The future tourism mobility of the world population: Emission growth versus climate policy

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Transportation Research Part A
5912 words + abstract + bibliography
Submitted: 30 September 2008

Abstract
Tourism as a sector accounts for a considerable share of global passenger transport, and is thus of interest in studying global mobility trends and emissions associated with transport. In 2005, tourism accounted for about 5% of global CO_2 emissions, three quarters of this caused by passenger transport. Given the rapid growth in tourism, with 1.6 billion international tourist arrivals predicted by 2020 (up from 903 million in 2007), it is clear that the sector will contribute to rapidly growing emissions, and thus increasingly interfere with global climate policy. This is especially true under climate stabilisation and "avoiding dangerous climate change" objectives, implying global emission reductions in the order of -50% to -80% by 2050, compared to 2000. Based on three backcasting scenarios, and using techniques integrating quantitative and qualitative elements, the paper discusses the options for emission reductions in the tourism sector and the consequences of mitigation for global tourism-related mobility by 2050. The paper ends with a discussion of the policy implications of the results.

Keywords: tourism, mobility, climate change, stabilisation, scenarios, backcasting

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1. Introduction

The current development of tourism-related mobility is a serious challenge for global climate change mitigation. Tourist mobility accounts for a substantial share of transport. It includes domestic- and international-, leisure- and business travel involving at least one overnight stay (for the definition of tourism see UNWTO-UNEP-WMO 2008: 121). Globally, emissions from tourism have been estimated to account for about 5% of overall CO_2 emissions, with three quarters of these being a result of tourist mobility, and 25% being attributable to on-site consumption, including accommodation (21%) and tourist activities at (4%) (UNWTO-UNEP-WMO 2008).

A share of 5% of global emissions may not appear to be relevant if compared to other sectors such as agriculture, but tourism is characterized by rapid growth. International tourist arrivals increased from 25 million in 1950, to 534 million in 1995, and 803 million in 2005. In the period 2005-2007 alone, international tourist arrivals grew by another 100 million to 903 million. If the trend continues, emissions from tourism will increase by more than 150% by 2035 (UNWTO-UNEP-WMO 2008). This growth in emissions has to be seen in the context of global reduction needs as outlined by IPCC (2007a, 2007b), with demands on industrialized countries to reduce emissions by 50-80% by 2050. This is likely to lead to a situation of contraction and convergence, i.e. where growing emissions from what is currently a relatively small sector, tourism, will rapidly become more important both in relative and absolute terms, as overall emissions decline (see e.g. Bows et al. 2006b, Tight et al. 2005). Understanding and controlling emission growth in tourism will consequently become increasingly urgent.

Emission reduction needs are outlined in the Kyoto Agreement. Although a consensus has emerged that global warming of less than +2℃ is no t likely to lead to dangerous interference with the climate system (cf. Meinshausen et al. 2006), the level of emission reductions to be reached by 2050 is still debated. Until recently, it was thought that reducing emission levels by 50% by 2050 (compared to 1990 levels) would be likely to prevent atmospheric CO_2 concentration of 450ppm, or what is considered to correspond to a warming by 2℃. However, some recent publications have pleaded for a 80% reduction of emissions worldwide by 2050 (Parry et al. 2008). Other authors have reasoned that the long term CO_2 concentration avoiding dangerous interference with the climate system should not exceed 350 ppm (Hansen et al. 2008), i.e. a level lower than current atmospheric concentrations of CO_2. If this goal was adopted, emissions would have to decline by about 3% per year after 2015 (Hansen et al. 2006).

Climate change is to a considerable extent addressed by modelling and scenario building techniques. With regard to transport, trend extrapolations or "business as usual" scenarios (Ceron et al. 2006a, Dubois et al. 2007, Peeters et al. 2007, UNWTO-UNEP-WMO 2008) all point to rapid growth in emissions in the order of a factor 2 to 3 over the next 30 years. Consequently, climate stabilisation objectives increase the need for backcasting techniques (Åkerman et al. 2006, Anderson et al. 2001, van Notten et al. 2003, Swart et al. 2002) and normative scenarios (Coates et al. 2003, van Notten et al. 2003, Prideaux et al. 2003) to identify pathways that could lead to emission reductions. Moreover, the time horizon involved (50-100 years) means that adaptive models that can capture changes in critical parameters must be built. Finally, ambitious emission reduction targets – both proposed by IPCC (2007a, 2007b) as well as adopted by governments – imply the need not only to consider developments in infrastructure and technology, i.e. quantitative changes relatively easily integrated in models, but also to explore the diversity of qualitative socio-cultural factors shaping, together with economic factors, current and future tourism demand. In future studies two cultures have emerged (Bradfield et al. 2005): the US school (mainly quantitative) and the French school (qualitative, De Jouvenel 1964, Godet 1997, Hatem 1993, Mermet 2003, Mermet 2005). The best way forward seems to integrate both, which is a methodological challenge (Raskin et al. 2005b). Regarding tourism futures, various attempts have been made in this direction by both tourism and transport stakeholders, as well as academics (e.g. Bows et al. 2007, Bows et al. 2006a, Ceron et al. 2005, Conseil Général des Ponts et Chaussées 2006, Dubois et al. 2007, ENERDATA 2004, Futuribles 2005, KUONI et al. 2006, Laboratoire d'économie des transports et al. 2008, Lyons et al. 2000, Peeters et al. 2004, Schafer et al. 1999a, Shell 2002, Thomson no date, Timms et al. 2005, UNWTO-UNEP-WMO 2008, WBCSD 2004). An analysis of these studies reveals common approaches, but also considerable differences and some potential shortcomings.

- The year 2050 is a time horizon frequently used, allowing consideration of long-term environmental issues, but avoiding the uncertainty of long-term society change. With regard to tourism, however, 2050 may already pose major challenges in making assumptions, for instance on consumption patterns.
- Many studies are hampered by a lack of data, which explains why tourism development scenarios are usually based on qualitative assumptions.
- National studies tend to focus on domestic transport, ignoring the development of international aviation. This is a major omission, given that air transport represents 40% of global tourism emissions, and implies a significant underestimation of transport volumes.
- Both backcasting and forecasting are used, but seldom with an exclusive focus on tourism. Within tourism, transport is paid great attention due to expected growth patterns and the difficulty of using non-carbon energy sources.
- There are very few long-term scenarios with a focus on climate change and tourism.

Table 1 summarizes important tourism and transport scenario-based surveys, substantiating the above summary.

