall significant shift away from car. Comparisons between 1998 and 2002/3 shows a marginal increase in the car share for day visits (from 71% to
73%) and no significant change to the very high share for trips to National Parks (Speakman 2005).

One may argue that there have been an insufficient number of schemes to date to be effective. However all schemes in rural areas require subsidy so widespread expansion is dependent on appropriate funding from Central or Local Government. Furthermore the literature highlights several schemes which have had to be abandoned (Cullinane 1997, Lumsdon et al. 2004, Dickinson et al. 2006) due to insufficient passenger numbers to meet financial targets. Furthermore local resident opposition to car restraint measures came out strongly from our research in Purbeck (Dickinson et al. 2006).

A truly integrated tourism and transport policy requires a much wider agenda. Policy options should extend beyond a reactive policy of encouraging modal shift within the current patterns of tourism demand to explore policy options which meet both tourism and transport objectives by influencing the pattern of tourism demand itself. For instance, an increase in the average length of stay including more overnight visitors at the expense of day visitors can achieve tourism growth as measured by tourism nights or tourism spending, with no increase in GHG emissions and without a major change in modal choice. A trend towards shorter domestic tourism trips is more ambiguous in terms of impact. Whilst a shorter O/D-transport trip would logically produce reduced GHG emissions, it will also reduce the scope for modal shift, particularly from car to rail and is an area for further research work.

The literature does identify some successful local schemes. The widely cited Moorbus network in the North York Moors National Park (DCMS 1999) and an integrated multi modal ticket (Wayfarer) used for leisure day trips into the Peak District National Park (Lumsdon et al. 2006) identify modal shift.

Both schemes share certain characteristics:

• Both have been operational for over 20 years which builds familiarity and confidence. Many short term schemes lasting for one season or less before withdrawal, usually on financial grounds, have little opportunity to become established (Dickinson et al. 2006).
• Significant numbers of their users have a car available at the point of use (around 42%).
• Both services appeal disproportionately to older age groups.

However their impact is marginal on overall modal split. For instance it is estimated that Moorbus carried 27,000 passengers and saved around 350,000 car miles in 2000, a very small percentage of all car drivers to the area. Furthermore it is heavily dependent on subsidy covering only 20% of costs with fare revenue (Breakwell 2005) so widespread replication will be expensive.
Table 6: Travel to National Trust attractions: Prior Park and Lyford in 1999 (Source: Market Research Group, Bournemouth University).

### Mode choice to Prior Park in 1999

<table>
<thead>
<tr>
<th>Transport Mode</th>
<th>Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td>41</td>
</tr>
<tr>
<td>Coach</td>
<td>5</td>
</tr>
<tr>
<td>Taxi</td>
<td>2</td>
</tr>
<tr>
<td>Bicycle</td>
<td>5</td>
</tr>
<tr>
<td>Motorbike</td>
<td>4</td>
</tr>
<tr>
<td>Lift</td>
<td>8</td>
</tr>
<tr>
<td>Walked</td>
<td>7</td>
</tr>
<tr>
<td>Parked/walked</td>
<td>24</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
</tr>
</tbody>
</table>

### Distance Travelled to Prior Park Share in 1999 (%)

<table>
<thead>
<tr>
<th>Distance</th>
<th>Member</th>
<th>Non-member</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 5 miles</td>
<td>19</td>
<td>23</td>
</tr>
<tr>
<td>5-14 miles</td>
<td>41</td>
<td>52</td>
</tr>
<tr>
<td>15-24 miles</td>
<td>31</td>
<td>12</td>
</tr>
<tr>
<td>25-34 miles</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>35-49 miles</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>50 miles +</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

### Mode choice to Lyford in 1999

<table>
<thead>
<tr>
<th>Transport mode</th>
<th>Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>82</td>
</tr>
<tr>
<td>Coach</td>
<td>3</td>
</tr>
<tr>
<td>Public Transport</td>
<td>1</td>
</tr>
<tr>
<td>Bicycle</td>
<td>3</td>
</tr>
<tr>
<td>Motorbike</td>
<td>3</td>
</tr>
<tr>
<td>Other</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 6: (continued).

<table>
<thead>
<tr>
<th>Distance travelled to Lyford</th>
<th>Share in 1999 (%)</th>
<th>Share in 2000 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Member</td>
<td>Non-member</td>
</tr>
<tr>
<td>Under 5 miles</td>
<td>18</td>
<td>25</td>
</tr>
<tr>
<td>5-14 miles</td>
<td>25</td>
<td>26</td>
</tr>
<tr>
<td>15-24 miles</td>
<td>24</td>
<td>27</td>
</tr>
<tr>
<td>25-34 miles</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>35-49 miles</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>50 miles +</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Prior Park in Bath is a National Trust attraction that was developed with no car parking facilities (Table 6) and visitor numbers have been in line with expectations with far fewer arriving by car. However comparison with another NT attraction (Lyford) indicates the policy has a significant influence on the distance travelled to the attraction, with visitors from over 25 miles underrepresented, resulting in a smaller catchment area. Whilst a clear benefit in terms of GHG emissions the potential of car restraint policies to hinder tourism growth in the longer term are demonstrated and longer term monitoring of visitor numbers will be interesting.

