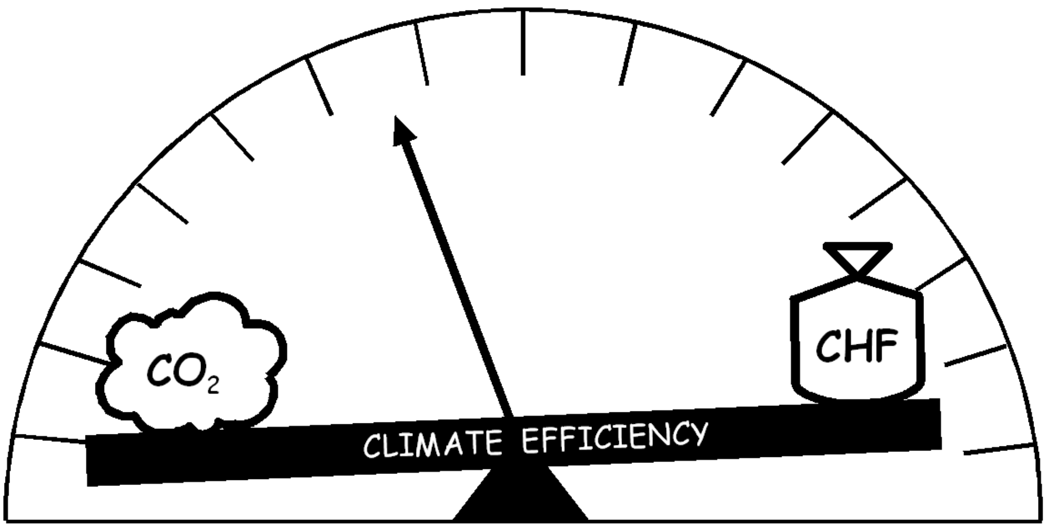
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

How Climate Efficient Is Tourism in Switzerland?

An Assessment of Tourism's Carbon Dioxide Emissions in Relation to Its Added Value



Diploma Thesis

Department of Environmental Sciences
ETH Zurich

Ana Sesartic & Matthias Stucki

September 2007

Supervisors
Prof. Dr. Dieter Imboden
Sabine Perch-Nielsen

Summary

The tourism sector is not only affected by climate change but also has an impact on the Earth's climate by emitting greenhouse gases (GHG). Consequently, the sector is under increasing pressure to make its contribution to the mitigation of GHGs. In this context, there is a growing interest in identifying those measures that are economically most efficient. In order to assist the determination of such measures, we calculated the climate efficiency of the tourism sector in the case of Switzerland. We defined climate efficiency as the amount of carbon dioxide emissions per generated added value. This concept allowed to identify which subsectors generate relatively high emissions and low added value (i.e. unfavourable climate efficiency) and should thus be focussed on for mitigation purposes.

To calculate tourism's climate efficiency, tourism industry players were considered, if they contribute added value to the Swiss economy. These business entities belong to the internal tourism industry that consists of domestic and inbound tourism. The data used for evaluating tourism's added value were taken from the Swiss Tourism Satellite Account 2003. The main data sources to calculate tourism's CO_2 emissions were the Ecoinvent Database 2006, the BFE (Swiss Federal Office of Energy) 2006a Energy Survey, and the Microcensus on Travel Behaviour 2007.

This research shows that tourism causes major GHG emissions and has an unfavourable climate efficiency, with considerable differences between its subsectors. It is responsible for 8.4% of the Swiss economy's direct CO_2 emissions. Compared to other Swiss economic sectors, tourism has the second highest emissions per added value with 0.23 kg CO_2/CHF. It is surpassed only by the transport sector. The tourism subsectors with the best climate efficiency are tourist agencies, tour operators, restaurants, and cultural services. The medium range is occupied by the accommodation sector and the sports & entertainment sector. Passenger transport, especially air transport, is the least efficient subsector. It causes 87% of tourism's CO_2 emissions.

The results indicate that measures for greenhouse gas mitigation should be focussed on the transport and accommodation subsectors. A special focus should be placed on air transport, the biggest emitter within tourism. On the one hand, the support (e.g. tax subsidies) of inefficient modes of transport like air travel should be substantially reduced. On the other hand, efficient modes of transport such as railways must be supported and subsidised in order to achieve an economically wise and environment-friendly solution. Additionally, the accommodation sector should improve its energy management for greenhouse gas mitigation purposes. Tourists can support GHG mitigation efforts by choosing transport, accommodation, and activity options that cause only lower emissions. Tourism has a high, but so far unrealised, potential for greenhouse gas mitigation.

Table of Contents

Acknowledgements

Writing and working on this diploma thesis was a challenging journey that was enriched by the support of people who accompanied us along the way.

We thank Professor Dieter Imboden for supervising our thesis, and for his valuable and encouraging feedback, which helped us stay on the right track. We are thankful to our advisor, Sabine Perch-Nielsen, for her continuous support of our work. We appreciate her dedicated interest in our thesis, and are thankful for her attentive reviewing and valuable suggestions, which helped to improve our thesis.

Our thanks also go to Jasmin Gülden from the Swiss Federal Office of Environment and Thomas Baumann from the Swiss Federal Office of Statistics for supplying us with crucial data without which the making of this thesis would not have been possible. Thanks, also, to Dr. Susanne Becken for permitting us to see excerpts of the as yet unpublished book “Tourism and Climate Change”. Furthermore, we thank all businesses that replied to our survey and provided us with information about their energy consumption.

Very special thanks go to Marc Zürcher for bringing our vision of GHG cloud charts into reality. We are also grateful to Michael Muench, as well as to Mladen and Bozana Sesartic for reviewing our report and making helpful corrections.

Special thanks go to the third member of our “efficiency office”, Simone Hegner, who made the writing of our thesis even more enjoyable. Thanks also go to the Environmental Physics team, for the congenial working atmosphere, the refreshing coffee breaks, and their feedback on our presentation.

Last but by no means least, our heartfelt gratitude goes to our families for their love, support, and constant encouragement they have showed us throughout our lives.

Glossary

Added value	**Added value** refers to the additional monetary value created by an economic unit. It can be calculated as the turnover minus the intermediate inputs.
CO_2-equ	**CO_2-equivalent** is the unit for an amount of greenhouse gases (GHG). The amounts of various GHGs are converted into kg CO_2-equivalents depending on their impact on climate change relative to that of carbon dioxide on a time scale of 100 years. This conversion is described in (IPCC, 2001).
Ecoinvent	The **Ecoinvent** database v1.3 (Ecoinvent, 2006) contains international industrial life cycle inventory data on energy supply, resource extraction, material supply, chemicals, metals, agriculture, waste management services, and transport services. Further description is given in chapter 2.3.
emission factor	**Emission factors** denote the amount of CO_2 or greenhouse gases emitted by processes and activities, such as modes of transport, accommodation services, or leisure activities. Examples of possible units for emission factors are [kg CO_2/pkm], [kg CO_2-equ/vkm], [kg CO_2/visitor night], or [kg CO_2-equ/visit]. See glossary entries for definitions of "pkm" and "vkm".
conversion factor	**Conversion factors** give the amount of CO_2 or greenhouse gases emitted by the consumption of energy sources such as combustibles or electricity. Units for conversion factors include [kg CO_2/t], [kg CO_2-equ/l], and [kg CO_2/kWh].
GDP	The **gross domestic product** is the market value of all goods and services produced within a given time by labour and property located in a country. This equals the sum of added value within a national economy.
GHG	**Greenhouse gases (GHG)** absorb and reflect radiation at specific wavelengths within the spectrum of infra-red radiation, thus creating the "greenhouse effect". The radiation origins from the sun and remains trapped by GHGs as heat in the atmosphere (IPCC, 2007b). Anthropogenic GHG emissions increase the greenhouse effect, thus causing global climate change. Subject to this thesis are those GHGs included in the Kyoto Protocol (UNFCCC, 1998): carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases.
NOGA	**Nomenclature Générale des Activités économiques** is the Swiss taxonomy of economic activities. It is used for structuring, analysing, and demonstrating statistical information. NOGA classifies companies

	and work places depending on their economic activities (BFS, 2002).
pkm	A **passenger kilometre** is the unit for transport performance of one person over a distance of one kilometre.
TSA	The **Tourism Satellite Account** is described in chapter 2.3.
turnover	**Turnover** is the amount of money generated by a company's activities, such as sales of products or services to customers, in a given period of time.
vkm	A **vehicle kilometre** is the unit for transport performance of one vehicle over a distance of one kilometre.

1 Introduction

"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. [...] From cheap to sustainable, that is the transformation we have to achieve."

Hans Uijterwijk (Peeters, 2007a)

Tourism is a growing industry. On a global scale, it already contributes 3.6 % to the gross world product (WTTC, 2007). In Switzerland, tourism also constitutes a substantial share of the economy; it contributed 3.4 % of Switzerland's gross domestic product (GDP) in 1998 and created 165'000 jobs, which equals 5.2 % of total employment (BFS, 2003b). The added value of tourism is generated by the following sectors: accommodation (31 %), catering industry (14 %), passenger transport (20 %), tourist agencies/tour operators (9 %), and others (26 %) (BFS, 2003b).

From a global point of view, the most pressing environmental problem caused by tourism is climate change caused by greenhouse gas (GHG) emissions (Gössling et. al., 2005). Globally, tourism is a major contributor to anthropogenic GHG emissions (Dubois & Ceron, 2005). Peeters (2007b) estimates the share of GHG emissions caused by tourism in 2000 to be 4 to 10 % worldwide.

However, tourism also stands to be strongly affected by global climate change. In Switzerland, for example, the snow line is projected to rise by 350 metres until 2050 due to global warming (Müller et al., 2007). Thus, the number of ski areas with snow reliability is projected to decrease, leading to economic losses in the mountain areas. Additionally, the receding permafrost will reduce the stability and security of mountain railways and buildings constructed on permanently frozen ground. The melting of glaciers will not only deteriorate the landscape and thus make it less attractive for tourists, but will also pose a serious threat to local residents due to a heightened probability of floods (Müller et al., 2007).

Since the tourism sector not only faces these risks, but also acts as a major contributor to GHG emissions, it is under growing pressure to take measures for GHG mitigation. In this context, there is a growing interest in identifying those measures that are economically the most efficient. In order to assist the determination of such measures, the analysis of tourism's climate efficiency is helpful. The underlying idea of climate efficiency is to compare the harm caused by an economic sector with the benefit it generates for society. Subsectors with low harm and high benefit can be seen as benchmarks, whereas subsectors with high harm and low benefit are economically reasonable starting points for mitigation policies. In this research, the considered benefit for society are tourism's financial gains, whereas the considered harm is tourism's contribution to climate change.

A review of the currently available literature in the field of tourism showed that there are wide gaps in knowledge. Previous research has mostly concentrated either on tourism's economic role or on tourism's climate impact. Tourism does not constitute an economic sector in national statistics. However, its economic role in Switzerland is evaluated in the Tourism Satellite Account (BFS, 2003b). Other important economic research related to tourism in Switzerland has been made by Rütter (1986) and Müller (2003, 2006). Tourism's climate impact and energy consumption has been studied mostly by Becken (2000, 2001a, 2001b, 2002, 2004), Becken & Simmons (2002, 2006), Becken & Cavanagh (2003), and Becken et al. (2001, 2003a, 2003b). Closest to a complete overview of energy data for tourism are studies conducted by Becken (2002) for New Zealand, as can also be seen in our data overview table in Annex III. However, some research on tourism's eco-efficiency have been conducted by Gössling et al. (2005). They focused on CO_2 as the most important GHG and defined eco-efficiency as the ratio of CO_2-equivalent [kg] to the turnover [Euro]. Still, the interface of tourism and GHG emissions remains under-researched (Becken & Hay, 2007) and there is a need for further research of tourists' energy demand related to the revenue gained, as indicated by Becken et al. (2001). GHG emissions and climate efficiency of tourism in Switzerland have not yet been assessed. Hence, we improved the eco-efficiency concept and applied it to the case of Switzerland.

The purpose of this diploma thesis is to assist the determination of economically efficient starting points for GHG mitigation in the tourism sector. For this purpose we calculated the emissions and the climate efficiency of the tourism sector and its subsectors in Switzerland. We defined the new term “climate efficiency of tourism” as the emission of CO_2 [kg] or GHG [kg CO_2-equivalents] per added value [Swiss Francs (CHF)]. In contrast to Gössling et al. (2005), we selected added value instead of turnover, since added value constitutes the better indicator for tourism's benefit. Unlike turnover, added value does not include intermediate inputs, which are benefits allocated to other sectors. The tourism sector’s effect on climate was assessed by two different approaches: CO_2 emissions of the operation processes (measured in kg CO_2) and GHG emissions of the whole life cycle (measured in kg CO_2-equ). Our analysis focused on tourism accommodation, transport, and activities within Swiss borders, i.e. domestic and inbound tourism.

The tourism sector's GHG emissions strongly depend on tourists' decisions, such as chosen destination, mode of transport, accommodation, and activities. Therefore, we changed the point of view from the national economy to the tourists themselves, in order to show how tourists' decisions influence the amount of GHG emissions, additionally to our climate efficiency approach. Hence, we converted the calculated total GHG emissions into emission factors of individual tourism services.