Source	Scenario Type	Quantitative/ qualitative	Timeline	Geographical scope	Thematic scope	Focus	Authorship
WBCSD 2004	Forecasting. Scenarios	Occasional quantification	2030	World	Mostly ground transport	Sustainable development	Business (cars)
Conseil Général des Ponts et Chaussées 2006	Forecasting	Quantitative	2050	France	All transport	Emissions	Administration
Laboratoire d'économie des transports et al. 2008	Backcasting	Quantitative	2050	France	All transport	Emissions	Consultants
Schafer et al. 1999a	Projections	Quantitative	2050	World	Passenger transport	Mobility Emissions	Academics
Peeters et al. 2007, Peeters et al. 2004	Projections	Quantitative	2020	EU Switzerland, Norway, Bulgaria and Rumania	Tourism & transport	All environmental impacts	Academics
Ceron et al. 2006b	Forecasting, Backcasting	Quantitative/ Qualitative	2050	France	Tourism, transport	Sustainable development, emissions	Academics
UNWTO-UNEP-WMO 2008	Forecasting, Backcasting	Quantitative/ Qualitative	2035	World	Tourism	Emissions	Academics

Table 1: Tourism and transport scenario surveys overview

Finally only a few long-term tourism and climate change scenarios exist, none of theme considering climate stabilisation. Existing works either assess crudely key driving forces behind emissions reductions (technological progress, behavioural change), deal only with one part of the tourism sector, such as aviation (Åkerman 2005, Henderson et al. 1999, Vedantham et al. 1998), or use quantitative forecasting techniques, based on more or less fixed relationships, for instance between GDP and mobility, while climate change and socio-cultural change may affect these relationships (Joly 2008, LET/LASURE 2006, Schafer et al. 1999b).

2. Methodology: the scenario factory

2.1 General framework

This article is an attempt to build three scenarios based on a future analysis of tourism and transport, using backcasting techniques, to explore directions that will lead towards climate stabilization. The methodological advancement is to integrate two sectors that have so far been analysed through either mainly qualitative (tourism) or quantitative (transport) approaches. Indeed, the integration of narrative discourse ('narrative-based', or 'qualitative' scenarios) and figures ('modeling-based' or 'quantitative' scenarios) appears to be one of the main challenges facing the discipline of future studies. In the framework of the Millennium Ecosystem Assessment, Raskin et al. (2005a: 40), following a critical assessment of global scenarios, stated:

> *The development of methods to blend quantitative and qualitative insight effectively is at the frontier of scenario research today. The scenario narrative gives voice to important qualitative factors shaping development such as values, behaviors, and institutions, providing a broader perspective than is possible from mathematical modeling alone. 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.*

Scenario building can be divided into a number of components or steps, depending on their qualitative or quantitative orientation (Nakićenović et al. 2000, Raskin et al. 2005b). Without referring to any chronology in this process, scenarios can specify 'guiding principles (A) defined out of a set of economic, societal, cultural 'trends' or 'megatrends' (B). These are converted into a number of variables and quantitative 'parameters' (C), which deliver the input to 'models' (D) that produce quantitative 'results' (E), which can be interpreted as 'impacts' (F) (see figure 1). Qualitative works tend to privilege steps (A), (B) and (F), while quantitative works focus on steps (C), (D), and (E). Depending on the objectives of the scenarios, work can start anywhere in between A to F: backcasting means defining goals prior to scenario building (E) and (F); working on "Visions" means beginning with (A); seeking a better scientific knowledge of a complex process means focusing on modelling (D). Nevertheless, all scenario development exercises start with a description and analysis of past and present trends. The differences in scenario pathways are a result of the development of this input, i.e. models for quantitative scenarios versus a systemic representation of variables in qualitative ones. In other words, models produce figures and numbers, which are however not always embedded in socio-economic contexts. Qualitative scenarios, on the other hand, consider socio-economic contexts but lack quantification.

In this situation, a methodological development should focus on the improvement of the linkages between the various components (Figure 1) through specific tools (sensitivity analysis) and with the help of sound modelling. For this purpose, a 'scenario factory' was created, combining an 'engine' – the model –, and storylines feeding the model. Consequently, an iterative process between quantitative and qualitative thinking is at the core of the method and of the model rationale. The following sections describe in further detail the 'engine' and the storylines.

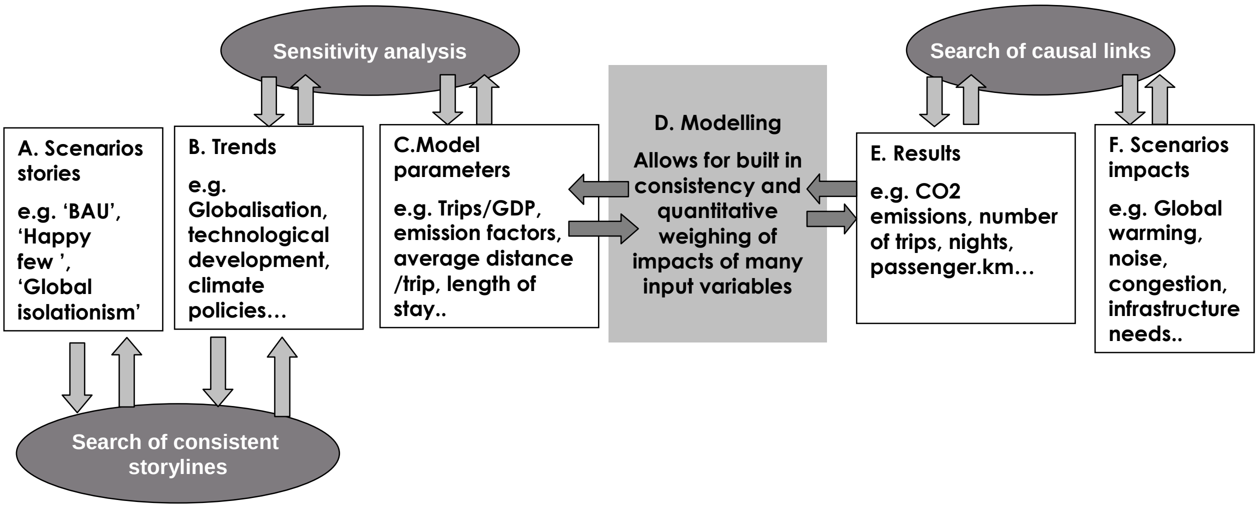

Figure 1: Stepwise scenario building

2.2 The engine: modelling trips, transport demand and emissions

Scenario parameters (box C, figure 1), models (box D) and results (box E) have been modelled using Powersim Studio 7 software. Basically, the model extrapolates trip numbers, guest nights, transport volumes, transport modes, and emission factors. The model is calibrated to consider the results of the 2005 and 2035 projections of global tourism as published by UNWTO-UNEP-WMO (2008: Chapter 11). The model distinguishes three tourism markets: international tourism, domestic tourism in industrialised countries (IC) and domestic tourism in developing countries (DC). The group of industrialised countries consists of the OECD90 countries (cf. IMAGE-team 2006), i.e. Canada, USA, Japan, Oceania and OECD Europe. Furthermore, three modes of transport are distinguished: air transport, car transport and 'other' (e.g. rail, coach, ferry).