Initial monitoring from road charging schemes show a greater impact on traffic levels. In London traffic reductions have been around 20% resulting in increased speeds for cars and bus (Turner 2003) whilst Durham has also been successful.

One approach for UK integrated policy is to use experience from Europe. Tourism transport in Europe is also car dominated with 68% of trips undertaken by car (Peeters et al. 2007) and rail share has fallen from 10% of passenger kms in 1970 to 6% in 2003 (Nash et al. 2004). However as in the UK there are examples of successful local schemes. For instance the Swiss association GAST (Gemeinschaft Autofreier Schweizer Tourismusorte) encompasses nine virtually car free tourist resorts and differs from the UK experience in one crucial respect, the greater integration of policy over a wider destination area (Høyer 2000). A successful initiative to encourage the use of public transport over a wider geographical area and influence O/D-transport is the RailAway initiative in Switzerland launched in 1999 (Lumsdon et al. 2006). The rail share for domestic tourism rose to 16.3% of trips by 2001 and accounted for 25% of passenger kms in 2005, demonstrating what can be achieved with appropriate price, promotion and packaged tourism products.

6.4 Wider Responsibility

Government policy can set an appropriate framework for encouraging environmentally responsible transport choices, but consumers also have to take responsibility for the difficult dilemmas and lifestyle choices required to reduce GHG-emissions. A significant modal shift from car to public transport requires a change in
consumer behaviour, which is not imminent. Local opposition to car restraint in tourist destinations has been reviewed and surveyed by Dallen (2007) and Gronau et al. (2007) who identify a hard core of car tourists strongly resistant to changing their mode of transport in both the UK and mainland Europe. In the longer term difficult choices involving personal responsibility to reduce carbon footprints will be required to drive modal shift.

7 Conclusions

Policies to reduce the dominant position of the car for UK domestic tourism travel have not succeeded. There are small increases in the car share for day trips, and although the market share for holiday trips by car has fallen slightly, this has been to the benefit of domestic air. Government policy has not addressed the fundamental inherent advantages of using the car for O/D-transport, nor will it until the introduction of a national road pricing scheme. Still it is far from clear that the Government has considered the impact of road pricing on tourism growth.

There has been more success in achieving modal shift for destination transport. Park and ride has emerged as an established policy approach and when well planned and established over time can significantly reduce car traffic in central areas (Oxford) although benefits are limited spatially and include negligible reduction to GHG emissions. Likewise the early evidence from local road charging schemes (London and Durham) is encouraging for reducing traffic in sensitive areas and again it is unclear how effective local schemes are in reducing O/D-transport by car. In many locations schemes run up against strong opposition from local residents unwilling to see their car use restricted.

This paper demonstrates Government policy has not come to grips with the complexity of advancing the objective of car traffic reduction combined with continued tourism growth. There is a clear need for a dedicated Government paper to advance integrated transport and tourism policies which needs to move policy forward and set clear targets, in particular the balance between local destination benefits and reducing GHG-emissions. The latter can be achieved in part by targeting a minority of car trips which create a disproportionate share of emissions combined with changing patterns of domestic tourism demand to longer average stays. The research agenda should review the impact of local car restraint schemes including road pricing on consumer attitudes and also on their travel behaviour, particularly with respect to O/D-transport. However achieving modal shift cannot be the sole responsibility of Government. The conflicts identified in this paper also have to be addressed by consumers accepting personal responsibility for their lifestyle choices.

There has been a decline in traffic growth over the last few years (see §2.1) which is encouraging in terms of reducing GHG emissions although the early evidence
is that this slow down of traffic growth has been accompanied by a slow down of tourism growth rather than any modal shift, with a 5% decrease in the number of day trips between 2003 and 2005 (The Countryside Agency 2006), demonstrating the difficulty of meeting both objectives.

References

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HOW HEAVY WILL THE BURDEN BE? USING SCENARIO ANALYSIS TO ASSESS FUTURE TOURISM GREENHOUSE GAS EMISSIONS

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b Centre de recherche interdisciplinaire sur le droit de l'environnement, de l'aménagement et de l'urbanisme (CRIDEAU- Université de Limoges)

Abstract - Climate change mitigation involves setting long term policy objectives, for 2050 or even 2100. Future studies can be a tool for decision making, by analysing the different parameters influencing current and future issues, by evaluating the effort required to curb the greenhouse gas emissions of tourism and transport, and by designing coherent combinations of instruments allowing to reach targets such as a reduction by a factor 4 of emissions. The aim of this paper is to assess critically existing research in the field of future studies linking tourism and transport, to examine what kind of tourism and leisure would be possible for the French under the constraint of a reduction by a factor 4 of emissions, by building a backcasting scenario. Furthermore, we describe the potential implications of such a scenario in the field of infrastructure development, technological improvement, but also of lifestyles and cultural change.