The second chapter describes our method and main data sources. The concept of climate efficiency is defined, and the calculation of emissions and climate efficiencies is described. The overall results are shown and discussed in the third chapter, and the potential for improvement of tourism's climate efficiency is shown. Finally, chapter four draws a conclusion from our research.

2 Methods and Data

“Precautions when surfing in contaminated data fluids: never surf alone or when under the influence of drugs or alcohol, and never dive head first into an unfamiliar source of data.”

Barbara Strebel (1997)

2.1 System boundary

The precise definition of system boundaries and terms is important, because the obtained results strongly depend on them. For this thesis, tourism is defined according to the Swiss Tourism Satellite Account (TSA) as the total of consumption activities outside the habitual environment. This includes travel for leisure, business, and other purposes, lasting maximum one year (BFS, 2003b). The economic sectors that belong to tourism are listed in Table 1, according to the classification systems of TSA and the more detailed one of NOGA (see Glossary). The tourist added value of tourism's subsectors consists of their turnover minus intermediate inputs, multiplied by the specific tourism share, as described in the TSA.

Generally, tourism was considered, if its added value is generated in Switzerland. This “internal tourism” consists of domestic tourism and inbound tourism. “Domestic tourism” refers to travel activities of domestic visitors in the economic area of Switzerland, whereas “inbound tourism” means the travel activities of foreign visitors in the same territory. An exception are some modes of transport for which different system boundaries needed to be applied due to lack of data. For example, in order to calculate emissions from air transport, the travelled flight distance of Swiss residents was considered, even though these emissions do not necessarily need to be connected to added value generated in Switzerland. This approximation is further explained and discussed in Annex I.

Table 1: Tourism sectors according to TSA and NOGA Switzerland (BFS, 2003b).

TSA Switzerland	NOGA taxonomy
1. Acommodation	
1.1 Hotel Industry	55.11 Hotels with restaurant 55.12 Hotels without restaurant
1.2 Non-Hotel Acommodation	55.21 Youth hostels, accommodations 55.22 Campground 55.23A Guest houses and tourist homes 55.23B Group accommodation (without lodges) 55.23C Other accommodation establishments
1.3 Holiday Home Use and Renting by owner	Holyday Home Use and Renting by owner
2. Catering Industry	
	55.3 Restaurants, Tea-Rooms, etc. 55.4A Bars 55.52 Caterers
3. Passenger Transport	
3.1.a Railways	60.1 Railway transport
3.1.b Mountain Railways and Other Special Railways	60.21C Mountain railways and other special railways
3.2 Land Transport	60.21A Passenger transportation, short distance 60.21B Passenger transportation, long distance 60.22 Taxi 60.23 Other passenger land transport
2.2 Water Transport	61.20A Inland water transport of passengers
3.4 Air Transport	62.1 Scheduled air transport 62.2 Non-scheduled air transport
3.5 Auxiliary Transport Activities	63.21 Supporting and auxiliary land transport activities 63.22 Supporting and auxiliary water transport activities 63.23 Supporting and auxiliary air transport activities
3.6 Renting of Transport Vehicles	71.1 Renting of automobiles 71.21 Renting of other land transport vehicles
4. Travel Agencies And Tour Operator	
4.1. Travel Agencies And Tour Operator	63.3 Travel agencies and tour operators
5. Culture	92. Entertainment, culture and sport
5.1 Visual Arts	92.31A Theatre and dance productions 92.31B Orchestras, bands and musicians 92.31C Individual fine artist 92.31D Other artistic activities or writing activities and presentations 92.32A Operation of concert and theatre halls 92.32 B Operation of auxiliary arts facilities
5.2 Museums And Other Cultural Activities	92.52 Museums 92.53 Botanical and zoological gardens and nature reserves activities
6 Sport And Entertainment	
6.1 Sport	92.61 Operation of facilities for outdoor or indoor sports events 92.62B Other sports related activities
6.2 Entertainment	92.13 Cinemas 92.33 Fairground and amusement parks 92.34 Other cultural and entertainment activities (e.g. Dancing schools) 55.40B Discotheques, ballrooms, night clubs 92.51 Libraries and archives 92.71 Gambling and betting 92.72 Other entertainment/recreation/leisure services

In order to calculate GHG emissions of tourism and its subsectors, system boundaries in terms of processes' life cycle and considered gases had to be defined. As shown in Table 2, we calculated emissions for two approaches: direct CO_2 emissions from combustion processes (measured in kg CO_2) and total GHG emissions from a life cycle point of view (measured in kg CO_2-equ). The former are referred to as “ CO_2 emissions” and the latter as “GHG emissions”. The boundaries were chosen as marked with a tick in the table below.

Table 2: Two approaches for life cycle system boundaries.

	Emissions from operation	Emissions from operation & embedded energy (life cycle approach)
CO2	✓	
GHG		✓

On the one hand, we determined direct CO_2 emissions from operation. It is appropriate to compare these emissions with added value, since both are directly generated by tourism sectors, in contrast to GHG emissions from the life cycle approach. Another reason to consider direct CO_2 emissions is that most previous research considers these emissions and we wanted our results to be comparable. Considering direct emissions from tourism, it is admissible to concentrate on CO_2, by far the most important GHG. CO_2 is responsible for 86 % of Switzerland's climate impact (calculation based on BAFU 2007). Other GHGs such as methane, nitrous oxide, and fluorocarbons are mostly emitted by non-tourism sectors such as agriculture and manufacturing. To simplify matters, these GHGs can be omitted.

On the other hand, the concept of GHG emissions from operation and embedded energy gives a broader view of tourism's responsibility regarding climate change. This life cycle approach additionally considers emissions from electricity production and infrastructure as well as all major GHGs. Because the life cycle approach also includes emissions caused indirectly by tourism, it is less useful to compare these emissions with the direct added value of tourism. For consistency, the life cycle emissions would have to be compared with the total of direct and indirect added value generated due to tourist demand. Notwithstanding, the life cycle emissions as such serve as a valuable indicator for tourism's climate impact.

The direct GHG emissions from operation and the total CO_2 emissions from the life cycle could not be assessed, as such data were not available. Nevertheless, the two calculated scenarios together give a satisfactory overview of the emissions related to tourism.

2.2 Concept of climate efficiency

Building on the research brought forth by Gössling (2005), we defined climate efficiency as the amount of emitted CO_2 (or GHG) per added value calculated in Swiss Francs (CHF). The data for tourism's added value in Switzerland were taken from the Tourism Satellite Account (BFS, 2003b) while the emissions in this study were calculated by ourselves.

The climate efficiency of tourism is amongst others influenced by the means of transport, average length of stay, and daily expenditures. Gössling et al. (2005) assessed the eco-efficiency of the tourist sectors accommodation, transport, and activities.

In order to avoid the confusion that can arise from the use of “higher/lower” we describe climate efficiencies as being “favourable/unfavourable”. A favourable climate efficiency is given when the ratio of CO_2/CHF is low (i.e. the amount of CO_2 emitted per added value being low). The opposite is true for an unfavourable climate efficiency, which means that the ratio of CO_2/CHF is high.

2.3 Calculation of tourism's climate efficiency

To calculate tourism's climate efficiency, figures for added value were taken from the Tourism Satellite Account, whereas CO_2 emissions from the operation process and total GHG emissions from the life cycle were calculated with data from various sources. Whenever different data sources for the same topic were available, the most recently published data was applied. If no adequate data was available, assumptions were made and transparently documented in Annex I.

The **Tourism Satellite Account (TSA)** is an economic account that is used for economic analyses of tourism and its subsectors, as for example an evaluation of tourism's contribution to GDP. The Swiss TSA (BFS, 2003b) assesses the added value and employment in the Swiss tourism sector. As not all added value of tourism sectors is generated by tourists, the TSA evaluates the sectors' specific tourism share. For the calculation of tourism's climate efficiencies, the added value and the tourism's share of the different economic sectors were taken from the TSA.

The CO_2 and GHG emissions were calculated for "NOGA 5" tourism categories (i.e. on the most detailed NOGA level, see Table 1) and aggregated to the tourism specific economic sectors in the TSA. Detailed information about the CO_2 and GHG calculations are given in Annex I. Two different approaches for calculating the emissions of the tourism-specific sectors were adopted to enable a comparison of the results from both calculations and assess the results' reliability.

The first approach for calculating CO_2 and GHG emissions used data from BFE (2006a). The unpublished BFE (2006a) dataset, from here onwards referred to as **Energy Survey**, gives raw data on the energy consumption per working place in various sectors, on the most detailed NOGA level. For each company surveyed, it contains information about the consumption of energy sources such as natural gas, heating oil, electricity, et cetera. This energy consumption of working places was converted into emissions with conversion factors from the **Ecoinvent** database (2006). This database contains international industrial life cycle inventory data on energy supply, resource extraction, material supply, chemicals, metals, agriculture, waste management services, and transport services. Conversion factors from Ecoinvent were used to estimate the direct emissions from consumption of energy sources (e.g. fuels and combustibles) and emissions from embedded energy of the infrastructure (e.g. heating boilers). The calculated emissions were divided by the number of employees in the corresponding working places, which resulted in emission data per employee for each assessed sector. The sector's total CO_2 and GHG emissions were extrapolated using data from BFS (2005). The unpublished BFS (2005) dataset, from here onwards referred to as **Employment Survey**, gives detailed figures on the employment in different economic sectors.

The second approach to calculate the CO_2 and GHG emissions used literature data. The

Microcensus on Travel Behaviour (BFS, 2007) is a survey of the population's travel behaviour in Switzerland. This survey was conducted in 2005 and provides statistical data on the following topics: daily travel patterns, purpose of trips and means of transport used, excursions with overnight stays, et cetera. Microcensus data on average traveled distances with various transport systems were extrapolated to the total Swiss population. This total mileage was converted into emissions with factors from Ecoinvent and other sources, thus providing CO_2 and GHG emission data of the transport sectors. Activities that rely on electricity as an energy source create no direct CO_2 emissions, as no combustion processes are involved. The emissions arising from electricity production were only included, if GHG emissions from life cycle were considered. For the calculation of these indirect emissions, the Swiss respectively the SBB (Swiss Federal Railways) electricity mix was used. Both of these cause much lower emissions than the European electricity mix, due to high shares of hydro and nuclear power.

Apart from the mentioned sources, other literature was considered, primarily for the accommodation sector. **Becken** (2001a, 2002, 2004), Becken & Simmons (2005). Becken et al. (2003a), **Gössling** (2002), and Gössling et al. (2005) published various emission factors for tourism services, such as transport systems, accommodation facilities and activities. An overview of reported emissions factors is given in Annex III. Although some of these factors were calculated by Becken for the case of New Zealand, many remain accurate under Swiss conditions. Whenever sufficient data from Ecoinvent, the Microcensus and the Energy Survey were not available for a specific tourism sector, the most appropriate emission factor from this literature was chosen. Calculations with literature data were also conducted to juxtapose these results against those calculated based on the previously mentioned data sources. This juxtaposition facilitated the assessment of the results' data quality, depending on their consistency.

Finally, a multiplication of the sector's emissions with the specific tourism share was necessary, as in most tourism specific sectors not the entire added value is gained from tourism. Restaurants, for example, generate added value from tourists, locals, and others. Therefore, the economic sectors' emissions from both calculations were multiplied with the corresponding tourism share from the TSA to obtain the emissions caused by tourism. In order to break tourism's added value and share of sectors from the TSA down to the most detailed NOGA level, relations of turnover rates between the sectors from the Turnover Dataset were used. The unpublished **Turnover Dataset** from the Swiss Federal Tax Administration (ESTV, 2003) provides detailed figures on the turnover of all economic sectors. To break the gross added value of the tourism sectors in TSA down to their NOGA subsectors, the subsectors' ratios in added value were assumed to be the same as in the turnover figures from the Turnover Dataset. This breakdown is further explained in Annex IV.

2.4 Greenhouse gas emissions of tourism sectors

In this chapter the calculation method of the GHG and CO_2 emissions of accommodation and catering services, transport services, as well as travel agencies and activities is presented. More detailed descriptions of the calculations are placed in Annex I.

2.4.1 Accommodation and catering services

In order to assess emissions connected to the accommodation and catering subsectors various sources beside the Energy Survey were considered. A publication from Amstutz & Schegg (2003) analyses the energy consumption and CO_2 emissions of the Swiss hotel stock. Becken & Simmons (2005) provide conversion factors for different accommodation options in New Zealand. Finally, various statistical information from BFS and others complete the data sources.

For guest homes, the GHG emission factors were calculated using energy consumption data from Imboden & Colberg (2005) and conversion factors from Ecoinvent. As from a life cycle point of view the operational phase of buildings takes up 85 % of building's energy consumption and emitted GHGs (Thormark, 2006; BFS, 2000; BFE, 2006b). 15 % of embedded energy were added to the GHG emissions to obtain the total GHG emissions from the sectors (see Annex I).

2.4.2 Transport services

The main data source beside the Energy Survey was the Microcensus which gives various data about the transport activities of the Swiss population. These data were extrapolated and multiplied with transport emission factors, mainly from Ecoinvent. The emissions calculated from the Energy Survey and the emissions calculated from the Microcensus were added up for each transport sector, since the former approach assessed the emissions from the operation of transport infrastructure and the latter emissions from the transport itself. Where data were not available from Microcensus, they were taken from other literature.