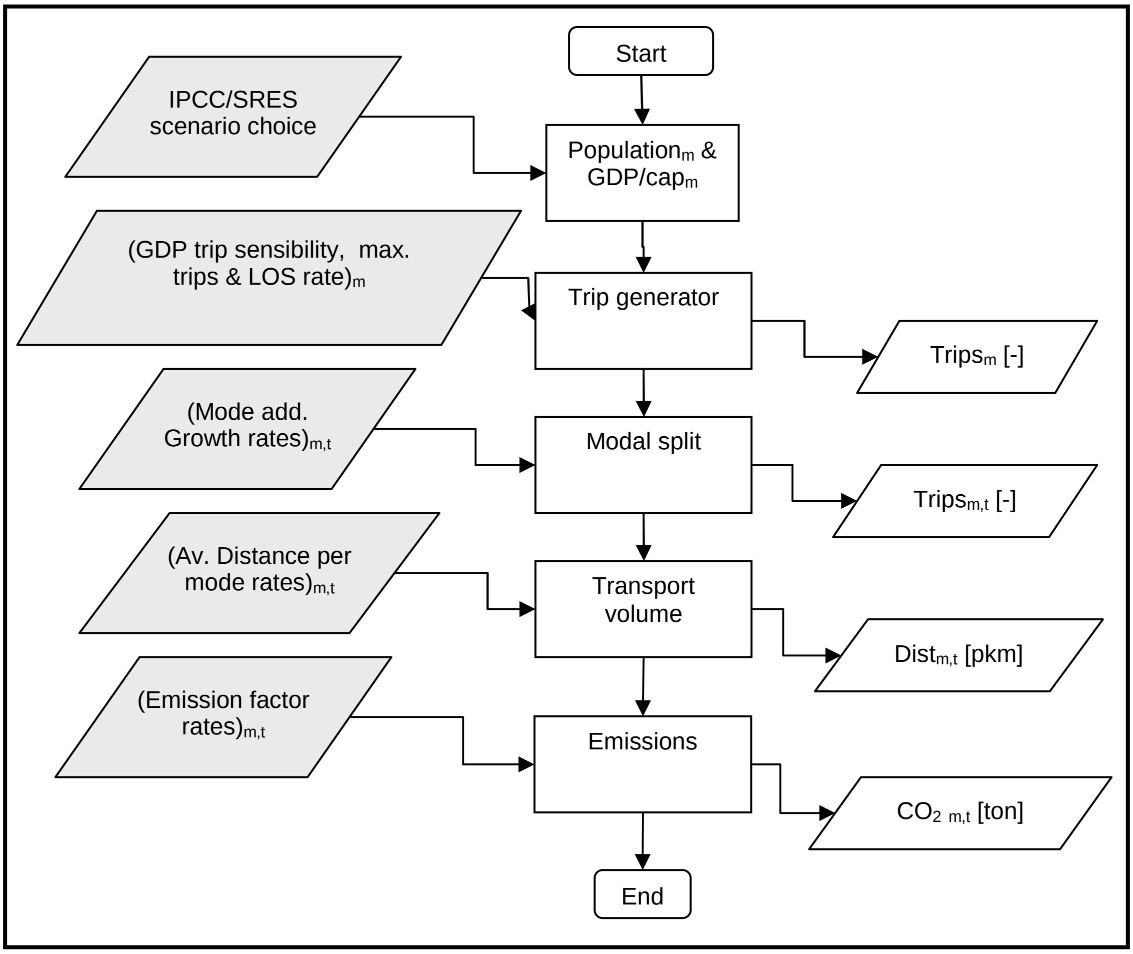

Figure 2: Model scheme showing input (shaded elements), model units (squares) and output (parallelogram). The indices refer to the three markets (m) and the three transport modes (t).

Figure 2 shows the model layout. The model has five units that calculate population and GDP/capita, number of tourism trips per market, number of trips per market and transport mode (modal split), transport volume (distances per market and mode), and CO_2 emissions (tons per market and mode).

- Context data for population and GDP growth is provided by IPCC SRES scenario projections.
- Per market "m", trip generation is based on the average number of tourism trips per capita as a linear function of GDP per capita, though this is limited by a maximum number of trips (1.2 international and 4.8 domestic trips per capita per year) per capita. The coefficients of the linear relationship of trips per capita and GDP per capita are calibrated to the UNWTO 2035 scenario (see UNWTO-UNEP-WMO 2008). Furthermore, the number of trips is assumed to increase with decreasing length of stay (LOS). As the number of nights is expected to be constant, the number of trips increases. Special attention was paid to the maximum number of trips above certain GDP per capita thresholds. This has been based on the results of an investigation by TNS NIPO (Mulder et al. 2007) showing that the *individual* number of trips levels off at a higher GDP per capita. It appears, however, that these limits will only be reached near the end of the 21st century, and thus have no impact on the results of the 2050 scenarios shown in this paper.
- The modal split in the model can then be changed by adjusting growth rates for different markets. The total number of trips per market is nevertheless maintained, as it is a result of the trip generation module, so additional growth for one transport mode will reduce growth of other transport modes.

- Transport distances are basically the number of trips per market-mode combination multiplied by the average distance per market-mode combination. This to some extent resembles constant time budgets for travel (see Schafer 2000, Schafer et al. 1999b).
- Finally the distances are multiplied by emission factors per market-mode combination to calculate total emissions. Emissions can be adjusted to reflect various levels of technological development and innovation.

2.3 Storylines for tourism transport demand

Scenario storylines generally combine various dimensions and/or trends. For example, the IPCC Special Report on Emission Scenarios develops four families of scenarios, defined in line with their position within the “global-regional” and “economy-environment”. Individual scenarios are positioned within each family referring to the value given to key trends, including growth in GDP or population (Nakićenović et al. 2000).

First, in order to limit the potential for change, a common context was defined for all storylines, regarding economic and population growth, and the general climate context. Indeed, all scenarios are developed in the context of strong and ambitious emissions mitigation policies, and this is not negotiable. Furthermore, the search for climate stabilisation implies constraints on consumption (households’ disposable income) and production (increased transport costs).

Then, based on a review of existing global tourism and transport scenarios, five mega-trends were identified, with 2-3 options for each regarding possible directions under climate stabilization scenarios: the “tourism and transport policies”, for instance, can favour international long-haul transport and tourism (option 1), or seek a less uneven distribution of mobility, through domestic tourism and ground transport (option 2). Finally, three storylines were identified (figure 5), following some guiding criteria, i.e. being realistic, in that they should be both politically acceptable and internally consistent, being contrasted, to allow comparison of policy options, and simultaneously leaving room for individual and political trade-offs. Authoritarian choices, like “forbidding air transport given its greenhouse gas emissions” were excluded for this last reason.