1 Introduction

The purpose of this paper is to confront the future of leisure and tourism mobility to environmental constraints and sustainability objectives. It focuses particularly on greenhouse gas emissions whose mitigation is increasingly recognised as an overwhelming factor of future environmental policies (IPCC 2001, Stern 2006). Tourism and recreation account for a growing share of the emissions from transport, which themselves represent a growing share of national emissions. Also it has been shown that, for tourism, the emissions from transport dwarf those from accommodation and activities at the destination (Becken et al. 2002, EPA 2000, Gössling et al. 2005). Since international air transport is not included in the Kyoto protocol though air transport is responsible for more than half of the contribution of tourism to global warming (Peeters et al. 2007), the issue of emissions from tourism has been largely ignored.

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This paper summarises part of a research for the French Ministry of transport. Demain, le voyage. La mobilité de tourisme et de loisirs des Français face au développement durable. Scénarios à 2050. Downloadable from www.tec-conseil.com
Recently some research has been published, focusing on describing the current situation (Becken et al. 2006, Becken et al. 2002, Dubois et al. 2005a, Gössling et al. 2005, Hoyer et al. 2001, Hoyer 2000, Kruger Nielsen 2001): what are tourism transport emissions, according to the modes of transport, the destinations, the types of tourism and of tourists? Understanding the present and the past is a prerequisite to research on tourism futures. The next logical phase has been to examine where the current trends are leading to. This type of analysis can focus on the medium term (2020 or so), which is quite sufficient to show that the future is not sustainable (Peeters et al. 2004, Peeters et al. 2007). Such forecasts often point to deadlocks and express the need to develop alternative visions of tourism and transport, in the medium and long term. It is then necessary to bridge with long term scenarios on the global environment whose time horizons often range from 2050 to 2100 and to show what a sustainable future could be. Such a picture of the future should be internally coherent (diverse coherent pictures are though possible), and should focus on ‘feasibility’, confronting scenario stories with issues such as technical feasibility, funding and investment, social and political acceptability.

Our approach to future studies combines modelling and building scenarios. The two have been frequently opposed, since French ‘prospective’ has been historically sceptic regarding modelling and planning, accused to consider either that the ‘future is written’ or that it can be totally controlled. Thus, future studies tried to transcend conventional deterministic models of change. Our approach is driven by a focus on demand, investigating its economic, social and cultural drivers, and paying in particular attention to the trade-offs between the various uses of time, an issue frequently overlooked when dealing with tourism and leisure mobility. We propose the hypothesis that the substitution potentials between the uses of time, including between tourism and home-based leisure, could give a way out of many environmental deadlocks, providing ruptures in tourism and recreation behaviours are accepted.

2 Methods

2.1 Tourism and transport, qualitative and quantitative methods

to integrate one field (tourism and recreation) with another (transportation). In the former, thinking appears to be generally qualitative even though large statistical data bases are available. In the latter, contemporary research on the future has been more based on quantitative approaches.

Future research is currently evolving. Some scientists and practitioners try to develop its scientific basis (Glenn et al. 1999, Mermet 2003, Mermet 2005), while others still consider it as a collection of practical tools which are output oriented rather than knowledge oriented. Global assessments such as the Millennium Ecosystem Assessment (MEA, 2005), UNEP Global Environment Outlook (UNEP 2002), or the IPCC SRES scenario (IPCC 2000) provide a state of the art of this field. The integration of narrative discourse (qualitative) and figures (quantitative) appears as one of the main challenges facing the discipline. In the framework of the MEA, Raskin et al. (2005) sorted existing global scenario studies into ‘modeling-based’ and ‘narrative-based’ and state: “The development of methods to blend quantitative and qualitative insight effectively is at the frontier of scenario research today... Narrative offers texture, richness, and insight, while quantitative analysis offers structure, discipline, and rigor. The most relevant recent efforts are those that have sought to balance these.”

Considering this debate, we feel it useful to unpack the process of scenario building into a few components/steps on which scenarios more or less dwell according to the qualitative or quantitative orientation of the work. These are: ‘Scenario stories’ (1), starting from a guiding principle, and articulating economic, societal, cultural ‘Trends’ (2), variables and quantitative ‘Parameters’ (3), feeding some ‘Models’ (4) that produce quantitative ‘Results’ (5) which can be interpreted as ‘Impacts’ (6). Narrative works tend to privilege steps (1), (2) and (6), while quantitative works insist on steps (3), (4), and (5).

Table 1 gives a short description of the steps. The numbering of steps is not chronological. All scenario development exercises start with a description and analysis of the past and present trends. The bifurcation comes from the diverging representations of this initial assessment: a model for quantitative scenarios, a systemic representation of variables in qualitative ones. The range of methods is very diverse. Some works insist on the elaboration of strong guiding principles, framing scenarios from which trends and impacts are deduced. Others start with a description of expected futures, and elaborate scenario stories to reach this goal (backcasting exercises). In short, models produce impressive figures and numbers, but with a low linkage to the socio-economic context which is deemed to allow the combination of parameters they use, while narrative scenarios are totally embedded in this context, but their results, if quantified at all, are poorly justified by a formalisation or by the linkages between trends and parameters, e.g. the linkages between the ageing of population and the evolution of departure rate on holidays.
Table 1: The components of a scenario analysis. GHG = greenhouse gas.