As for air transport, it was impossible to calculate the emissions specifically related to its added value, since no consistent data for aviation's emissions and added value were available. Therefore an approximation had to be made. While the calculated emissions are based on travel data of Swiss residents and thus include flights generating added value outside Switzerland, the added value given by the TSA includes services for non-Swiss residents which also generate added value for the Swiss economy. The calculated emissions were compared against air transport's added value even though the system boundaries differ. Despite the inconsistent system boundaries, the applied approach for the calculation of air transport's climate efficiency gives useful results that are verified by a control calculation for the case of the SWISS International Air Lines. For more details, see Annex I.

The emissions of private cars were calculated in the same way as emissions of passenger transport services, based on Microcensus emission factors.

Added value of private cars

The Swiss Tourism Satellite Account does not take into account the category of private cars, because the private use of cars does not directly generate an added value for the economy (people do not pay a fare for using their own car). Nevertheless, this kind of transport is an important form of tourist transport and emits considerable amounts of GHG. Therefore, its added value and GHG emissions were calculated in order to compare its climate efficiency with that of other modes of transport.

The tourism's added value of private cars was calculated as described by Rütter-Fischbacher (1991). TCS (2007) gives data about the average operation cost per km of a car in Switzerland. These costs were extrapolated to the total Swiss car stock to obtain the total turnover of the car category. The Microcensus shows that 10 % of the distances travelled by car are journeys with overnight stays. To obtain tourism's turnover the total turnover was multiplied with this share, petrol costs of Swiss habitants abroad were subtracted, and costs for petrol and road tax discs of foreigners were added. ARE (2006) estimated the direct added value's share of private car's turnover to be 45 %, which arises from capital investment (i.e. amortisation, deprecation, and taxes). This results in an added value for tourism's share of private cars of 1'855 million CHF.

2.4.3 Travel agencies and activities

This sector includes travel agencies and tour operators, cultural services, sports and entertainment. For these tourism sectors, emissions were calculated using only the Energy Survey. As these sectors are strongly dependent on buildings, 15 % of emissions from embedded energy were added as described in Annex I.

2.5 Calculation of greenhouse gas emissions associated with individual tourism services

Apart from the tourism sectors' emissions and climate efficiencies, individual tourism services' GHG emissions were assessed. In order to include the embedded energy emissions of electricity, we focused on the life cycle approach, as there are no direct emissions from electricity. The emission data of individual tourism services show which accommodation facilities, travel modes, and activities have relatively high or low emissions. This allows for a comparison between various tourist options by their emissions.

The total GHG emissions of the accommodation sectors, calculated as described in the chapter before, were divided by specific guest numbers to obtain emissions per visitor night. The emissions of the transport sectors were divided by total passenger kilometres to obtain emissions per pkm.

For the calculation of GHG emissions connected to tourist activities such as entertainment, sports, and culture, two different approaches were implemented. A survey on the energy consumption of tourist activities was conducted by sending a questionnaire to 45 businesses. Nine questionnaires were returned and evaluated. The energy data from this survey were converted into GHG emissions, using conversion factors from Ecoinvent.

Additionally, guest numbers and employment data of tourist activity businesses were compiled. The employment data were multiplied with emissions per employee in the specific NOGA sectors, which are based on the Energy Survey. The evaluated emissions of tourist activity businesses were divided by guest numbers to get GHG emissions per visit.

3 Tourism's Greenhouse Gas Emissions and Climate Efficiency

The results show that tourism causes substantial greenhouse gas emissions and has an unfavourable climate efficiency, with considerable differences between its subsectors. A key position is held by the transport sector, headed by air traffic, which is responsible for a majority of tourism's emissions.

3.1 Greenhouse gas emissions and climate efficiency of the overall tourism sector

Considering GHG emissions from a life cycle point of view, tourism's emissions amount to 4.93 million tons CO_2-equ/a or 3.11 million tons CO_2/a, respectively. Disregarding emissions from private cars, the tourism sector's direct emissions amount to 2.31 million tons CO_2/a. This represents a share of 8.4 % of Swiss economy's CO_2 emissions (BFS, 2005b). The climate efficiency of characteristic tourism sectors (without private cars) is 0.23 kg CO_2/CHF.

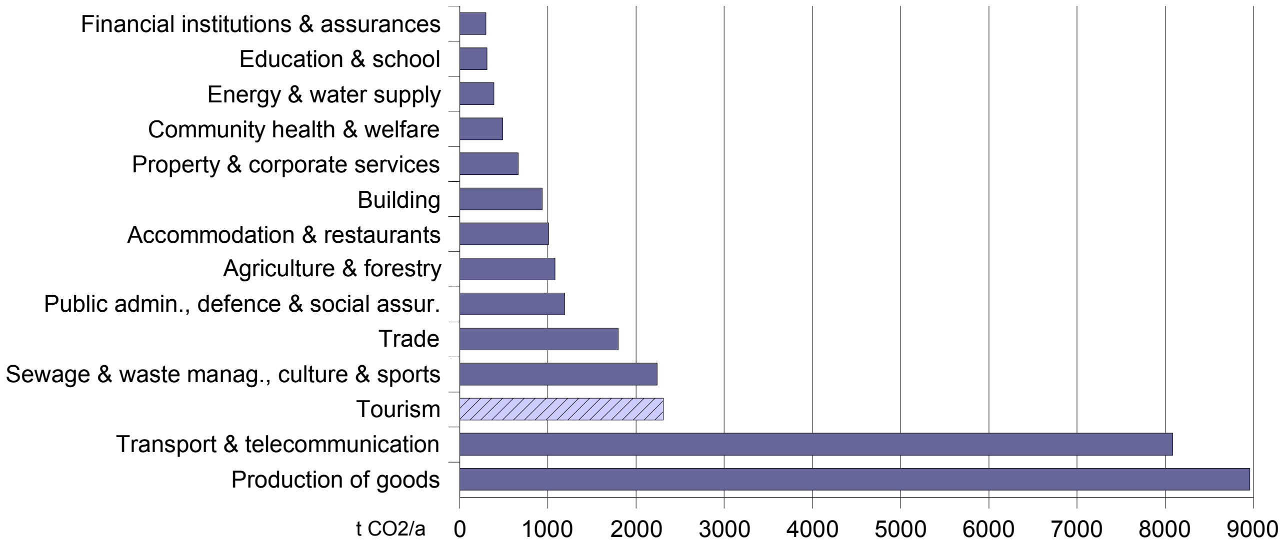


Figure 1: Annual CO_2 emissions of tourism and economic sectors in Switzerland. Adapted from BFS (2005b), except for tourism (own calculations).

In comparison to other economic sectors, tourism's emissions are third highest behind the transport & telecommunication sector and the production of goods (see Figure 1). It is essential to note that tourism is a composite sector, with sectors like transport or production of goods contributing to both its emissions and its added value.

Today, tourism has the second least favourable climate efficiency compared with other Swiss economic sectors. Figure 2 demonstrates that only the climate efficiency of the transport, communications, & information sector is less favourable (0.30 kg CO2/CHF; BFS, 2005b). According to Müller (2003), tourism's energy consumption in relation to the gross added value made it the sector with the third most unfavourable climate efficiency in 1982, which is consistent with our results.

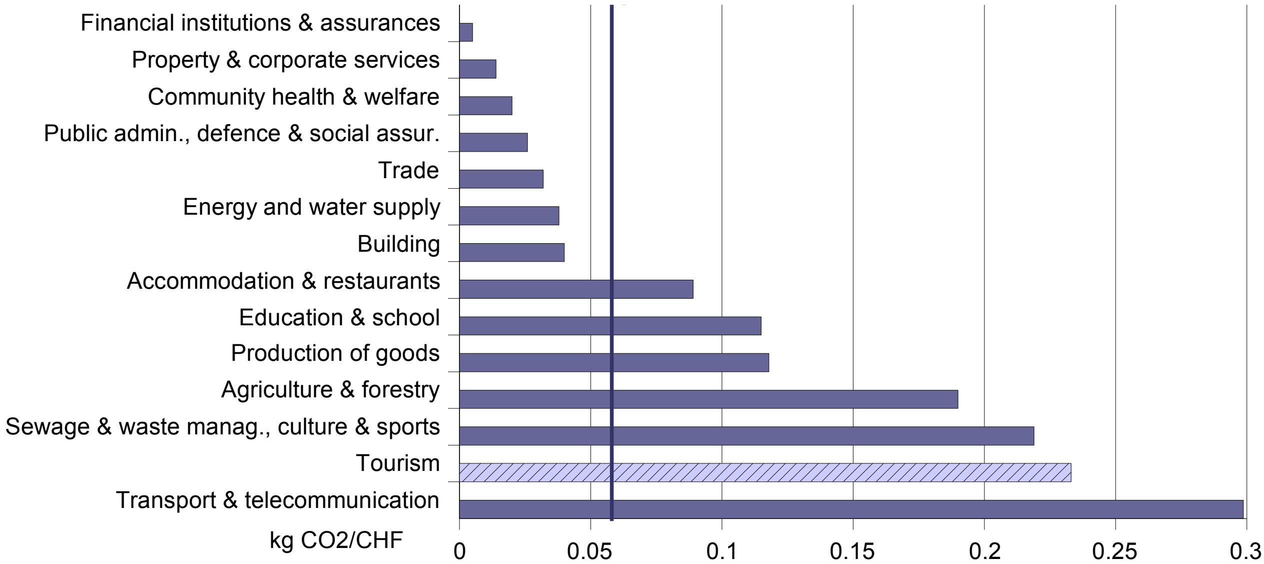


Figure 2: Climate efficiencies of tourism and economic sectors in Switzerland: CO_2 emissions in relation to added value. The vertical line denotes the average value. Adapted from BFS (2005b), except for tourism (own calculations).

The calculated climate efficiency of tourism is remarkably unfavourable, considering that the average Swiss economy's climate efficiency is 0.06 kg CO_2/CHF (BFS, 2005b). Such an unfavourable climate efficiency can result from high emissions, low added value, or both. In the case of tourism, the unfavourable climate efficiency comes from tourism's high emissions due to its high transport share. Transport services, and air transport in particular, are responsible for substantial amounts of CO_2 emissions.

On a national level, the climate efficiency is defined as CO_2 emissions per GDP. Compared to other European countries, Switzerland generally shows a relatively favourable climate efficiency in most sectors due to Swiss economy's highly efficient energy use of combustibles (BFS, 2005b). By contrast, transport and telecommunication in Switzerland have above average emissions per added value, which also makes tourism's climate efficiency less favourable.

The decoupling of CO_2 emissions from GDP over time has been slower in Switzerland than in other European countries. Since 1970, the amount of CO_2 emissions per GDP unit has decreased by 30 % in Switzerland, whereas the decrease in countries like the United Kingdom, Denmark or Norway has been over 50 % (BFS, 2005b). The reason for this slower decrease can be found in the moderate growth of the Swiss GDP, and Swiss industry emitting already relatively little CO_2 in the past, thus having a smaller reduction potential than other countries.

As tourism has higher emissions per generated added value than most economic sectors in Switzerland, measures for improving its climate efficiency must be considered in the national climate strategy. When planning a GHG mitigation strategy for tourism, it is important not only to consider the emissions according to the Swiss CO_2 law, but also the climate impact from international air transport and other GHG emissions apart from CO_2. Where such climate measures would be most efficient within tourism, can be estimated by analysing the climate efficiencies of tourism's subsectors, which is done in the following chapters.

3.2 Greenhouse gas emissions and climate efficiency of tourism sectors

The tourism sectors according to the TSA are accommodation, restaurant services, passenger transport, tourist agencies, cultural services, and sports & entertainment. To these sectors we added the sector of private transport (i.e. transport by private car).

The calculations for Switzerland show that transport contributes 84 % to tourism's GHG emissions, accommodation 12 % and activities including catering 4 % (see Figure 3). Considering CO_2, 87 % of tourism's emissions are caused by transport, 10 % by accommodation, and 3 % by activities including catering. According to Peeters (2007b), 87 % of GHG emissions from global tourism are caused by transport, 9 % by accommodations, and 4 % by activities. Therefore, our results appear to be very robust. Figure 6 at the end of this chapter gives a graphical representation of CO_2 emissions from tourism's subsectors. Detailed results on both TSA and NOGA levels can be seen in Annex II.