Figure 5 summarises this process.

2.4 Integrating storylines and models

In 1997, a famous chess match took place between Garry Kasparov, the world champion, and Deep Blue, a computer specifically designed for this challenge. Kasparov won the first tournament in 1996 (4-2), but lost the revenge in 1997 (2,5 – 3,5). This episode illustrates the human-machine dilemma in the field of future studies, and therefore the opposition between two cultures: a fascination for automated techniques on one hand, scepticism of models’ internal relationships, enthusiasm for experts brainstorming and ‘Genius Forecasting’ (Glenn 2003) on the other hand. Integrating storylines and models can be done in several ways.

One option is to use automatic optimisation techniques, through reverse modelling, to define the “best set” of parameters to reach the CO_2 emission targets under predefined constraints. The process would, through qualitative thinking, define some margin of evolution (e.g. transport policy leads to a development of train transport between +100% and + 300% by 2050), leaving it to the model to optimise the parameters within these boundaries. An iterative process (adapting the storyline or the model) would help to build better informed and more consistent images of the future of world tourism mobility. Preliminary tests have shown that this is possible, but full implications of the method need further research.

Another option, retained for the present research, is to integrate storylines into the model following a step-by-step procedure, through guided experts brainstorming. In several steps the different main trends (e.g. technological development) were translated to the model input parameters (e.g. air transport emission factors, average distance per trip) and the impacts evaluated (see Figure 3). Before the next step this output was evaluated with a view on reaching the goal of 66% emission reductions with respect to the 2005 baseline. If an unexpected evolution was observed, explanations were sought, or the parameter input refined. Per scenario seven steps were made. The general idea is that such an iterative method leads to smaller error margins, as all assumptions are constantly reconsidered.

Figure 3 illustrates the stepwise change of input and the tracking of hypotheses, exemplified here by the scenario “Happy few’ (see Section 3). Each individual relationship is explained by a written justification, and recorded. This traceability is often missing in scenarios attempting to combine qualitative and quantitative elements (EEA no date, ten Brink 2006). The X1 run represents the general trend scenario. X2 and X3 are the first megatrends (globalisation). X4 added technology, X5 climate policies, X6 tourism and transport specific policies and X7 lifestyle components/additional measures to arrive at the emission goal.

																							Emissions annual rate of change															
Scenario	Trips/GDP			LOS			Additional growth rate									Add. av. dist. growth rate									Acco.			Act ivities			Transport								
Market	Int	IC	DC	Int	IC	DC	Int			IC			DC			Int			IC			DC			Int	IC	DC	Int	IC	DC	Int			IC			DC		
Mode							A	C	O	A	C	O	A	C	O	A	C	O	A	C	O	A	C	O							A	C	O	A	C	O	A	C	O
X1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X2	-	-	-	0	0	0	-	0	+	-	0	+	-	+	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0	+	0	0	+	0
X3	+	-	-	0	0	0	+	0	0	0	0	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0	+	0	0	+	0	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-
X5	-	+	0	+	+	+	-	0	+	-	0	+	-	0	+	-	-	+	-	-	+	-	-	+	0	0	0	0	0	0	0	-	0	0	-	0	0	-	0
X6	0	0	-	0	0	+	-	0	0	-	0	0	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X7	-	0	-	0	+	-	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	-	0	0	0	-	-	-	0	-	0	0	-	0	0	-	0
Overall	-	-	-	+	+	+	-	0	+	-	0	+	-	-	+	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Figure 3: Development of the “Happy few”(S1) storyline. +/- and 0 represent changes with respect to the previous step. Note that for emissions, a ‘positive’ rate of change means lower reductions and ‘negative’ rate higher reductions. Int=international, IC=domestic industrialised countries, DC=domestic developing countries, A=air, C=car and O=other, Acco.-Accommodations.

Figure 4 shows the results of the “Happy few” scenario by step X1-7, as an index of the baseline. The graph shows how changes in the various parameters (total number of tourist trips, total tourist nights, and shares of air trips/car trips) result in emission reductions (-80% by 2050).

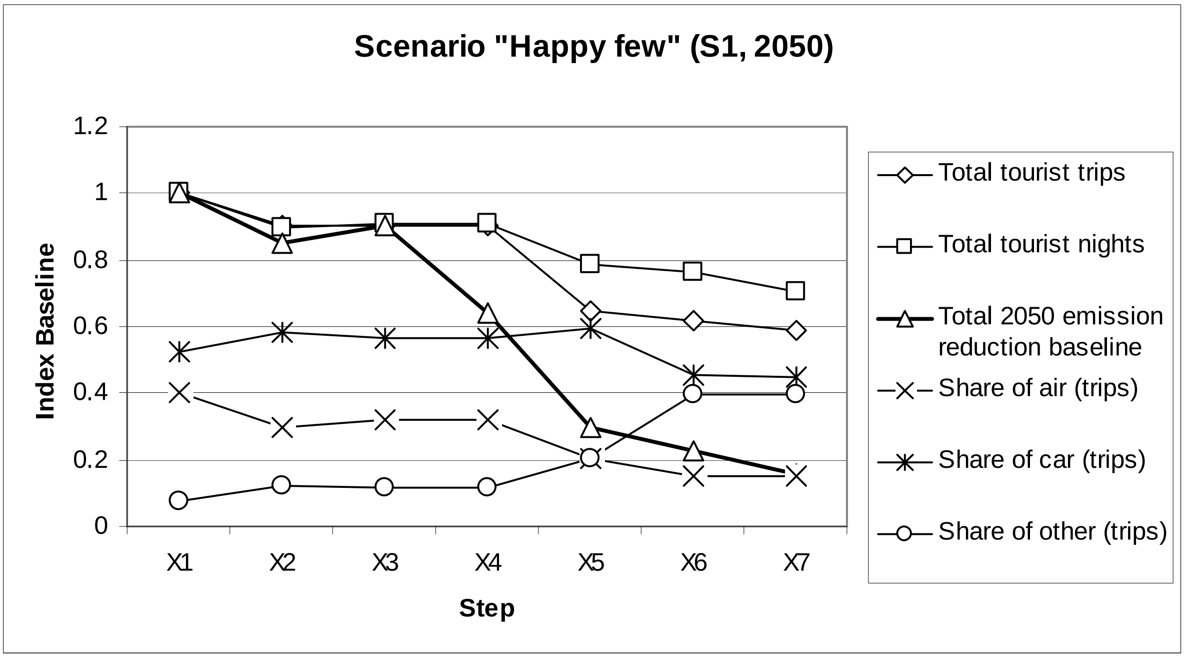

Figure 4: Stepwise changes in scenario “Happy few” (S1).