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</tr>
</thead>
<tbody>
<tr>
<td>e.g. “business as usual…”</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Economic</td>
<td>• Number of trips</td>
<td>• More or less</td>
<td>• Passenger km</td>
<td>• Congestion</td>
<td></td>
</tr>
<tr>
<td>Social</td>
<td>• Average distance</td>
<td>sophisticated</td>
<td>• GHG- emissions</td>
<td>• Noise-Climate change</td>
<td></td>
</tr>
<tr>
<td>Environmental</td>
<td>• Modal split</td>
<td>• Different combination of parameters</td>
<td>• Number of trips by transport mode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cultural, e.g.:</td>
<td>• Load factor</td>
<td>determine different</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>economic growth,</td>
<td>• Elasticity</td>
<td>scenarios</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>population ageing</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Rather than on the quality of the modelling, our efforts concentrated on the improvement of the linkages between the components of a scenario analysis (the three ellipses in Figure 1): e.g. how can the relationship between each individual societal trend (economic growth and departure rate, reduction of working time and departure rate, etc.) be documented from the bibliography or from statistics? How can a set of trends be assembled/combined into coherent scenario stories with a guiding principle? How can the results obtained by the model be translated into impacts: e.g. establishing a relationship between the number of pkm (passenger kilometres) travelled and the congestion of infrastructure. The steps from 1 to 6 in Figure 1, correspond to the chronological order chosen in our work: building the model, then analysing possible future trends and their impact on model parameters, etc. In a step ‘0’ - analysing past and present trends - the most important factors for change (trends) have been selected so as to develop the model.

Figure 1: The steps in creating scenarios and analysing impacts.
2.2 Modelling

We limit our field of research to recreation and leisure tourism of French residents in France and abroad, thus excluding foreign visitors to France, as well as business travel. Rather than examining future developments of tourism and leisure mobility by projecting mean values or elasticities into the future, which seems inappropriate for a long term future of 2050 (ENERDATA 2004), we chose to analyse the future of different mobility patterns, empirically designed so as to seize the potentials for behavioural evolution identified in the current bibliography on tourism (emerging trends, such as bi-residentiality, already observed in the tourism demand).

We thus first defined five types of mobility (Ceron et al. 2005), characterised by a mean distance of trips, and a number of trips referring to current statistical data:

- very long distance mobility (distant Europe + overseas)
- long distance mobility (France + neighbouring countries)
- outings (excursions + week ends nearby)
- bi-residential mobility
- short distance leisure mobility

These types of mobility are combined (in various proportions) into five patterns, with a modal breakdown:

- conventional traveller
- great traveller (Parisian…)
- home-centred
- bi-residential
- home bound.

The model thus divides the tourism and leisure mobility demand into 100 segments (5 patterns by 5 types of mobility by 4 transport modes). To each transport mode corresponds GHG (greenhouse gas) emission factors.

This process has led us to take some distance with several usual statistical categories of tourism and recreation, since, for instance, neither nights spent away from home, nor crossing a border are satisfactory criteria to assess the environmental impacts of current or future behaviours. The types of mobility we use therefore mix traditional categories (e.g. long distance mobility is a mix of international tourism in neighbouring countries, and domestic tourism in seaside or mountain resorts). Conversely, changes in the distance of trips, in their destinations, the length of stays etc. can show that the benefits expected from a tourist trip or its environmental impacts are evolving.

The model allows shifting from an individual approach of demand as described above to a global approach, based on the mobility of households. For year 2000, the model was calibrated with existing databases giving the number and modal breakdown of tourism trips and pkm travelled for tourism and leisure. For 2000, air transport represented for instance 61% of tourism and leisure related GHG emissions.
emissions; 9\% of “great travellers” households were responsible of 32\% of those GHG emissions.

### 2.3 Sensitivity analysis

After this step we examine how the situation in 2000 could evolve to 2050 following the changes occurring within six categories (see Table 2) and 13 factors (see Figure 2). For each factor, a ‘central’ (business as usual) assumption was defined, as well as ‘high’ and ‘low’ assumptions, regarding their possible effects on GHG emissions. For example, a context of global peace and prosperity is an incentive to travel more (‘high’ assumption) and contrasted to this, global terror and instability would very likely lead to a decrease in international mobility (‘low’ assumption). Each assumption of each factor is accompanied by a ‘micro-story’ or a ‘description’; these basic blocks are assembled into scenarios storylines.