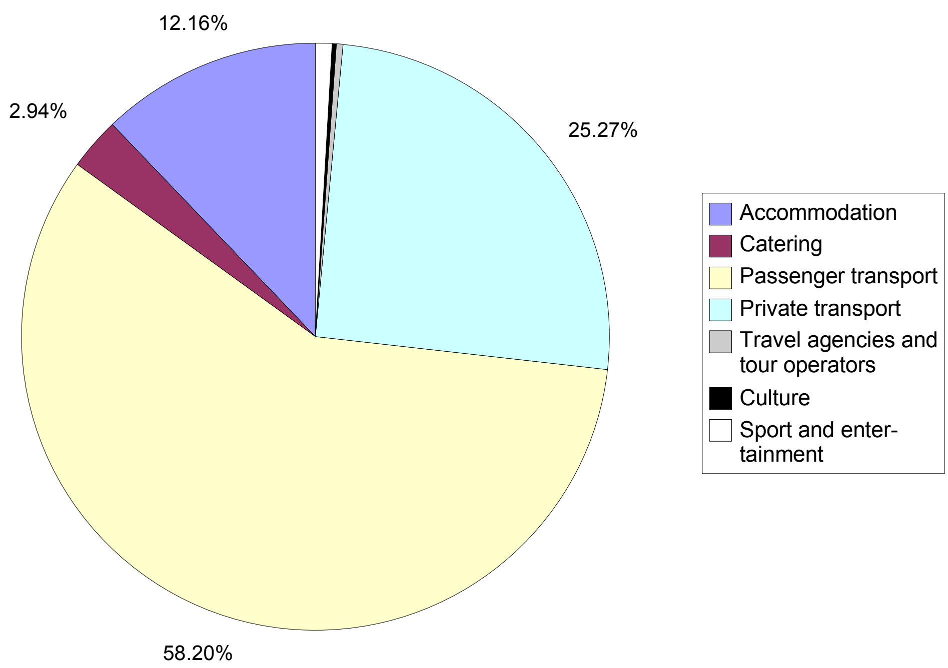


Figure 3: Tourism subsectors' share of greenhouse gas emissions.

Within the sector of passenger transport, air transport constitutes the main source of GHGs. The passenger and the private transport have the most unfavourable climate efficiencies (0.74 or 0.43 kg CO_2/CHF, respectively), as shown in Figure 4. Disregarding supporting and auxiliary transport services, the climate efficiency of tourist passenger transport amounts to 1.03 kg CO_2/CHF, which is less favourable than the average climate efficiency of the national passenger transport sector (0.76 kg CO_2/CHF; BFS, 2005b). The difference between passenger transport in general and tourist transport arises from tourism's high share of air transport, which causes large emissions. Accommodations, restaurant services, cultural services, and sports & entertainment all have medium climate efficiencies, whereas the climate efficiency of tourist agencies is highly favourable, since their services are not energy intensive.

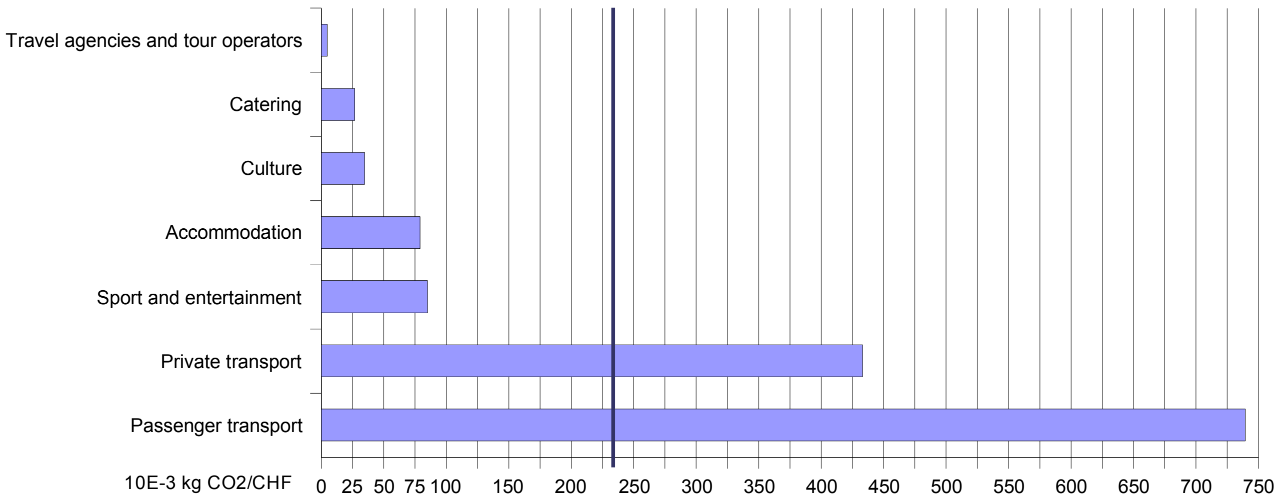


Figure 4: Climate efficiency [10^{-3} kg CO_2/CHF] ranking of tourism subsectors. The vertical line denotes the average value.

The value of a comparative rating of tourism's subsectors is limited, as all these subsectors depend on each other. Tourist agencies cannot persist without the accommodation sector, cultural services need transport systems that bring customers to the locations, and customers of the sports & entertainment sector also demand restaurant services. As all these sectors strongly interact, they must not be considered separately.

Nevertheless, a comparison of the tourism sectors can show where the major emissions come from and where they are linked to a relatively low added value. Figure 5 shows how added value and CO_2 emissions of tourism's subsectors are correlated. Subsectors below the line have higher emissions relative to their added value than subsectors above. Mitigation measures are most effective if implemented in sectors with major emissions, and they are often economically most efficient in subsectors with unfavourable climate efficiencies. Due to the fact that transport subsectors are the major emitters and have the most unfavourable climate efficiencies, they have the highest potential for mitigation measures.

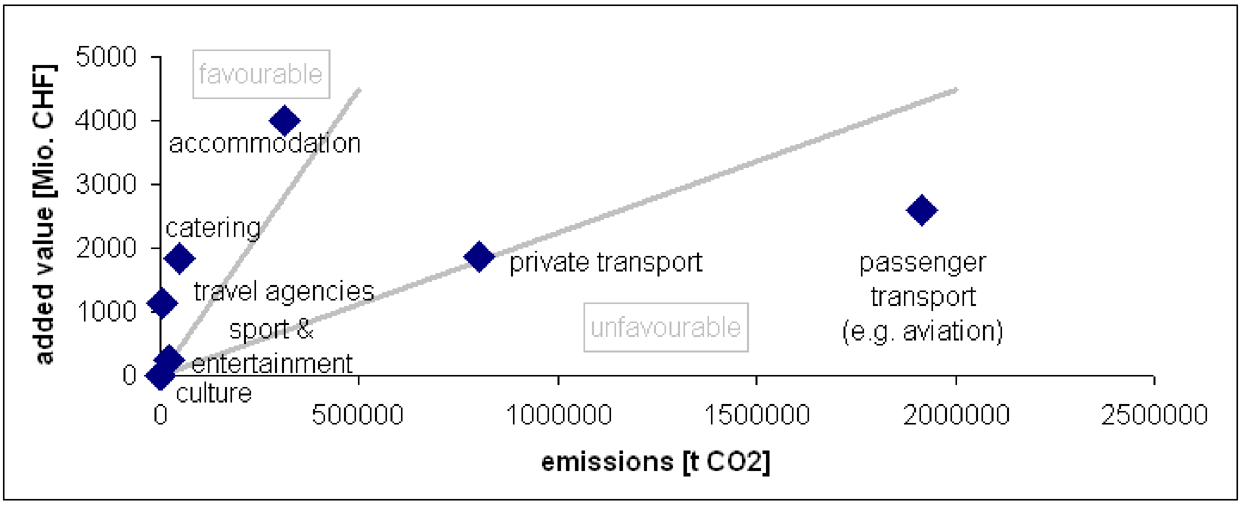


Figure 5: Tourism's added value versus its CO_2 emissions

The results indicate that the approach of calculating direct CO_2 emissions is consistent with the approach of calculating GHG emissions from the life cycle. As CO_2 is the major anthropogenic GHG and operation is the life cycle phase with most emissions, the direct CO_2 share of the calculated GHG emissions is high. The results show that 63 % of tourism's total direct and indirect GHG emissions are CO_2 emissions from operation processes. For the tourism sectors, this CO_2 share varies between 21 % and 68 %. The sectors with the highest CO_2 share on the GHG emissions are air transport and land transport. These modes of transport run on fossil fuels, the combustion of which causes high direct CO_2 emissions. The lowest CO_2 share is shown by standard railways, mountain railways, and travel agencies, since their main energy source is electricity from hydro and nuclear power. As the consumption of electricity does not directly emit CO_2, their direct CO_2 emissions remain low. Nevertheless, electricity production causes GHG emissions. These emissions are contained in the calculated GHG emissions from the life cycle approach.

In the following subchapters, the GHG emissions and climate efficiencies of the major tourism's subsectors – accommodation, catering, transport, travel agencies, and activities – are analysed in more detail. The emission data refer to tourism's share of the economic sectors. Since the examined services and facilities are not only used by tourists but also by other individuals, the total emissions of the corresponding sectors are higher. The calculated climate efficiencies are valid for both tourism's share as well as the entire sector, as they are assumed to be equal. For climate efficiency data expressed in kg CO_2-equ/CHF see Annex II.

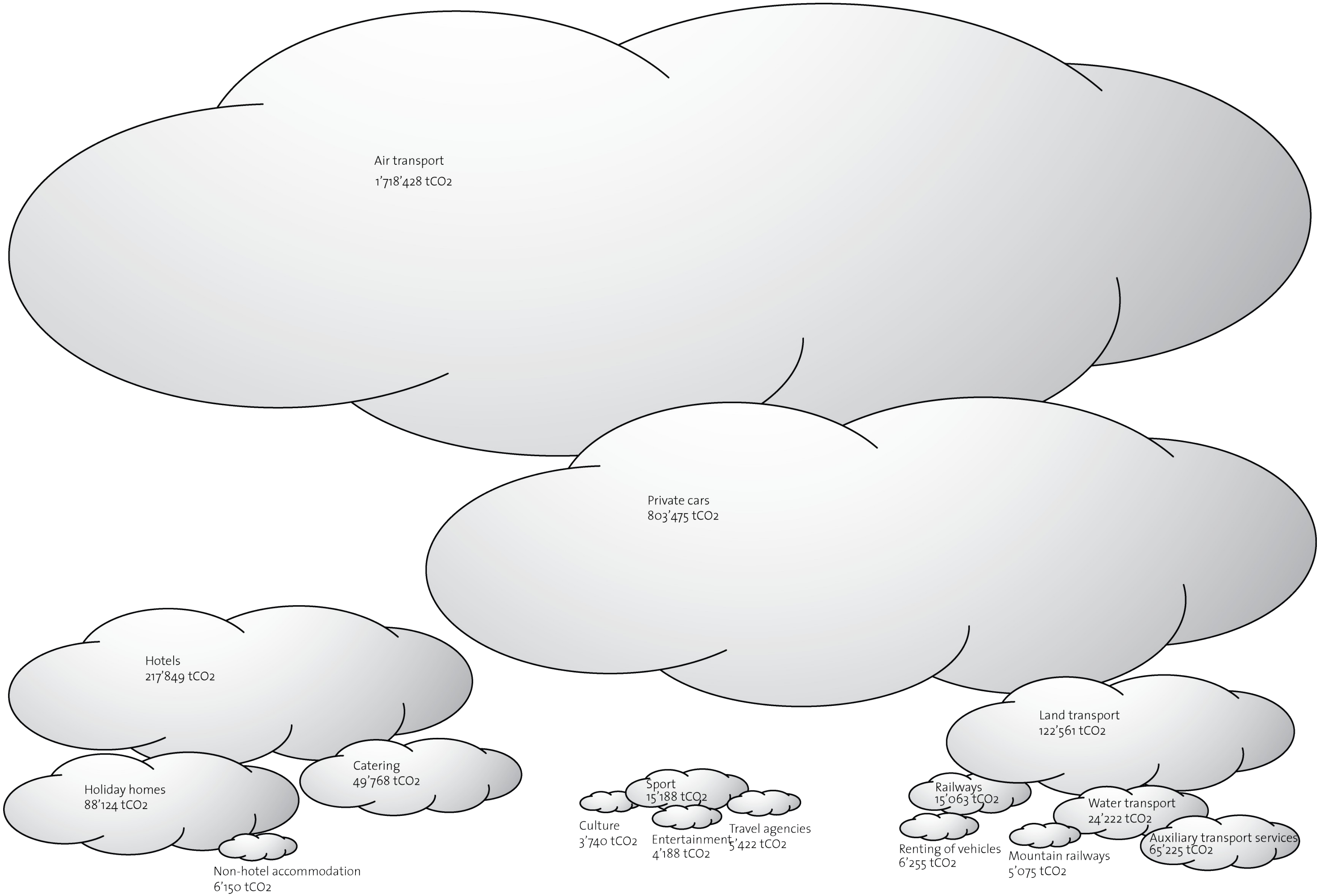


Figure 6: Tourism's CO_2 emissions in Switzerland. The cloud surface ratios correspond to the emission quantity ratios of the tourism sectors.

3.2.1 Accommodation and catering services

The accommodation and catering sector emits 0.36 million tons CO_2/a or 0.75 million tons CO_2-equ/a, respectively, including indirect energy consumption. Behind transport, it constitutes the second largest category, causing 15 % of tourism's GHG emissions.

The average climate efficiency of the accommodation and catering sector is 0.07 kg CO_2/CHF. As on Figure 7, guest houses and tourist homes (0.29 kg CO_2/CHF) show the least favourable climate efficiency. The middle range is occupied by group accommodation (0.09 kg CO_2/a), hotels (0.08 kg CO_2/CHF), and youth hostels (0.05 kg CO_2/CHF). The most favourable climate efficiency is shown by private holiday homes, catering subsectors and campgrounds (all with 0.03 kg CO_2/CHF).