2.5 Definition of emission targets

Backcasting demands the identification of emission reduction goals. Defining these for the tourism sector raises several questions, such as whether tourism should be treated “favourably” within a global emission reduction framework, given its strong growth and limited options for reducing emissions through technology. The following assumptions are made:

- In line with IPCC 4th assessment report (IPCC 2007a), atmospheric concentrations of CO_2 should not exceed 450 ppm by 2100.
- The focus is on “allowable” emissions by 2050, not the pathway to achieve these, i.e. whether emission reductions should be constant (e.g. -3% per year) or whether further growth in emissions would demand more rapid future emission reductions.
- By 2050, global emissions should be 67% of those in 2000, i.e. corresponding to the averaged 50-80% reduction goal by IPCC (2007a), i.e. maintaining the climate within a 2.0-2,4℃ warming threshold by 2100.
- Tourism is granted a special treatment in emission reductions, in that the sector is allowed to use flexibility mechanisms (carbon trading and offsetting) for 20% of its reduction demands. Consequently, the sector itself has to achieve about a halving (-54%) of its emissions (baseline 2000).
- Emissions from tourism amounted to 1.3 Gt in 2005 (UNWTO-UNEP-WMO 2008: 46). Given the 2000-2005 growth of world tourism (+18%), the 54% compared to 2000 leads to a reduction of 66% compared to 2005, i.e. 443 million tons by 2050.

3. Results

3.1 Developing three storylines

Overall, three scenarios like the “Happy few” storyline were developed (see 3.2). They were based on the five megatrends “international governance”, “technological development”, “climate policies”, “tourism and transport policies” and “lifestyles”.

International regulation and integration: two main options were identified: intensified globalisation (economic, political and cultural cooperation) versus regional cooperation leading to diverging regional blocks.

Technological development refers to the efficiency of transports. This is a result of factors like economic growth, international cooperation on research and technology transfers, and climate policies. “Strong” and “medium” technological developments are distinguished.

With regard to *climate policy instruments,* three options for mitigation are distinguished: global climate policies relying on economic instruments such as pricing, taxation and carbon trading; regional diverging climate policies, strong for ground transport but less efficient for international aviation (see the present situation, with the inclusion of aviation in EU carbon trading scheme, but without any global agreement at ICAO); and a global system of individual carbon budgets and quotas (Bows et al. 2006a, Starkey et al. 2005).

Tourism and transport policies can target first high-income international tourists, and thus favor investments in airports (global hubs). They can alternatively promote the wider and less uneven access to mobility, leaving individuals to make their choice within their time-, money- and emission constraints. Or they can favour only domestic tourism and ground transport, be it highway- or high speed train networks.

Without changes in *lifestyles and travel culture* it is often impossible to reach backcasting targets using other options (Ceron et al. 2006a, Dubois 2008, Dubois et al. 2007). The problem remains as to how lifestyles and cultures may change in a coherent way*.* The culture of travelling is the result of several factors: time and money for leisure and travel (e.g. existence of paid leave, disposable income, organisation of working time), incentives to leave home (unattractive houses, neighbourhood, cities or local environments), cultural curiosity, the appeal of exoticism (cultural exchanges or isolationism), education (environmental awareness, generational effects), the impact of advertising on travel fantasies, etc. We distinguish three general lifestyles. In the first, the acceptance of a strong social stratification leads to elitism. Members of a rich class with long working hours who seek to distinguish themselves socially and escape day to day life through short breaks become frequent travellers. There is a polarisation between those who “have” and those who “have not”, especially visible where property is expensive. In the second lifestyle, local living conditions are valued much higher then exoticism or cultural exchange. Some desire for exoticism and other cultures remains, but is now connected to infrequent long haul travel. In the last lifestyle the culture is more isolationist, at the cost of cultural curiosity. Travelling becomes more dangerous due to persistent international tensions and more arduous due to failed investment in international transport infrastructure.