![Figure 2: Potential individual effects of factors on tourism and leisure pkm travelled by 2050. Square: central hypothesis, line: low and high hypothesis.](image)

### 2.2 Forecasting and backcasting

Research into the field of transports usually relies on the most common methods of future studies (i.e. scenarios in a forecasting perspective) but climate change issues have lead to call on other approaches such as backcasting, so as to be able to deal with issues linked to the stabilisation of GHG emissions at an acceptable level (ENERDATA./IPP/ECN/STE-Juelich/Verbundplan 2002, Radanne 2004, Stern 2006, Swart R.J. et al. 2004, Tyndall Centre 2005). Actually, both approaches can
be useful to design a more sustainable tourism mobility: contrasted forecasting scenarios can help identifying risks and potentials for actions, while backcasting scenarios allow assembling ensembles of measures and policies in a coherent way.

We first built a ‘central’, business as usual (BAU) forecasting scenario. For this we used individual ‘central hypothesis’ on factors, though avoiding contradictory situations and double counting.

Two extreme forecasting scenarios, a low emission scenario named ‘A conflicting de-development’, and a high emission one, named ‘The world is ours’, were built based on ‘low’ respectively ‘high’ hypothesis for the factors. The scenario ‘guiding principle’ is deduced from assembling the ‘micro-stories’ describing the future for each of the factors. Facing the BAU scenario, we built a sustainable development backcasting scenario based on a reduction by a factor four of nation-wide emissions by 2050. This is a governmental objective (De Boissieu 2006) which derives from a stabilisation goal of all greenhouse gases at a level of 550 ppm, itself reflecting a supposedly acceptable increase of 2°C in global mean temperatures; similar goals are set in the UK or in California (Stern 2006).

The definition of the targets for tourism and leisure is a critical issue. First, the emissions of international aviation related to tourism were added to the results of the calculations under the UNFCC framework, to define both French overall emissions in 2000 and the target for 2050. Second, the construction of the scenario was preceded by a discussion on how tourism and leisure should be treated in a sustainable future. To what extent should these kinds of mobility be privileged or not, owing to their valuation by society, and to the particular difficulty to curb some of their emissions (lack of substitute fuels for aviation)? A target of 13 Mton CO$_2$-e (carbon dioxide equivalents) in 2050 for leisure and tourism transport was retained, which corresponds to a factor 3 reduction for tourism and leisure. Third, though climate change appears as an overwhelming concern, it has to be weighted against economic and social dimensions of sustainable development (e.g. an equitable access to mobility) and other environmental dimensions such as, in the present case, noise, the congestion of transport systems and of the European sky or the availability of fuel resources. Thus, seven objectives, derived from the ‘Mobility 2030’ exercise of the World Business Council for Sustainable Development (WBCSD 2004) were considered as the requisites of a sustainable mobility scenario.
Table 2: Seven objectives for a sustainable mobility scenario.
Derived from WBCSD (2004).

<table>
<thead>
<tr>
<th>WBCSD Objectives</th>
<th>Sustainable development scenario objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limit transport-related GHG emissions to sustainable levels.</td>
<td>Include tourism transport in a factor 4 reduction strategy of GHG emissions in France.</td>
</tr>
<tr>
<td>Narrow the «mobility opportunity divides»….</td>
<td>Increase the holiday departure rate.</td>
</tr>
<tr>
<td>Preserve and enhance mobility opportunities for the general population of both developed and developing-world countries.</td>
<td>The choice of a factor 4 reduction of GHG emissions leaves room for developing countries to increase their mobility.</td>
</tr>
<tr>
<td>Ensure that the emissions of transport-related conventional pollutants do not constitute a significant public health concern anywhere in the world.</td>
<td>The trend is to a reduction of conventional pollutants a) with the enforcement of European standards, b) with a reduction of tourism transport by road. An attention should however be paid to feed-back effects between GHG reduction and conventional pollutants.</td>
</tr>
<tr>
<td>Reduce transport related noise.</td>
<td>Stabilization or reduction of road transport in the scenario; concern about rail-related noise</td>
</tr>
<tr>
<td>Mitigate congestion.</td>
<td>Stabilization or reduction of road transport; concern about rail congestion.</td>
</tr>
<tr>
<td>Significantly reduce the total number of road vehicle-related deaths and serious injuries.</td>
<td>a) Stabilization or reduction of road transport compensated by less hazardous collective transport b) Improvement of road security measures (speed limitations).</td>
</tr>
</tbody>
</table>

The combination of trends enabling to reach these goals is expressed in the scenario storyline and, using the model, leads to a breakdown of household mobility between different types of mobility and transport modes.