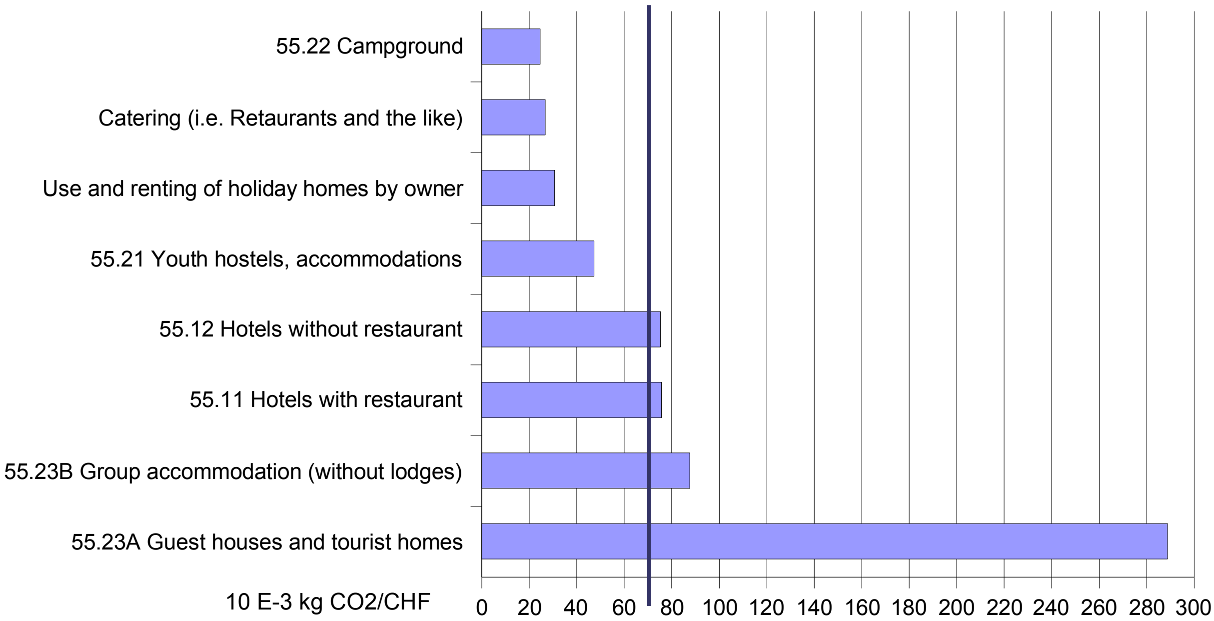


Figure 7: Climate efficiencies [10^{-3} kg CO_2/CHF] of the NOGA accommodation sectors. The vertical line denotes the average value.

The climate efficiency of guest houses and tourist homes is surprisingly unfavourable, a result of their relatively low added value. Campgrounds are ten times more efficient than guest houses and tourist homes. This is presumably attributable to the low energy consumption of campgrounds combined with their relatively high added value. Group accommodation, hotels, and youth hostels have medium climate efficiencies, since they are responsible for both relatively high emissions and substantial added value. For catering's climate efficiency the emissions from the production of food and beverages were not considered. It is probable that including these indirect emissions would make catering's climate efficiency less favourable.

3.2.2 Transport services

The passenger transport subsector (without private cars) emits 1.92 million tons CO_2/a or 2.87 million tons CO_2-equ/a, respectively, including indirect energy consumption. Additionally, the use of private cars by tourists emits 0.80 million tons CO_2 or 1.25 million tons CO_2-equ, respectively. Air transport is the largest source of CO_2 within the tourism sector, with 1.72 million tons CO_2/a emitted. If the increased effect of aviation emissions due to emissions of aerosols and GHGs in the upper troposphere were included, air transport's overall impact on the anthropogenic greenhouse effect would be even higher.

The average climate efficiency of passenger transport services is 0.74 kg CO_2/CHF. Figure 8 ranks the transport systems' climate efficiencies, showing that air transport has by far the least favourable climate efficiency amounting to 4.25 kg CO_2/CHF. Private cars have an unfavourable climate efficiency of 0.43 kg CO_2/CHF. Other subsectors with unfavourable climate efficiencies are water passenger transport (0.41 kg CO_2/CHF), and some sectors of public land transport (0.10 kg CO_2/CHF) such as short distance (0.72 kg CO_2/CHF), long distance(0.60 kg CO_2/CH), and other (0.30 kg CO_2/CHF) passenger land transport. The transport sectors with the most favourable climate efficiencies in Switzerland are standard railways (0.02 kg CO_2/CHF), and mountain railways (0.01 kg CO_2/CHF).

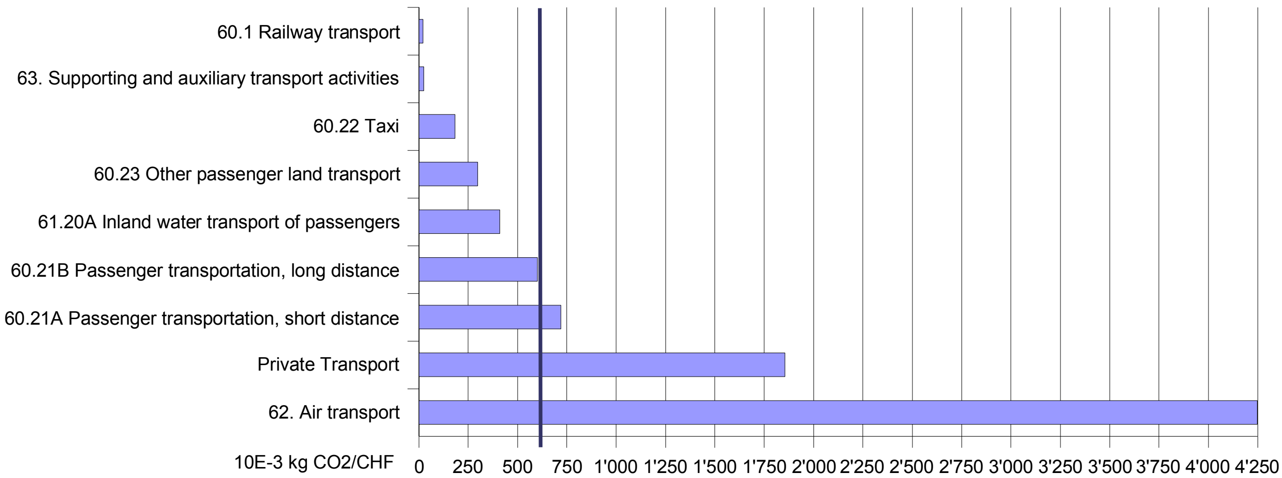


Figure 8: Climate efficiencies [10^{-3} kg CO2/CHF] of the NOGA transport sectors. The vertical line denotes the average value.

Standard railways and mountain railways have small direct CO_2 emissions, as these transport systems run mostly on electricity and not on fossil fuels. Even if indirect emissions are included, railway's GHG emissions remain small compared to other transport systems, since the Swiss railway companies' electricity has high shares of hydro power. In countries with a more GHG intensive electricity production (e.g. UK or Germany), railways' climate efficiency is less favourable than in Switzerland.

The climate efficiency of private transport is very uncertain, as the total GHG emissions from private cars depend strongly on the underlying emission factor for private cars. In return, the emission factor depends on the assumed load factor of cars, i.e. the number of people travelling in one car. In this research, the Swiss average load factor (1.57) was adopted. Since tourists often travel in groups, the average load factor of tourist's use of private cars is probably higher, thus changing the emission factor of cars and leading to a result with less GHG emissions from private cars. Additionally, private cars' climate efficiency depends also on the calculation approach for a car's added value. In this research, the added value was considered as the capital investment for cars. Other added value approaches could monetise private drivers' expenditure of time, they could consider private cars as if they were rented, or they could asses private cars indirect added value effect from their intermediate inputs.

The different transport sectors vary widely in their contribution to GHG emissions and gross added value. A GHG mitigation policy should support and expand transport sectors that generate high added value and low GHG emissions, such as standard railways and mountain railways. Whenever possible, more efficient transport methods must be substituted for medium distance flights because air transport is the major GHG emitter within the transport sector. In the European Union, about 55 % of all tourism transport (measured in pkm) is air transport (Rheinberger et al., 2007). The current growth in aviation is a fundamental problem that cannot be solved by technology alone (Peeters et al. 2007b).

3.2.3 Travel agencies and activities

The travel agencies and tour operators subsector is responsible for less than 0.01 million tons CO_2/a, respectively 0.02 million tons CO_2-equ/a. It is the tourism subsector with the most favourable climate efficiency (<0.01 kg CO_2/CHF).

Tourist activities generate added value for the economic sectors of cultural services, sports, and entertainment. They cause emissions of 0.02 million tons CO_2/a or 0.05 million tons CO_2-equ/a, respectively. Relating to the added value, this results in emissions of 0.07 kg CO_2/CHF. Figure 9 compares the climate efficiencies within this sector. Relatively unfavourable climate efficiencies are displayed by fairground entertainment and amusement parks (0.29 kg CO_2/CHF), operation facilities for sports events (0.26 kg CO_2/CHF), other cultural & entertainment activities (0.15 kg CO_2/CHF), such as circuses, and botanical & zoological gardens (0.11 kg CO_2/CHF). Orchestras, bands & musicians, and gambling & betting activities have the most favourable climate efficiencies with less than 0.01 kg CO_2/CHF.

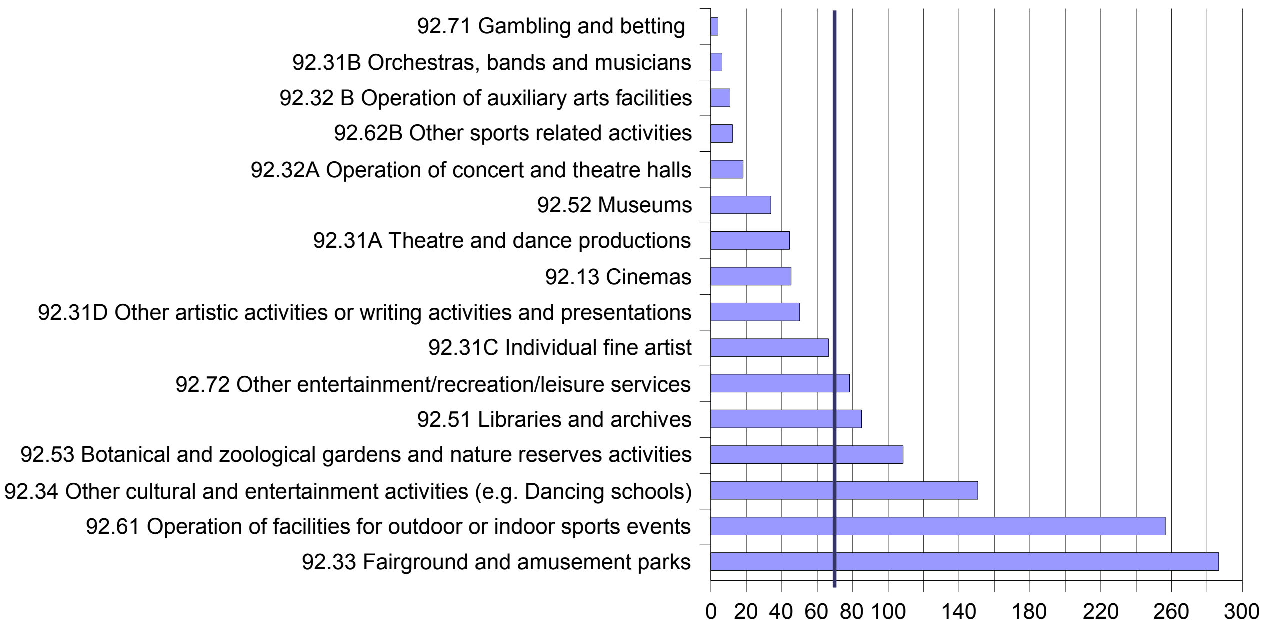


Figure 9: Climate efficiencies [10^{-3} kg CO_2/CHF] of the NOGA activity sectors. The vertical line denotes the average value.

Travel agencies and tour operators have a favourable climate efficiency, because they generate a considerable amount of added value (1'141 million CHF per year, BFS 2003b) and insignificant GHG emissions. In addition, travel agencies are economically important as they attract new business for other tourism subsectors. By that logic, however, travel agencies could also be considered responsible for emissions of the arranged commissions, such as from air transport.

Fairground entertainment and amusement parks as well as operation facilities for sports events have unfavourable climate efficiencies almost comparable to those of the transport systems. Despite their high emissions per added value, their tourist emissions remain minor due to small tourism shares in the sector. As fairground entertainment and amusement parks as well as operation facilities for sports events emit by far the most CO_2 and have the least favourable climate efficiency, these sectors should be analysed in higher detail for GHG mitigation purposes. Sports facilities may cater for completely different sports, such as ice skating, swimming or tennis, and thus may differ widely in CO_2 emissions and added value.

3.3 Potential for improving climate efficiency

“The planet has a fever. If your baby has a fever, you go to the doctor. If the doctor says you need to intervene here, you don't say, 'Well, I read a science fiction novel that told me it's not a problem.' If the crib's on fire, you don't speculate that the baby is flame retardant. You take action.“

Al Gore

Our results show tourism's responsibility for major greenhouse gas emissions. Tourism has a less favourable climate efficiency than most economic sectors in Switzerland. With regard to the threats of climate change, tourism needs to face the task of mitigating its GHG emissions and thus improving its climate efficiency. Considering tourism's GHG emissions, a key position is held by the transport sector, especially air traffic.