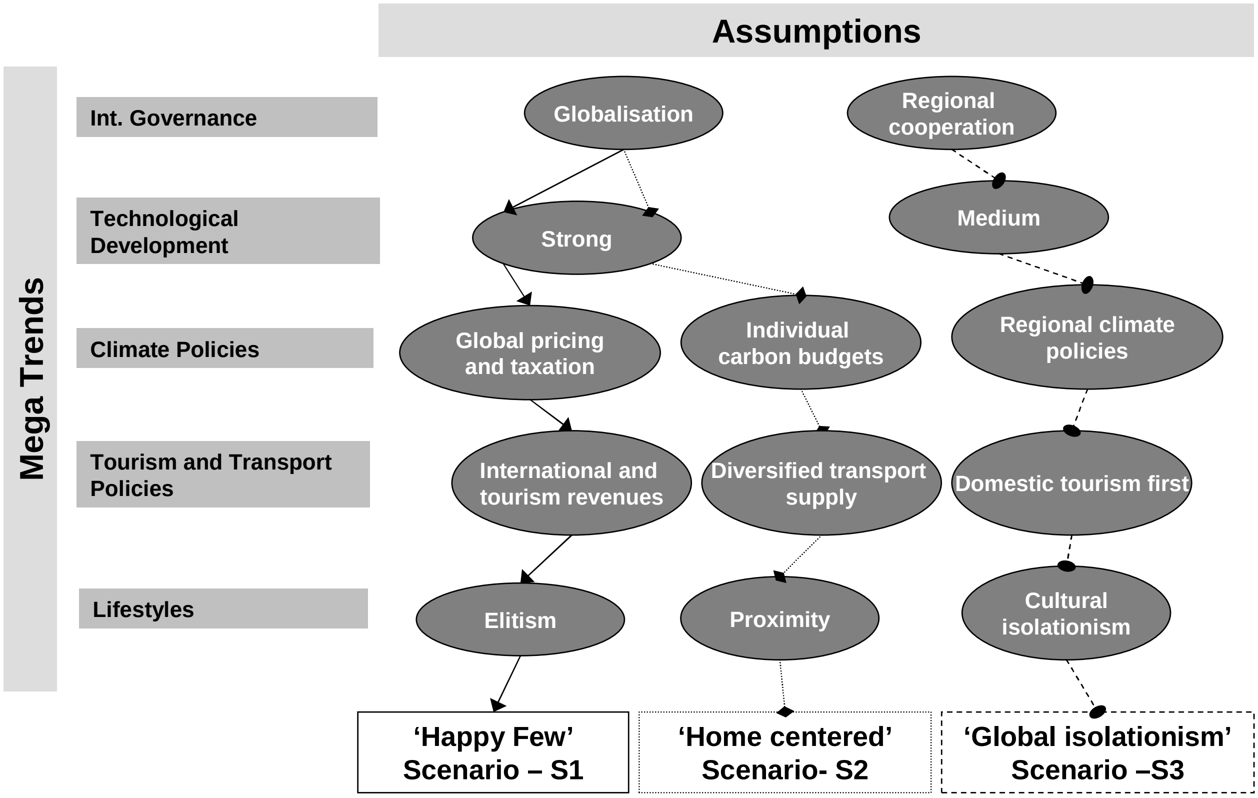

Figure 5 : The scenario's rationale and construction pathways

3.2 The storylines of the scenarios

3.2.1 The "Happy few" scenario (S1)

Global governance vastly improves, including cooperation to cope with climate change. Growth is rather high, even if limited by climate policies, transfers of technology are fluid. The travel of individuals does not suffer from heavy regulatory constraints. Some major features of western developed countries (ways of life, values to a certain extent) become outspread to the rest of the world. Technological progress is high, though no unexpected or highly improbable breakthrough is made. By 2050, a 48% reduction in per pkm emissions for aviation (engine, airframe improvement, partial shift to turboprops, "open skies") is expected. An early introduction of hybrid cars (2010-2012) is expected, leading with other factors to a reduction of emissions by 55%. The energy efficiency of trains increases by 60%. Climate change policy is focusing on taxation, which leads to new investments in low-carbon technology and infrastructure. As a consequence, air travel becomes rationed, leading to elitism. Still, long haul tourism by air is not difficult to access, but only for the "happy few". New infrastructures for train (high speed and others) develop at a medium rate, and allow continental travel for the masses. Socio-economically, people have to work for longer hours in order to earn decent salaries, while high incomes are limited to managers. The retirement age increases. The divide between those at work and those no longer at work (pensioners), preparing for work (students) or unable to work (unemployed) grows. Those with money have limited time for holidays and feel they need to pay high prices for their holidays. Others have plenty of free time for cheap vacations at home or for visiting friends and relatives. This reinforces social polarisation.

3.2.2 The "Home centred", or "Tourism… not too far!" scenario

This scenario makes the same assumptions for international governance and technology as the previous one. One major difference, however, is that climate policy introduces individual or household carbon budgets, which can be traded up to a certain limit (20%). The limited global carbon budget is evenly shared, and involves a strong focus on low carbon technology, and thus faster technological development than in the “Happy few” scenario. For individuals with energy-intense lifestyles, marginal costs for more tourism are high; for the wealthier, options to buy permits may be limited. Though long-haul tourism is to some extent maintained by the design of climate policies (i.e. developing, tourism-dependent countries may use carbon quotas to subsidize their tourism systems), it is clear that tourism policies matching this scenario will strongly favor domestic- and continental tourism. Overseas tourism becomes an exception, but is still possible (like a 4 months journey in Asia in a life-time). There is also a strong investment in rail transport, while hybrid cars maintain individual mobility and access to remote domestic destinations in the countryside.

3.2.3 The “Global isolationism” scenario

Global governance is limited to the minimum in a multi-polar world. There is strong competition for access to energy and raw materials, leading to more conflicts, which in turn reduce economic growth. Technological progress is hampered by the lack of cooperation in research and technology transfers, and by moderate economic growth. There is no global convergence between countries; each of them tends to replicate its traditional values and to develop specific ways of life. This can be negative in terms of emissions or positive (still an important share of collective transport in developing countries). The lack of international governance results in minimum international climate policy, which does prevent the development of strong regional policies. International aviation is therefore less regulated, regarding carbon emissions, than in previous scenarios; meanwhile, it is less desired and its modal share and average distance tends to declines. The development of tourism policies answers a high demand for domestic tourism and proximity leisure, given this reduced desire to travel to long-haul destinations. The loss of cultural curiosity and some isolationism reinforce this picture of future societies.

3.4 Overview model results

The model calculates time series using constant rates of change. Figure 6 shows time series for both transport and total emissions as a share of emissions in 2005. Clearly, in the S1 scenario reductions focus on both transport and other elements of tourism, while S2 is based on greater non-transport reductions and, vice versa, S3 on greater transport emission reductions. The rationale behind this from the storylines is that S1 allows the maintenance of more air transport for the ‘happy few’.

Notably, backcasting objectives could not be reached in any of the 3 scenarios without compromising storylines or applying overly unrealistic assumptions. Total tourism emissions resulted in 780 Mt CO_2 (Happy few), 704 Mt (Proximity tourism) and 677 Mt (Global isolationism), all of them significantly higher than the target of 443 Mt. The expected demographic and economic growth, together with improved access to mobility in developing countries, outpace emission reductions introduced by technology and, investments in infrastructure for collective transport. The question is how to reduce emission by 2% a year, relatively to 2005, when tourism is currently growing at a rate of 4-5% a year.