Table 3: (on opposite page) Factor four scenario summarised storyline.
<table>
<thead>
<tr>
<th>Category/Subcategory</th>
<th>Trend by 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographics</strong></td>
<td><strong>Population growth</strong> French population: 57 million.</td>
</tr>
<tr>
<td></td>
<td><strong>Ageing of population</strong> 29% over 65 years and 18% over 75 years. Reduction of departure rate, increase of collective means of transport.</td>
</tr>
<tr>
<td></td>
<td><strong>Generational effect</strong> New generations (below 50 years old) travel less (economic constraints, cultural change) than older ones used to travel at the same age.</td>
</tr>
<tr>
<td></td>
<td><strong>Evolution of family structure</strong> Moderate decline of number of persons per household.</td>
</tr>
<tr>
<td><strong>Economics</strong></td>
<td><strong>Economic growth</strong> Annual rate 1.5%-2%. A substantial part of additional revenue is devoted to the reshaping of the economy (habitat) towards more sustainable patterns: more demand for tourism mobility, but less than in the BAU scenario.</td>
</tr>
<tr>
<td></td>
<td><strong>Unemployment &amp; social insecurity</strong> More equalitarian distribution of income, voluntary policies regarding access to holidays: increase of departure rate in the conventional pattern.</td>
</tr>
<tr>
<td></td>
<td><strong>Diminution of working time</strong> Moderate diminution. Pressure on workers (many retired people). Additional spare time mainly devoted to proximity leisure.</td>
</tr>
<tr>
<td></td>
<td><strong>International context</strong> Current situation prolonged. International tensions not really refraining from travelling.</td>
</tr>
<tr>
<td><strong>Transport technology &amp; policy</strong></td>
<td><strong>Technology</strong> Strong technological progress. Energy efficiency improves by 60% for air transport, 70% for cars, 50% for train and 35% for other modes.</td>
</tr>
<tr>
<td></td>
<td><strong>Infrastructure choices</strong> Fast European spreading of high speed train networks, renewal of secondary lines, transport on demand, quality inter-urban bus transport, no longer development of regional airports.</td>
</tr>
<tr>
<td></td>
<td><strong>Transport pricing</strong> Heavy taxation of air transport (100-200 euros per seat). End of the low cost model in Europe. Increased cost of road transport (fuel cells are still costly, high price of fuel). The competitiveness of train is improved.</td>
</tr>
<tr>
<td></td>
<td><strong>The tourism market</strong> More organised trips involving collective means of transport (train), tour-operators more involved in leisure near the home. New soft-mobility or long stays products.</td>
</tr>
<tr>
<td><strong>Society and lifestyles</strong></td>
<td><strong>Habitat</strong> High environmental quality habitat, not more comfortable (smaller homes, due to environmental constraints), high level of public investment in urban environments, gardens, suburban natural spaces, cultural activities.</td>
</tr>
<tr>
<td></td>
<td><strong>Cultural change</strong> ‘Slowing down’ of mentalities and end of hyper mobility patterns. Trips are more exceptional. More home-centred lifestyles, in which very long distance travel is a rare but highly prepared and satisfying event.</td>
</tr>
</tbody>
</table>
3 Results and discussion

3.1 A quantification of tourism and leisure mobility: its impact in a sustainability scenario

The scenario shows it is possible to accept a moderate increase in tourism and leisure mobility, even under these strong constraints. Overall tourism and leisure mobility reaches 291 billion pkm in 2050, which is 34% more than in 2000 (the business as usual scenario leads to 742 billion pkm).

The increase in individual distance travelled per year is only 12% (up to 4553 pkm per year for leisure and tourism purposes), the remainder of the growth of the total is caused by the increase of the population. These results reflect the positive values related to tourism (contacts between people, etc.), which are preserved in the scenario. Nonetheless, a reduction of the environmental impacts and a compliance with other dimensions of sustainable development imply that such results can only be reached through a considerable redistribution of mobility between the types of trips, transport modes and categories of tourists. For example very long distance mobility (overseas travel by air) is globally maintained almost at the same level as in 2000, where it would grow at a fast pace in the BAU scenario. Another difference is that long haul trips are more equitably shared. First, the scenario accepts a fall of 20% in the mean distance of trips, driven by an increase in the cost of air travel. One intercontinental trip a year for 10% of households in 2000 is replaced in 2050 by one intercontinental trip every seven years for 70% of households. Long distance mobility decreases (0.67 trip per year and per individual compared to 1.2 in year 2000). This is largely a consequence of the level at which very long distance mobility is maintained, and related to the assumption that exoticism will remain more attractive than traditional European resorts. An increase in outings compensates the fall in long distance mobility (3.7 outings per individual compared to 1.99 in year 2000). Leisure near the home is another manner to compensate: this type of mobility doubles by 2050.

So, two main factors characterise the sustainable development in this scenario. A change in tourism/leisure behaviour and habits, and a change in the modal share. Compared to 2000, when train and bus had only 14% of the market shares (in pkm), these two transport modes represent 51% in 2050 (Figure 3). Aviation, by far the most polluting in terms of GHGs is limited to 19%.
**Figure 3:** Modal split in the sustainable development scenario. Breakdown of pkm for all distances in 2000 (inner circle) and 2050 (outer circle).

**GHG emissions**
A constraint of 13 Mton CO$_2$-e (one third of the amount in year 2000) from tourism and leisure in 2050 was set as a target. The BAU scenario would lead to 80 Mton CO$_2$-e. Emissions per person fall by 71% with respect to the amount in 2000.