If willing to implement a GHG mitigation policy, governmental and non-governmental tourism offices, travel agencies, tourists, and others have several options.

Generally, GHG mitigation measures are more effective in sectors with substantial emissions and more economically efficient in sectors with unfavourable climate efficiencies. The efficiency of such measures depends also on the specific cost for implementation. A sector with high emissions and high added value can have the same climate efficiency as another sector with low emissions and low added value. However, the sector with higher emissions has a higher reduction potential and hence we assume that costs for mitigation measures are lower in that sector. Additionally, its higher added value acts as a buffer against financial loss which may occur due to GHG mitigation by reducing the sector's turnover. If a small sector with little added value has to reduce the same amount of GHG emissions as a big sector with the same climate efficiency but more added value, the small sector is relatively more financially affected.

Many mitigation measures not only decrease global warming but as a positive side effect also generate employment and therefore additional added value. Such an equilibrium between social, economical and ecological aspects of human society should be a role model for sustainable development.

The transport sector emits the most emissions and has the least favourable climate efficiency. Therefore, we see the following exemplary measures for reducing transport and improving its climate efficiency:

- Air transport's climate efficiency can be improved by reducing its CO_2 emissions (Figure 10; ①). An optimised aviation management could decrease fuel consumption and therefore emissions by 6 % to 12 %. An example could be to improve the coordination of plane arrivals and departures (Pompl, 2002). Significant fuel savings could arise from more direct routing, reduction in in-flight delays and improved capabilities to plan and implement fuel-efficient routing, speeds and altitudes (Williams et al., 2007).
- Air transport's climate efficiency can also be improved by increasing its added value compared to the generated emissions (Figure 10; ②), for example by raising the price of airfare. Prices could be raised with kerosene taxes or feebates on an international level. "Feebates" are finance initiatives imposed by government that charge users of unfavourable transport means and put the money towards payments for users of favourable transport means. Part of the additional proceeds from kerosene taxes could be used to provide energy efficiency incentives.
- GHG emissions can also be mitigated substantially by reducing transport in general (Figure 10; ③). The growth of tourism and the growth of passenger-kilometres need to be decoupled by changing current mobility trends towards longer and less frequent trips (Peeters, 2007b). If short-haul holiday destinations are rather promoted than long-haul destinations, tourists could spend their holiday budget in more climate efficient tourism sectors than transport. In 2006, tourists were responsible for 81 % of all long-distance (i.e. over 100 km) journeys made by residents of the EU (van Goeverden, 2007). In light of global warming, air transport needs to be not only modified but reduced.

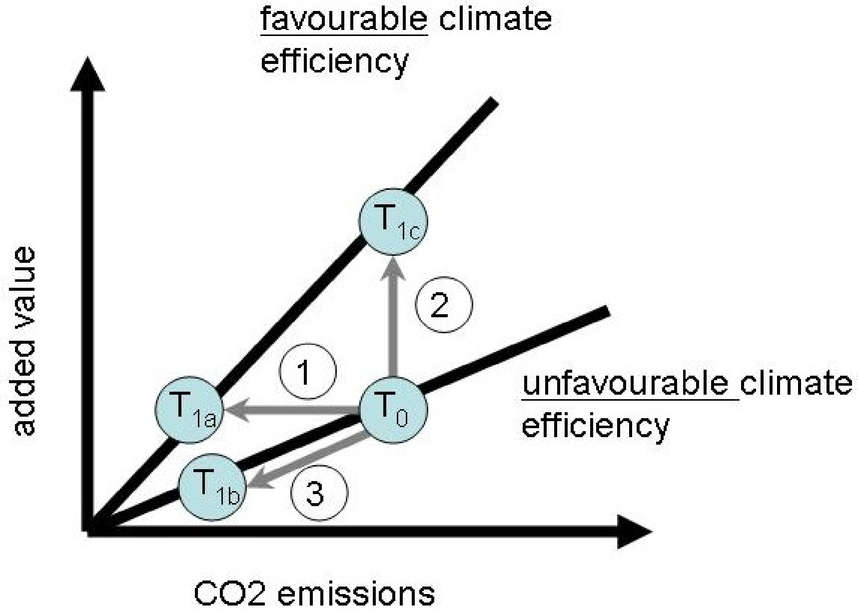


Figure 10: Feasible options for sustainable development of tourist transport; 1: reduction of emissions, 2: increase of added value, 3: reduction of transport

– Another strategy to reduce transport's GHG emissions is to change the mode of transport (Figure 11). Climate-efficient public transport needs to be generally strengthened and promoted, together with an improved infrastructure. Additionally, the replacement of short and medium distance air trips (Figure 11, T_A) by more efficient transport (Figure 11, T_B) systems such as railways would mitigate GHG emissions. Tourist offers that integrate walking with cycling or travel by bus and rail as part of the experience, need to be encouraged (Robbins et al., 2007).

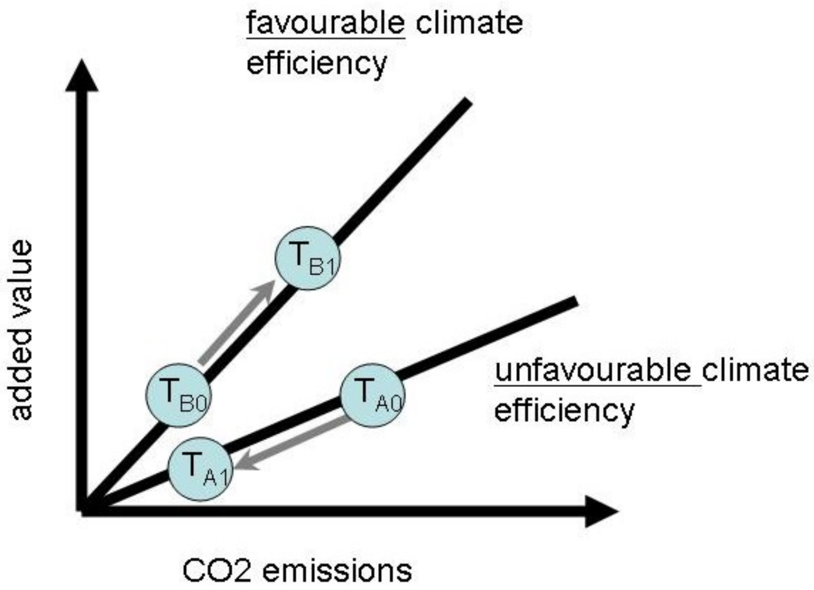


Figure 11: Substitution of unfavourable transport modes

The accommodation and catering sector generally has an intermediate climate efficiency. Therefore it is advisable for all subsectors to improve their climate efficiency. A few measures are given here:

- As accommodation and catering services are associated with buildings, it is reasonable to take measures to improve buildings' energy management, such as heating systems with renewable energies, improved insulation, and other building technologies.
- Political institutions and governmental agencies could employ more stringent energy efficiency standards for buildings, together with a compulsory energy rating of accommodation and catering services.
- Providers of accommodation and catering services could meet their electricity needs with electricity from renewable energy sources.

As for culture, sports & entertainment, general measures for energy saving are advisable. Operation facilities for certain sports in particular have high energy requirements and emissions. Further research could assess climate efficiencies of different sports, enabling decision-makers to form a qualified opinion.

3.4 Greenhouse gas emissions associated with individual tourism services

Tourists make numerous decisions that determine the amount of GHG emissions. They choose a specific accommodation, modes of transport to get to their destinations as well as for travelling within the destination area, and the activities they want to engage in during their time there. Table 3 shows the GHG emissions connected to those tourist choices. In contrast to the calculations before, a focus is laid on GHGs from the life cycle approach. A balanced comparison between the climate impact of different individual tourism services should include GHG emissions from production of electricity and infrastructure due to the high electricity requirements of some individual tourism services. The results expressed in kg CO_2 can be seen in Annex IV.

The tourist accommodation with highest emissions per guest night are hotels (20 kg CO_2-equ/guest night). This result is consistent with data from Becken & Simmons (2005). Tourist homes and youth hostels have medium emissions, whereas the emissions from group accommodation and campgrounds are relatively low. Taxis, postal buses, and mountain railways have high GHG emissions per passenger kilometre. Private cars and planes have medium GHG emissions, whereas railways and short-distance traffic such as buses and trams have the lowest GHG emissions per passenger kilometre.

Tourist activities show a wide range of GHG emissions. Some sports activities such as indoor swimming (2.9-4.6 kg CO_2-equ/visit) and golf (3.3 kg CO_2-equ/visit) have the highest emissions. Cultural activities such as museums and theatres have medium GHG emissions, even though the considered data gave a broad range of results (0.3-3.9 kg CO_2-equ/visit). Exhibitions, casinos, and zoos show medium emissions as well. The lowest GHG emissions are caused by restaurants, bars and discotheques, indoor sports, and catering.

The high GHG emissions of the hotel sector arise from its high service standard. Tourist homes don't provide any services to the guests, but emissions per guest night (e.g. from heating) still remain important since they are shared by only few guests. In Switzerland, the GHG emissions from holiday homes are an important part of the building sector's emissions. Nevertheless, most holiday homes do not meet the tourism definition, as their owners visit them on a regular basis. Youth hostels and group accommodations both provide only basic services to their guests and have many more guests per space than hotels. Therefore, their emissions per guest night are also lower than those of hotels. Campgrounds, too, have very low emissions, due to the fact that they provide very little service to their guests. Several initiatives (e.g. Hotelpower and WWF Climate Group) are working on GHG mitigation within the accommodation sector.

Table 3: GHG emissions caused by individual tourism services

	Tourist single service	GHG emissions	Data Quality
		kg CO2-equ/guest night	1 = low 2 = medium 3 = high
Acommodation	Hotel	19.8	3
	Tourist home	5.5	1
	Youth hostel	5.0	2
	Group acommodation	1.4	2
	Campground	0.7	2
		kg CO2-equ/pkm	
Transport	Taxi	0.36	2
	Long-distance traffic (postal bus)	0.33	2
	Mountain Railway	0.31	2
	Private Car	0.20	2
	Plane	0.16	2
	Short-distance traffic (bus, tram)	0.10	2
	Railway	0.02	3
		kg CO2-equ/visit	
Activities	Indoor swimming pool	2.9-4.6	1
	Golf	3.32	1
	Museum	2.0-2.8	2
	Theater	0.3-3.9	2
	Exhibition	1.55	1
	Zoo	0.1-1.1	2
	Casino	1.10	1
	Restaurant, Tea-Room etc.	0.92	2
	Bars, Discotheques etc.	0.77	2
	Sport indoor	0.67	1
	Catering	0.14	1

The choice of transport mode and destination are a tourist's most important decisions considering climate impact, since transport is the tourism sector with the highest GHG emissions, as discussed in the chapters before. Taxis may have high emissions per passenger kilometre, but as they are used for short distances, their total GHG emissions remain unimportant. Furthermore, they are often combined with railways (low emission), thus substituting private cars. Nevertheless, for short-distance transport, suburban railways, trams, and buses have much lower GHG emissions than taxis. The high emissions of postal buses and mountain railways might be surprising at first sight. These results occur because not only emissions from the transport itself were considered, but also those from the infrastructure, e.g. the administration offices. These modes of transport have relatively high GHG emissions from infrastructure, compared to relatively few passenger kilometres.

Considering GHG emissions per pkm, private cars and airplanes occupy the medium range. But in contrast to taxis and mountain railways, they are used for long-distance journeys. Therefore, the total GHG emissions from aviation and private cars are very high, which makes them major GHG emitters in tourism. The emissions per passenger kilometre travelled by car depend on the load factor. In Switzerland, the average load factor of cars is 1.57 (BFS, 2007). The load factor of car journeys with leisure purposes is 1.92. Both load factors result in rounded emissions of 0.2 kg CO2-equ/pkm. If the load factor exceeds 2.1, the GHG emissions decline to 0.1 kg CO2-equ/pkm. Since tourists often travel in groups, cars can become a rather environmental-friendly transport mode, if several people travel in the same car.

For short-haul flights, emissions per passenger kilometre are much higher per average flight, which makes planes less favourable than private cars. Short-distance transport has low GHG emissions, because trams and buses carry many passengers compared to the emitted GHGs. Railways are the mode of transport with the lowest GHG emissions. They have low impact on climate for both short-distance and long-distance trips, thus being the most environmentally friendly mode of transport in Switzerland, which is not necessarily true for other countries.

Tourist activities have much lower total GHG emissions than tourist transport and accommodation. Nevertheless, there are big differences in the amount of emissions from various tourist activities. Indoor swimming causes the highest emissions, because of its energy requirement for heating of water and facilities. We assume that the high emissions of playing golf stem from the high energy consumption for maintenance of the grounds (especially lawn mowing) for relatively few users. Museums and theatres show a broad range of emissions depending on their heating source. Along with exhibitions, they are activities with medium GHG emissions. Zoos have very high visitor numbers. Therefore, their emissions are divided by many guests and are low on a per guest basis. Restaurants, bars, and catering services also have many guests compared to their relatively small infrastructure. Thus, eating and drinking out is connected to very low GHG emissions, since indirect emissions from food production and processing are not included in the GHG calculation.