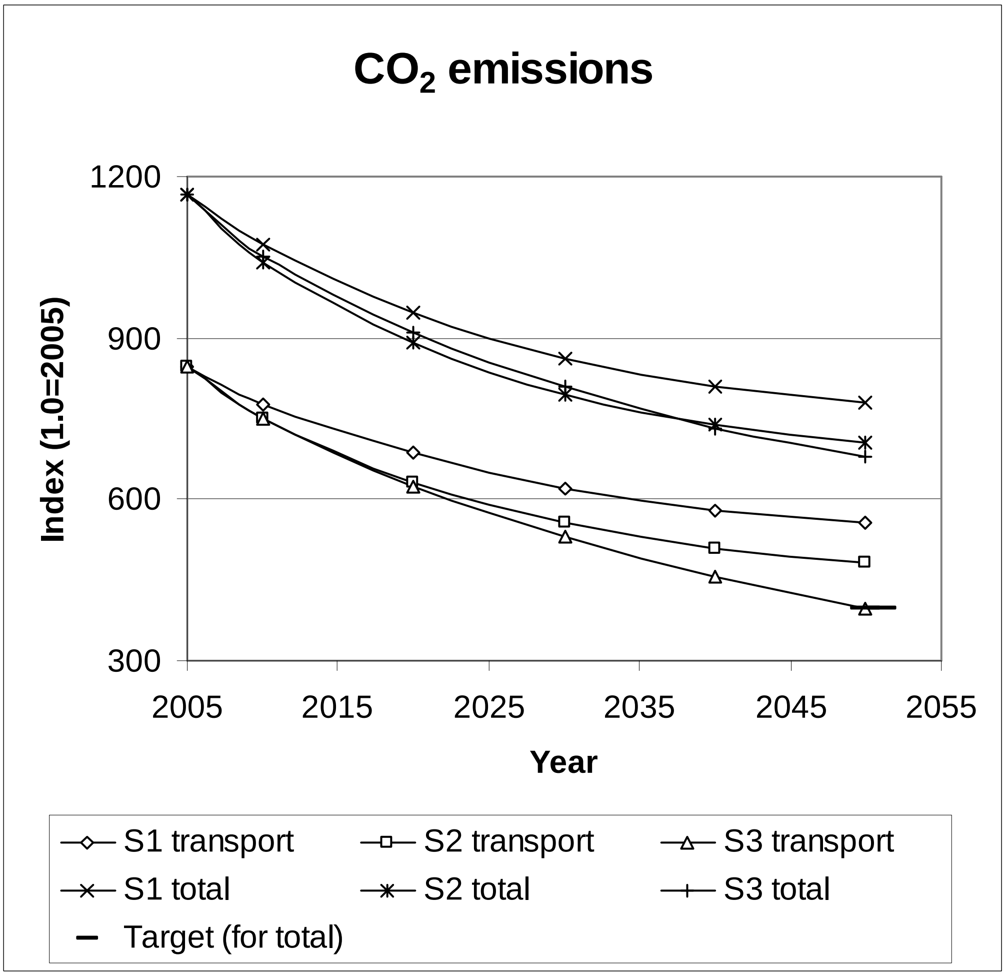

Figure 6: time series of the development of emissions per scenario. Transport emissions in the "Proximity tourism" scenario tend to increase at the end of the scenario period (2050). All other trend lines are still pointing downward in 2050.

Scenarios: "Happy few" (S1), "Proximity tourism" (S2) and "Global isolationism" (S3)

Figure 7 shows that in all scenarios the number of trips and guest nights, as well as the overall transport volume is significantly lower than the trend 2050 baseline. Compared to 2005 however, the growth in trips and guest nights is generally lowest in the "Global Isolationism" scenario and highest in the "Proximity tourism" scenario. In the "Happy few" scenario, only the rich travel regularly and freely, leading to a middle path in emission reductions. In the "Proximity tourism" scenario, average length of stay increases, while the number of trips and kilometres travelled declines. The average emission factor includes not only technological efficiency improvements, but also changes in operations, seat density and seat occupation rates. In "Global isolationism", technological development is hampered by the lack of international cooperation and the low market development. In the "Proximity tourism" scenario, the individual carbon budgets put a strong constraint on the market, thus increasing carbon cost to a high level. This makes investments to reduce emissions more economical than in the 'Happy few' scenario, which is comprised of only soft (economic) measures to reduce emissions.

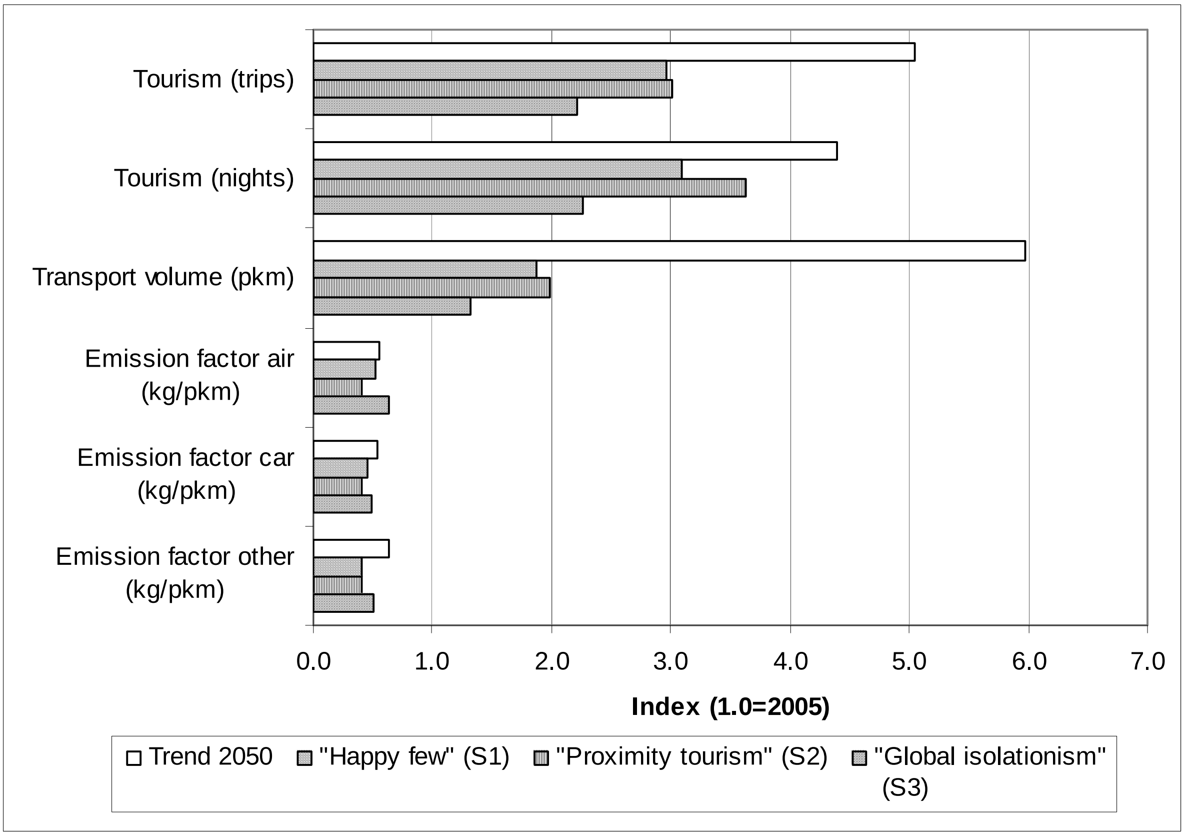

Figure 7: Results for all three scenarios in 2050 as index of 2005.

"Tech Air" gives the index for the final overall emission factor in 2050; "Tech Car" the same for cars, etc. A low index here means a lower emission factor and thus more technological development.

The distribution over the three markets and transport modes differs substantially between scenarios. Figure 8 provides an overview of trip numbers. The "Happy few" scenario contains a high share of international tourism and allows for considerable growth of domestic tourism in developing countries. Note that domestic tourism in developing countries will account for more than half of all tourism air transport. Differences in income and the use of energy-intense transport (air & car) remain high in this scenario. The "Proximity tourism" scenario equalises tourism even more: given the population growth in developing countries, their overall tourism mobility grows faster than in industrialised countries. This scenario depends even more on rail and coach, based on the notion that (high speed) rail offers a reasonable alternative to air over relatively short distances. The "Global isolationism" scenario finally shows a much lower growth for all markets, including international travel. All means of transport remain important, though, with cars growing to a higher share in developing countries (domestic) than in industrialized countries. The isolationism of these blocks means that developing countries go through all stages of development as did the industrialized countries before.