**Access to recreation and tourism**
The departure rate for tourism reaches 71% (68% in year 2000), which is not the maximum attainable, but yet represents a serious social progress if the ageing of the population is considered. Those who want to travel and are physically able do so. Most of the financial and professional obstacles to (sustainable) mobility are overcome. This scenario not only endeavours to maintain mobility at a level comparable to that of year 2000, but also redistributes it socially. Furthermore it also considers that enriching travel experiences (i.e. increasing the welfare content of an average tourist trip) would lessen the dreams of hyper mobility.

**Noise and congestion**
The development of pkm for each mode gives the basis to analyse the impacts of the scenario regarding noise and congestion. As the scenario shows a decrease of the modal shares of planes and cars, its effects on the congestion of skies and interurban road links, as well as on noise are expected to be positive. The same cannot be said for rail transport which, for tourism and leisure purposes, increases by 250% on interurban links and is nearly multiplied by ten within urbanised areas. This poses severe problems in terms of noise and space availability: additional space for rail infrastructure is difficult to find since in the meanwhile, according to the scenario, urban car transport for tourism and leisure remains stable (+5%).
Figure 4: Development between 2000 and 2050 of tourism transport (pkm) by transport mode and type of traffic – Sustainable development scenario.
Conventional pollutants
The modes of transport the scenario favours call upon electricity (trains, tramways etc.). This probably reinforces the arguments for a massive boosting of nuclear energy which does not emit GHGs but has other potential drawbacks, and is probably more in France than elsewhere a core question of the energy debate (De Boissieu 2006). The decrease in car traffic linked to tourism (-32%), combined with an improvement of energy efficiency also contributes to lowering conventional pollutants emissions.

Safety
The modal shift from car transport for tourism to rail and general measures such as speed limits will have a favourable impact.

Miscellaneous
The scenario should also have other environmental impacts such as an increase of the fragmentation of natural habitats owing to the new rail infrastructures, or an additional pressure on countryside nature with the development of recreation facilities next to the home.

3.2 Pathways for a sustainable tourism and leisure mobility: key potentials for emissions mitigation
The BAU scenario leads to an unacceptable future, owing to a doubling of GHGs emissions which, added to those of other activities lead to an unsustainable world. Some analysts dealing with decarbonisation react to these prospects by suggesting to largely give up international and long haul tourism (Hoyer et al. 2001). This can be viewed as a logical answer and, somehow, the fact that this would be ‘socially unacceptable’ cannot be considered as a counter argument because there is no possibility to negotiate with the laws of physics that govern climate change. We nevertheless think there is obviously a wide variety of possible factor 4 scenarios (ENERDATA 2004). They can for example put the emphasis on solar energy and biomass or on nuclear energy, or make different societal choices (e.g. elitism in travel versus more equalitarian perspectives). All of them, including ours, have the merit of showing the extent of the changes that are necessary. They also show that the possibilities to act on each variable have all their own limits. The factor 4 scenario we have built refers to reasonable prospects for each factor of change and avoids the mentioned limits by using a combination of technical developments (not sufficient alone…), economic and behavioural changes (indispensable…).

• Technology. We are fairly confident that the environmental deadlock associated with air travel is technically insurmountable for the next fifty years. This conviction is founded on a massive literature from eCLAT members and others (De Boissieu 2006, ENERDATA 2004, Giblin 2005, Godard 2006, Gössling 2003, Graham 2000, Olsthoorn 2001, Peeters 2002, Penner et al. 1999, Tyndall...
The prospects for the other modes of transport (rail and GHG neutral road transport) are less reliable. Regarding rail transport, the consensus among scientists seems weaker than for air transport, owing in particular to different national contexts. To reduce GHG emissions for car transport, the scenario supposes a mix of alternative solutions implying energy sources (biofuels, hydrogen, GHG neutral electricity) and technologies (fuel cells, hybrid ‘vehicles’). The share of each alternative solution in the mix is disputable. The feasibility of a hydrogen economy is highly debated (McDowall et al. 2006), as well as its applications to car transport through fuel cells (Romm 2006). Also the advantages of biofuels are not as obvious as they seemed at first (Holden et al. 2005). Moreover, even if these alternative solutions progress, it is likely that the pace will not be fast enough to meet the demand from all sectors and activities. To what extent will the demand from tourism and leisure be prioritised? Would it, for example, be wise to attribute the electricity from wind to personal transport (through hydrogen and fuel cells) if this implies maintaining electricity production from coal to feed other activities (Rameshol et al. 2006.) In that case, hybrid vehicles relying partly on petrol might be a better global alternative as the electricity can be used more efficiently elsewhere. In spite of these constraints, our scenario relies on relatively optimistic prospects (GHG efficiency gains ranging from 35% to 70% depending on transport modes).