3.5 Review of the Method

This research applied the concept of climate efficiency, which compares emitted greenhouse gases with the corresponding generated added value. While an environmentalist might look at emissions, an economist might focus on monetary measures. We went a step further towards combining both approaches, aiming to show the amount of created damage per monetary gain.

In contrast, one could also look at climate efficiency and estimate which sectors achieve the highest added value with a defined amount of emissions. The favourability of a sector's climate efficiency is independent from the way the climate efficiency is defined (as CO_2/CHF or CHF/CO_2). We chose the former option, but the results can also be inverted, thus representing the latter. Both approaches are possible and the choice is dependent on the target audience.

We calculated emissions applying two approaches: direct CO_2 emissions from combustion processes and total GHG emissions from a lifecycle point of view. The direct GHG emissions from operation and the total CO_2 emissions from the lifecycle could not be assessed as such data were not available. For future research, it would be interesting to look at those two missing data fields. The direct GHG emissions could be compared with the direct added value, thus encompassing the complete climate impact of tourism.

Also, for a more accurate calculation of climate efficiencies, the first priority would be to collect more detailed data on the added values of private cars and holiday homes. These sectors are a special case and their added values are not clearly known, since they are partially generated by private individuals. In order to elaborate a practical guide for tourists who want to know how their activities influence the amount of emissions, additional data should be collected for tourist activities through comprehensive surveys.

Another crucial issue concerns added value, as not everything that has a social value generates added value. Holidays, often the main purpose of tourism, have an inherent benefit through leisure and cultural exchange. Those values cannot be described through added value, although they have indirect effects on the economy. After taking time off to relax, employees can be more productive and efficient which also benefits the company. Additionally, travel affords new (business) contacts and broadens perspective, thus also paving the way for new investments and consequent profits.

As an alternative to the climate efficiency approach, it is possible to compare the economic loss induced by tourism's contribution to climate change with the economic benefit of tourism. The Stern Review on the Economics of Climate Change (Stern, 2007) concludes that investments of one percent of gross world product per year are required in order to avoid the worst effects of climate change. Inaction would risk a decline of the gross world product by 0.6 to 12.3 % each year (90 % range; market impacts and risk of catastrophe) compared to what it otherwise might be. Since tourism depends more directly on climate conditions than other sectors, it is strongly influenced by global warming. At present, the positive and negative financial effects on tourism cannot be quantified.

4 Conclusion

On the one hand, tourism in Switzerland is highly affected by climate change due to its strong dependency on climate conditions such as snow reliability, permafrost, air temperature, and sunshine duration. On the other hand, tourism also contributes to the climate change as it is responsible for a sizeable amount of CO2 emissions (8.4 % of Swiss economy's CO_2 emissions). Tourism's climate efficiency (0.23 kg CO_2/CHF of added value) is much less favourable than that of the Swiss economy as a whole (0.06 kg CO_2/CHF).

Within tourism, the transport sector and especially air transport have by far the least favourable climate efficiencies. Therefore, it would be economically reasonable to take mitigation measures in this sector, where high emissions are connected to relatively low added value. In the transport sector, decision makers could improve the climate efficiency by supporting efficient modes of transport, such as railways, rather than inefficient modes of transport, such as air travel.

Accommodation and catering services have medium climate efficiencies and could be improved by upgrading their heating systems, for example. Tourism activities have a favourable climate efficiency, on average. A further analysis could identify reasonable starting points for mitigation measures in activity sectors with climate efficiencies with less than average favourability.

Because tourism has high emissions and an unfavourable climate efficiency, it is important to consider it specifically in a national strategy for GHG mitigation. The tourism sector has a high potential for significant GHG mitigation measures, which as of yet remains untapped.

5 Bibliography

Amstutz, M., & R. Schegg (2003). *Hotel-Power. Energieeffizienz und CO2-Emissionen in der Schweizer Hotellerie.* Schlussbericht der Phase 1, BFE-Projekt Energieeffizienz und CO2 Emissionen der Schweizer Hotellerie. Luzern.

ARE (2006). *Die Nutzen des Verkehrs - Teilprojekt 2: Beitrag des Verkehrs zur Wertschöpfung in der Schweiz*. Zürich, Bundesamt für Raumentwicklung.

BAFU (2004). *Luftschadstoff-Emissionen des Strassenverkehrs 1980-2020.*Schriftenreihe Umwelt Nr. 355. M. Keller & R. Zbinden. Bern, Bundesamt für Umwelt.

BAFU (2006). *Emissionen nach CO2-Gesetz und Kyoto-Protokoll*. Bern, Bundesamt für Umwelt.

BAFU (2007). *Switzerland's Greenhouse Gas Inventory 1990-2005. National Inventory Report 2007*. Bern, Bundesamt für Umwelt.

Becken, S. (2000). *Energy use in the New Zealand accommodation sector - report of a survey. Landcare Research and Tourism Research and Education Centre (TREC), Lincoln University.*

Becken, S. (2001a). *Energy consumption of tourist attractions and activities in New Zealand - Summary report of a survey. Landcare Research and Tourism Research and Education Centre (TREC), Lincoln University.*

Becken, S. (2001b). *Vergleich der Energieintensität zweier verschiedener Reisestile*. Tourismus Journal 5(2): 227-246.

Becken, S. (2002). *Tourism and transport in New Zealand - Implications for energy use. Tourism Recreation Research and Education Centre (TREC), Lincoln University.*

Becken, S. (2004). *Leisure, energy costs of.* Encyclopedia of Energy, Elsevier. 3: 623-634.

Becken, S., & J.-A. Cavanagh (2003). *Energy efficiency trend analysis of the tourism sector.* Lincoln, Landcare Research.

Becken, S., C. Frampton, & D. G. Simmons (2001). *Energy consumption patterns in the accomodation sector - the New Zealand case*. Ecological Economics 39: 371-386.

Becken, S. and J. Hay (2007). Tourism and Climate Change: *Risks and Opportunities.* Channel View Publications.

Becken, S., & D. G. Simmons (2002). *Understanding energy consumption patterns of tourist attractions and activities in New Zealand*. Tourism Management 23: 343-354.

Becken, S., & D. G. Simmons (2005). *Tourism, fossil fuel consumption and the impact on the global climate*. Tourism, Recreation and Climate Change. C. M. Hall & J. Higham (eds.). Clevedon, Channel View Publications: 192-206.

Becken, S., D. G. Simmons, & C. Frampton (2003a). *Segmenting tourists by their travel pattern for insights into achieving energy efficiency.* Journal of Travel Research 49: 48-56.

Becken, S., D. G. Simmons, & C. Frampton (2003b). *Energy use associated with different travel choices.* Tourism Management 24: 267-277.

BFE (2001). *Energieverbrauch im Schienenverkehr – Bericht über die Kurzstudie*. C. U. Brunner. Zürich, Bundesamt für Energie.

BFE (2006a). *Energieverbrauch in der Industrie und im Dienstleistungssektor 2002 bis 2004*. Bern, Bundesamt für Energie.

BFE (2006b). *Umweltauswirkungen von Energiestandards - Perspektiven für den Gebäudepark* Schweiz. M. Baur, D. Philippen, R. Frischknecht and M. F. Emmenegger. Bern, Bundesamt für Energie.

BFS (2000). *Bauen. Umweltstatistik Schweiz Nr. 11*. Neuchâtel, Bundesamt für Statistik.

BFS (2002). *NOGA Allgemeine Systematik der Wirtschaftszweige*. Neuchâtel, Bundesamt für Statistik.

BFS (2003a). *Die Fremdenverkehrsbilanz der Schweiz 2002*. Neuchâtel, Bundesamt für Statistik.

BFS (2003b). *Satellitenkonto Tourismus in der Schweiz. Statistik der Schweiz*. G. A. Gaillard, H. Rütter and A. Berwert. Neuchâtel, Bundesamt für Statistik.

BFS (2003c). *Eidgenössische Volkszählung 2000 – Bevölkerungsstruktur, Hauptsprache und Religion*. Neuchâtel, Bundesamt für Statistik.

BFS (2005a). *Arbeitsstätten und Beschäftigte nach ausgewählter NOGA 5*. Unpublished. Neuchâtel, Bundesamt für Statistik.

BFS (2005b). *Treibhausgasemissionen der Wirtschaftsbranchen - Pilot-NAMEA für die Schweiz 2002*. Statistik der Schweiz. J. Füssler, G. Beltrani, O. Schelske, B. Oettli, D. Sutter, & J. Heldstab. Neuchâtel, Bundesamt für Statistik.

BFS (2006). *Taschenstatistik der Schweiz 2006.*Neuchâtel, Bundesamt für Statistik.

BFS (2007). Mobilität in der Schweiz - Ergebnisse des Mikrozensus 2005 zum Verkehrsverhalten. Statistik der Schweiz. Neuchâtel, Bundesamt für Statistik.

Dubois, G., & J.-P. Ceron (2005). *Greenhouse gas emissions from tourism under the light of equity Issues.* Tourism, Recreation and Climate Change. C. M. Hall & J. Higham (eds.). Clevedon, Channel View Publications: 97-114.

Ecoinvent (2006). *Ecoinvent database v1.3*. Swiss Centre for Life Cycle Inventories. Swiss Federal Laboratories for Materials Testing and Research. Dübendorf.

ESTV (2003). *Branchenumsatz auf NOGA 5 Ebene*. Bern, Eidgenössische Steuerverwaltung.

Geisel, J. (1997). *Ökologische Aspekte zum Reisebustourismus in Luzern und Ausflugstourismus auf den Pilatus*. Institut für Geoökologie und Geographie, Universität Fridericiana zu Karlsruhe.

Gössling, S. (2002). *Global environmental consequences of tourism*. Global Environmental Change 12: 283-302.

Gössling, S., P. Peeters, J.-P. Ceron, T. Patterson, & R.B. Richardson (2005). *The eco-efficiency of tourism*. Ecological Economics 54: 417-434.

Goeverden, C. D. van (2007). *Long distance travel in Europe: the potential of the train*. Tourism and climate change mitigation - methods, greenhouse gas reductions and policies. Paul Peeters (ed.). Breda, Stichting NHTV Breda.

Hochuli, A. & F. Maurhofer (2006). *Fakten und Zahlen 2006*. Bern, Seilbahnen Schweiz.

Imboden, D. & C. Colberg (eds.) (2005). *Bericht zur Fallstudie Energiestadt WS 2004/05*. Zürich, Departement D-UWIS, Eidgenössische Technische Hochschule Zürich.

IPCC (2001). *Climate change 2001: the scientific basis. Working group I contribution to the third assessment report of the Intergovernmental Panel on Climate Change*. J. T. Houghton, Y. Ding, D. J. Griggs, M. Noguer, P. van der Linden, & D. Xiasou (eds.). Cambridge: Cambridge University Press.

IPCC (2007a). *Climate Change 2007: Impacts, adaptation and vulnerability. Summary for policymakers. Working group II contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report*. Cambridge: Cambridge University Press.

IPCC (2007b). *Climate Change 2007: The physical science basis. Working group I contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report*. S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt M. Tignor, & H. L. Miller (eds.). Cambridge: Cambridge University Press.

Lässer, C. & T. Bieger (2005). Travel Market Switzerland – Basic Report and Variables Overview. St.Gallen, Institut für Öffentliche Dienstleistungen und Tourismus.

Müller, H. (2003). *Tourismus und Ökologie - Wechselwirkungen und Handlungsfelder.* München, Oldenbourg.

Müller, H. (2006). *Wertschöpfung am Beispiel des Tourismus*. Grundlagen ökonomischen Denkens. Bern, Forschungsinstitut für Freizeit und Tourismus (FIF).

Müller, H., F. Weber, & E. Thalmann. (2007). *Tourismus, Klimaänderungen und die Schweiz* 2050. Bern, OcCC / ProClim.

Peeters, P. (2007a). *Mitigating tourism's contribution to climate change - an introduction*. Tourism and climate change mitigation - Methods, greenhouse gas reductions and policies. Paul Peeters (ed.). Breda, Stichting NHTV Breda.

Peeters, P. (2007b). *Tourism and climate change mitigation*. Methods, greenhouse gas reductions and policies. NHTV Academic Studies No. 6. Breda, NHTV.

Peeters, P., V. Williams, & S. Gössling (2007). *Air transport greenhouse gas emissions*. Tourism and climate change mitigation - Methods, greenhouse gas reductions and policies. Paul Peeters (ed.). Breda Stichting NHTV Breda.

Pompl, W. (2002). *Luftverkehr - Eine ökonomische und politische Einführung*. Berlin, Springer.

Rheinberger, U., M. Schmied, & K. Götz (2007). *Greenhouse gas emissions reduction by target group tailored holiday offers*. Tourism and climate change mitigation - methods, greenhouse gas reductions and policies. Paul Peeters (ed.). Breda, Stichting NHTV Breda.

Ruschmann, D. (2007). *Der Kranich stützt das Schweizerkreuz*. Published in Bilanz on 16/03/2007.

Rütter, H. (1986). *Die Wertschöpfung von Unternehmen und Wirtschaftszweigen in der Schweiz*. Zürich, Schulthess.

Rütter-Fischbacher, H. (1991). *Wertschöpfung des Tourismus in der Schweiz. Beiträge zur Tourismuspolitik Nr. 2*. Bern, Bundesamt für Industrie, Gewerbe und Arbeit.