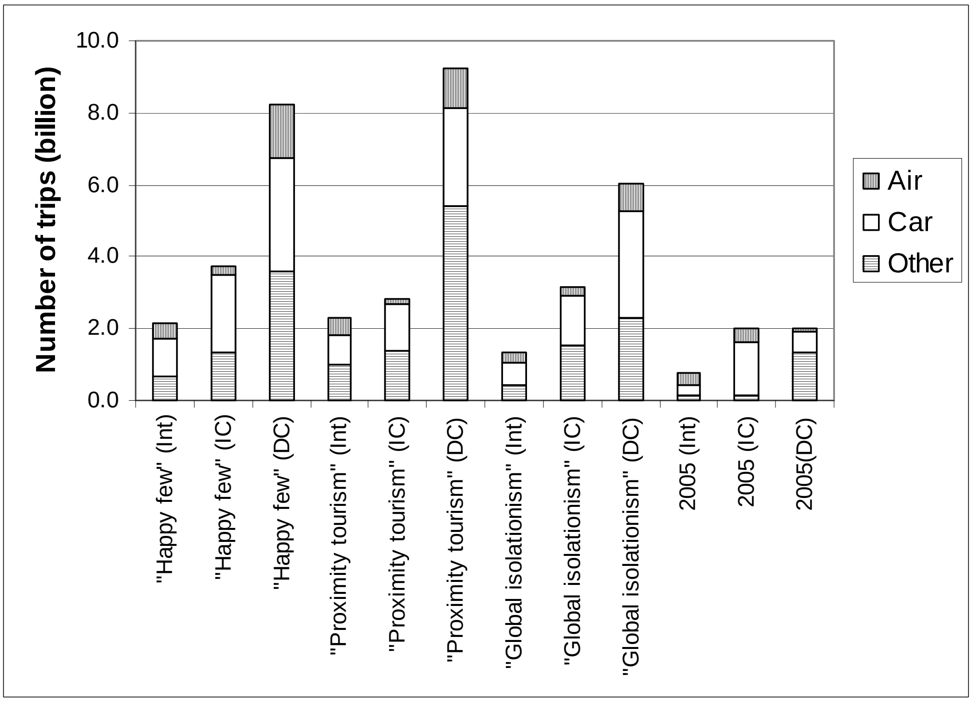

Figure 8: Distribution of trips over the different markets and transport modes.

Int = international, IC = domestic within industrialised countries and DC = domestic within developing countries.

Figure 9 shows the distribution of emissions. An important result here is that the burden of tourism (and emissions) shifts from the developed world to the developing world in all scenarios. Whereas in 2005 domestic tourism in developing countries had the lowest share of emissions, it reaches the highest emissions in all scenarios by 2050. Furthermore, emissions from air transport continue to dominate in all scenarios, though their relative share declines. In two scenarios (“Happy few”, “Proximity tourism”), international tourism continues to account for the highest share of emissions. The ”Happy few” scenario results in equally high amounts of emissions from both international tourism as well as domestic tourism in developing countries. The emissions of other transport modes become more significant than in 2005, but air transport continues to dominate.

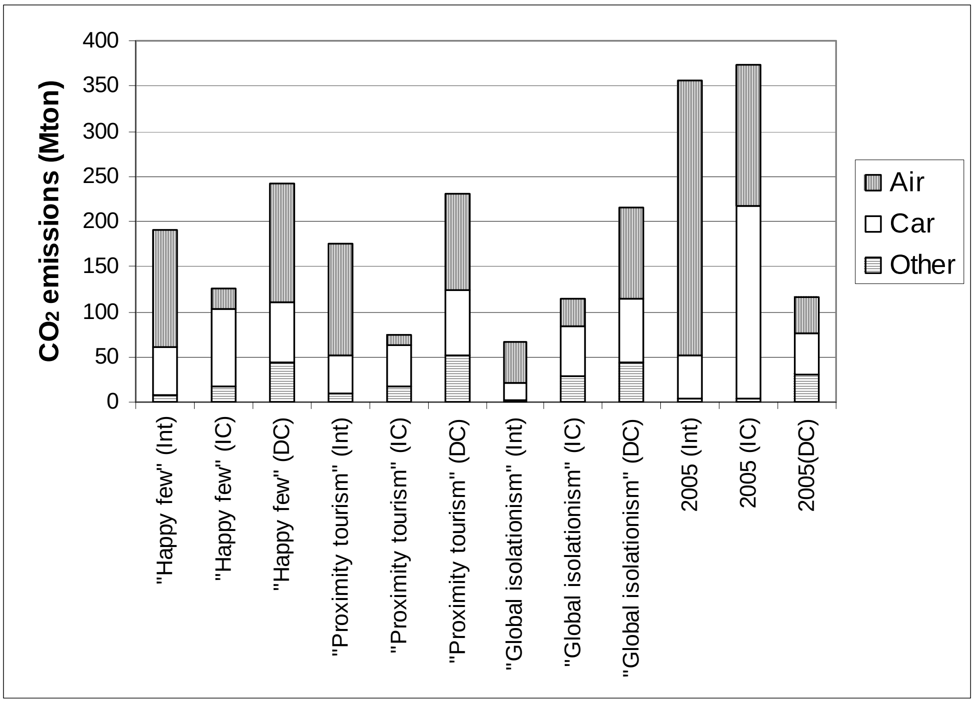

Figure 9: Distribution of CO_2 emissions over the different markets and transport modes. Int = international, IC = domestic within industrialised countries and DC = domestic within developing countries.

4. Conclusions

The results indicate that in a situation where tourism and transport are required to reduce emissions by a percentage equally high as in all other economic sectors (though with the option of considerable trading and/or offsetting), only substantial changes in the way we travel will lead to (moderate) emission reductions. Clearly, none of the scenarios developed in this article achieves the level of emission reductions climate policy would necessitate. Climate stabilization objectives leave some room for tourism mobility, but only if a major shift in the use of transport modes is achieved in combination with a reduction in the distances traveled, and the rapid introduction and development of new low-carbon technologies.

More specifically, in all scenarios, air transport will grow slower than other transport modes, to the point where growth stagnates or even declines. The most substantial reductions in emissions are achieved in domestic tourism in developing countries and in international tourism (slow growth in S1 and S2, stagnation in S3), while domestic tourism in developing countries can accommodate some development. In contrast, public surface-based transport (train and coach) would see exponential growth by a factor 2 to 7 by 2050.

Importantly, the principle of contraction and convergence, i.e. disproportionally large emission reductions in industrialized countries to allow for further growth in emissions in developing countries will mean that current travel patterns in industrialized countries have to go through more considerable change. Clearly, neither technology nor investments in infrastructure such as new rail networks will be sufficient to achieve overall emission reductions in the order of 60% by 2050 (as compared to 2000). Demand management thus becomes increasingly important, with options including new pricing structures, incentives, or individual emission quotas. Ultimately, the de-carbonization of the tourism system may even imply that societies have to discuss which forms of tourism and transport can still be supported. This may, in many respects, boil down to questions of climate justice, i.e. of who can travel, for which length of time, with which transport modes, for which purpose, and with which level of comfort.

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