- Infrastructure. The scenario relies on a strong development of the entire European network for high speed trains (including new or renewed services such as sleepers), to provide an alternative to air transport on distances up to 3000-4000 km. This would naturally imply a considerable investment, not easily affordable for slow-growth economies like European ones. Furthermore building such infrastructures takes time for technical and social reasons. Is there an alternative to the emphasis the scenario puts on rail? Could another balance with road transport be envisaged? How can the deadlock of rail transport in cities the scenario leads to be dealt with? All this calls for a real revolution in ways of thinking and priorities to overcome difficulties currently considered as insurmountable, such as the common deficit of rail networks for example (DATAR 2003).

- Economy. No massive modal shift will occur without a thorough internalisation of the environmental and social costs of transportation. The scenario relies on a heavy taxation of air transport, high enough to discourage the use of the aircraft, especially on medium distances. Such a choice obviously has some heavy sectorial implications and it will be necessary to choose between conflicting objectives: for example between mitigating GHG emissions and developing the aviation industry (Tyndall Centre 2005). Stemming from this dilemma, an important question is whether the high technological capacity acquired by the aviation industry could shift its focus toward developing new sustainable means of surface transport systems? Why couldn’t the aviation industry be implied in
building new types of cars or trains when the oil industry itself will not hesitate to diversify within a few decades? Could tour operators yield more profits from new products, implying longer stays, and thus more local spending and less dependence on air transport?

• Society and culture. The key point is the need to introduce a new culture of travelling. In short, how can we have people travel less, even if they have time and money? The assembly of household travel patterns pictures the lifestyles of a society. How could the travel patterns defined in the scenario, implying less frequent trips and longer stays, as well as a shift from very long and long distance trips to outings and short distance leisure mobility be attained and spread? Looking at the strong changes between current tourism and tourism fifty years back, proves strong change to be possible (Boyer 2005, Viard 2002a). The novelty rather lies in the fact that the scenario depicts a future which is in many ways a rupture with the current trends of tourism and leisure demands and with the contemporary desires of the greater part of the population (more frequently, further away, faster). These desires are, however, to a large extent shaped by the industry in terms of cost, appeal and marketing efforts. Facing this situation, the emerging trends ('slow tourism', one high quality holiday every two years), favourable to a sustainable tourism development seem quite anecdotal and frail. When will it be necessary that significant ruptures with current trends start to appear (see for an extensive analysis Stern 2006)? One can of course backcast mid-term pictures of tourism from the outcome in 2050. But this does not tell much about the implementation of such intermediate goals especially if they require that we change our behaviour immediately, discard some habits we value and stop dreaming to a future which has hitherto been desired and advertised as accessible (KUONI et al. 2006, Thomson no date)? Nothing will happen without a gain in people’s consciousness. Lifestyles cannot be changed without people’s consent and without an improvement of living conditions at home to a point that it will at least moderate the desire to leave. On those points, we must admit that potentials for action (environmental education, advertisement) appear weak compared to the issues. The ideal solution would be to offer a range of services (common transports etc.) and amenities (urban recreation), attractive enough to divert people from travelling far and/or frequently. This is partly illusive because appealing recreation near the home will not annihilate the call for exotic destinations and also since such voluntary policies seem to governments financially out of reach.

4 Conclusion: recommendations for policy and further research

This paper shows that under a constraint of complying with a fourfold reduction of GHG emissions nationwide by 2050, maintaining the access to holidays and to some extent to long haul leisure travel is feasible. This is by no means a trivial
conclusion. This picture of tourism and leisure mobility implies modifications in lifestyles and technology which do not seem to outpace the extent of changes our societies have known throughout the last half century. It is clear that the changes called for contradict present trends, which spontaneously casts some doubts on their feasibility. Facing such scepticism it must be reminded that if our societies do not regulate themselves they will face more unwanted, far harsher regulations driven by external events (see for example Stern 2006). The mix of solutions to reach a factor four goal for the economy and a factor three goal for tourism (see above) presented here is not unique and can be debated. The feasibility of each of the changes of trends we suggest can of course be disputed, but it is clear that if less is demanded from one type of change (e.g. increasing less the modal share of train) compensation needs to be sought elsewhere (e.g. less pkm by aircraft or less total tourism and leisure mobility). Identifying such key trade-offs and assessing the constraints and social impacts will be a logical follow up to our research.

Another development could be to build on this attempt to combine narrative and quantitative approaches of future studies. First by using a more comprehensive critical methodological assessment of tourism and transport scenario exercises: assumptions (e.g. optimistic assumptions on technological progress) and methodological starting points (quantitative scenarios produced through a combination of parameters, without preliminary analysis of the socio-economic context justifying the choice of such parameters) should be debated. Second, by formalising the methods described above, exploring their potentials, for example to produce unexpected but realistic scenario storylines and to test the impacts of different combinations of basic assumptions. Third by improving the modelling by processing national tourism and transport surveys, allowing to produce means (distance travelled by types of mobility), typologies (of travellers) or to check whether the emerging trends in mobility, observed and described by tourism sociology, can be statistically identified and quantified.

5 References


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