SAC (2007). *Schweizer Alpen-Club*. From http://www.sac-cas.ch/ accessed on 07/07/2007. Bern, Schweizer Alpen-Club.

SBB (2004). *Umweltbericht 2002/2003*. Bern.

Schafer, A. & D. G. Victor (1999). *Global Passenger Travel: Implications for Carbon Dioxide Emissions*. Energy 24: 657-679.

Schaible, F. (2007). *Gäste bringen Leben ins Geisterhaus*. Published in Cash on 03/05/2007.

Schmied, M., M. Buchert, C. Hochfeld, & B. Schmitt (2002). *Umwelt und Tourismus: Daten, Fakten, Perspektiven*. Berlin, Umweltbundesamt.

SJH (2007). *Swiss Youth Hostels*. From http://youthhostel.ch/ accessed on 07/07/2007. Zürich. Schweizer Jugendherbergen.

Stern, N. (2007). *The economics of climate change: the Stern review*. Cambridge, Cambridge University Press.

Strebel, B. (1997). *Traveller's Health, Communicable Diseases & Transmittable Disorders from the Quarantine Health On the Net Prevention Clinic*. Showed on http://www.irational.org/cern/virus.html at the First Cyberfeminist International exposition Hybrid Workspace at Documenta X, September 1997, Kassel, Germany.

STV (2006). *Schweizer Tourismus in Zahlen 2006*. Bern, Schweizer Tourismus-Verband.

Swiss (2007). *Zahlen und Fakten*. From http://www.swiss.com/web/DE/about_swiss/company/Pages/facts_figures.aspx accessed on 07/07/2007. Basel, Swiss International Air Lines AG.

TCS (2007). *Kilometerkosten 2007*. Emmen, Touring Club Schweiz.

Thormark, C. (2006). *The effect of material choice on the total energy need and recycling potential of a building*. Building and Environment 41: 1019-1026.

UNFCCC (1998). *Kyoto Protocol to the United Nations Framework Convention on Climate Change*. United Nations.

VöV (2007). *Fakten und Argumente zum Öffentlichen Verkehr der Schweiz*. Bern, Verband öffentlicher Verkehr.

Williams, V., R. Noland, A. Majundar, R. Toumi, & W. Ochien (2007). *Mitigation of climate impacts with innovative air transport management tools*. Tourism and climate change mitigation - Methods, greenhouse gas reductions and policies. Paul Peeters (ed.). Breda, Stichting NHTV Breda.

WTTC (2007). *Switzerland - Travel & tourism navigating the path ahead* - The 2007 Travel & Tourism Economic Research. TSA Country Reports, World Tourism Council.

6 Annex

Annex I Method and Data

Annex II Results

Annex III Emission Factors From Literature

Annex IV Breakdown to NOGA 5 Level

Annex I: Method and Data

Annex I contains the detailed description of the greenhouse gas (GHG) emissions calculation. The figures (e.g. 55.10A) in front of the following subheadings (e.g. Hotels with restaurants) refer to the NOGA (see Glossary) code of the service concerned.

Accommodation and catering services

For assessing the emissions connected to the accommodation and catering subsectors, the considered sources were the Energy Survey (BFE, 2006) and a publication from Amstutz & Schegg (2003) that analyses the energy consumption and CO_2 emissions of the Swiss hotel stock. Additionally, emission factors from Becken & Simmons (2005) for different accommodation options were used, as well as statistical information from BFS.

Generally, for buildings, we considered the energy used for operation (cleaning, logistics, etc.) and added 15 % of embedded energy to get the total emissions. Various sources indicate that emissions from construction and deconstruction, as well as indirect energy of the building material amount to 15 % of total emissions:

Table 1: Overview of embedded energy percentages for buildings

Source	**Data**	
Thormark (2006)	Operation energy = 85-95 % of total energy consumption	
BFS (2000)	Operation energy = 85 %	Construction = 15 %
BFE (2006)	Operation energy = 85 %	Bare brickwork = 15 %

55.10A Hotels with restaurant & 55.10B Hotels without restaurant

Amstutz & Schegg (2004) calculated the total CO_2 emissions of the hotel sector based on four different data sources and concluded that the emissions amount to 530'000 t CO_2/a. These calculations consider only emissions caused during the operation phase of hotels. Considering the embedded energy as well, the hotel sector emits 623'529 t CO_2/a.

The Energy Survey gives the energy requirement of 179 hotels with restaurant and 6 hotels without restaurant, separated into different energy sources. Using GHG and CO_2 conversion factors for different energy sources (Ecoinvent, 2006), emissions per employee were assessed for the two hotel subsectors and then extrapolated to the hotel sector. Finally, the emissions of the sectors were multiplied with the corresponding tourism share.

55.21 Youth hostels, accommodation

Emissions from accommodation affiliated to the Swiss Youth Hostel Association and the Swiss Alpine Club (SAC) were assessed using emission factors per guest night from Becken & Simmons (2005) and the number of guests. The guest numbers of youth hostels are given by SJH (2007), whereas those of SAC accommodation were estimated from the SAC (2007) website.

A second calculation was made using data from the Energy Survey. Because this survey does not give any data on this particular tourism sector, the same GHG and CO_2 emission factors per employee were applied as for the “hotel without restaurant” sector. This assumption was made, since the “hotel without restaurant” subsector was the most alike type of accommodation with available data.

55.22 Campground

The GHG emissions from campgrounds were calculated using guest numbers from the Swiss Tourism Alliance (STV, 2006) and conversion factors from Becken & Simmons (2005). Gössling (2005) estimated conversion factors almost six times higher than Becken & Simmons (2005), but his factors are a global average, whereas Becken & Simmons have chosen factors for New Zealand. Switzerland's GHG situation of energy supply is more similar to New Zealand's than to the World's average. Hydro power is the main electricity source in both countries, thus their electricity mix accounts for relatively low GHG emissions. Therefore, factors from Becken & Simmons (2005) were used for further calculation. The Energy Survey dataset gives data on four campgrounds. GHG and CO_2 emissions were assessed the same way as in the sectors discussed previously.

55.23A Guest houses and tourist homes – Use and renting of holiday homes by owner

It is difficult to separate the NOGA sector of commercial “Guest Houses and Tourist Homes” from “Use and Renting by Owner”. Schaible (2007) gives the number of total holiday homes in Switzerland as 419'000. Lässer & Bieger (2005) estimate that 84 % of owners do not rent their holiday homes to a third party (non-friends and non-relative). The remainder can be divided into owners who rent their holiday homes directly to third parties, and owners who rent their homes using commercial holiday home agencies. Based on Lässer and Bieger's estimation, we made the assumption that only 10 % of holidays homes belong to the commercial NOGA sector, i.e. being rented out on a professional basis.

The average CO_2 and GHG emissions of holiday homes, which amount to 3.63 t CO_2/a or 4.62 t CO_2-equ/a, respectively, were calculated from energy consumption costs of 500 holiday homes in Vaz/Obervaz (Imboden & Colberg, 2005) and conversion factors from Ecoinvent. The average emissions were multiplied with the number of holiday homes in the particular sector.

55.23B Group accommodation establishments – 55.23C Other accommodation establishments

Data from Energy Survey were converted into emission data as described for the hotel sector. Because the Energy Survey gives only data from one establishment for this sector, which is afflicted with uncertainties, the same GHG and CO_2 conversion factors per employee were chosen as for the “hotel without restaurant” sector.

For a second calculation the number of guest nights (BFS, 2003a) was multiplied with conversion factor of 1 kg CO_2/guest night (Becken & Simmons, 2005).The results from the approaches are consistent, as the first amounts to 5'310 t CO_2 and the second to 5'900 t CO_2.

In the “other accommodation establishments” sector, only a calculation with data from one company from the Energy Survey analogue to the sectors before could be done.

55.3 Restaurants, Tea-Rooms, etc. – 55.40A Bars – 55.52 Caterers

In these sectors only a calculation with data from one company from the Energy Survey analogue to the sectors before could be done.

Passenger transport services

The Energy Survey dataset includes the consumption of energy from various sources such as heating oil and electricity. However, the consumption of fuels for transport purposes was not considered. Therefore, the emissions from the operation of transport infrastructure were calculated from the Energy Survey as described in the report, and added to the transport emissions from the consumption of fuels. For calculating emissions from fuel consumption, Microcensus survey data, Ecoinvent, and other sources were used.

60.1 Railway transport

The main railway company in Switzerland is SBB (Swiss Federal Railways), which holds about 60 % of the railway network. In the SBB environmental report (SBB, 2003) data on annual passenger kilometres (pkm) and energy requirement are provided. Ecoinvent gives data on GHG emissions per pkm for long distance railway transportation and for regional trains as well as GHG emissions of the SBB electricity mix. This electricity mix causes relatively low GHG emissions as it consists by 89 % of hydro power (SBB, 2003).

Data similar to those given by SBB (2003) are presented by STV (2006) and Microcensus. The GHG inventory (BAFU, 2007) assesses the total GHG emissions of railways as 100'000 t CO_2-equ. BFE (2001) also gives data on pkm for SBB and total railway transportation in Switzerland. The GHG emissions calculated from these data are much lower than these from BAFU (2007).

The probably best data are given by the Public Transport Alliance (VöV, 2007) as its numbers include not only passenger transport with SBB but all railway on normal and narrow gage. Therefore the VöV data were chosen to calculate the railway's climate efficiency.

60.21C Mountain railways and other special railways

Using Geisel's 1997 diploma thesis about the case of tourism in the Pilatus mountain region, we calculated an average energy requirement of cable cars and cog railways and thus the GHG emissions of this subsector. Müller et al. (2007) and Hochuli & Maurhofer (2006) give data on the number of different mountain railways in Switzerland and the total amount of transported passengers.

60.21A Passenger transportation, short distance

Short distance transportation is regular passenger transportation (local & short distance) according to schedules, with autobus, tramway, trolleybus, metro and underground vehicles, school bus etc. Data were available for tramway and buses, presented by Microcensus survey, Ecoinvent, and Swiss annual statistics (BFS, 2006).

60.21B Passenger transportation, long distance

Regular long distance passenger transportation (excluding railways and car trips) according to schedules, consists only of postal bus transport. For the calculations, data from Microcensus and Ecoinvent were used.

60.22 Taxi

From Microcensus we calculated the person kilometres travelled with taxis. Using the GHG emissions for cars from Ecoinvent and the Swiss average car occupation (BFS, 2007), we calculated the total GHG emissions from direct and indirect energy and fuel requirement.

60.23 Other passenger land transport

For other passenger land transport we calculated the GHG emission from bus trips, using data from Microcensus and factors from Ecoinvent. The GHG emission from bus trips reported in BAFU (2004) differs strongly from our calculated GHG emissions.

61.20A Inland water transport of passengers

Using data from Microcensus and GHG factors from Gössling (2005) we calculated the GHG emission of inbound water transport of passengers. The GHG emissions of water transportation as calculated in BAFU (2007) are much higher than in our calculation. However, our results are consistent with data from VöV (2007).

62.1 Scheduled air transport

According to the NOGA classification (BFS, 2002), scheduled air transport includes the transport of passengers or freight by air over regular routes and on regular schedules, as well as renting of aircraft and personnel for scheduled air transport. Regular charter flights are not included.

For assessing the CO_2 and GHG emissions of scheduled air transport, the average Swiss flight behaviour in Microcensus was calculated with 6.735 million Swiss residents aged six and above (BFS, 2003c), and emission factors per passenger kilometre from Ecoinvent. This gives the CO_2 and GHG emissions of Swiss residents' air travel behaviour.

The emissions according to BAFU (2006), which makes calculations according to the Swiss CO_2 law, are almost twice as high as the emissions calculated from Microcensus. But the emission data from BAFU were calculated from the sale of aviation fuels. It is less useful to compare these emissions with the added value of air transport in Switzerland, as various airline companies refuel their aircrafts within Switzerland without generating much added value for Switzerland's economy.

The assessed emissions were multiplied with tourism's share of air transport and divided by tourism's added value from air transport to calculate the climate efficiency. The comparison of Swiss residents' emissions from air transport with the air transport's added value in Switzerland is an approximation for air transport's climate efficiency. One one hand, the assessed emissions also include air transport activities connected with added value outside Switzerland (i.e. for foreign airlines, not included in TSA's added value). On the other hand, the added value in TSA also includes services for people not residing in Switzerland, but generating added value for the Swiss economy.

Nevertheless, the approximation is reasonable as the following calculation for Swiss International Air Lines Ltd. shows. Swiss International Air Lines Ltd. is a Swiss resident airline company and therefore all its services are included in TSA. This company sold 22'074 million passenger kilometres and offered 5'300 jobs in 2006 (Swiss, 2007; Ruschmann, 2007). From this data we calculated the company's emissions of 441 t CO_2 per employee and year, which is consistent with the calculated 413 t CO_2 per employee and year for the NOGA sector “air transport”.

62.2 Non-scheduled air transport

This way of transport includes non-scheduled transport of passengers or freight by air, scenic and sightseeing flights, regular charter flights, renting of air-transport equipment with operator.

While calculating, we were faced with a number of data gaps. Therefore it was only possible to calculate the GHG emissions of helicopter flights. Charter flights could not be calculated due to lack of data. As for scenic flights, we assumed that most were made with helicopters and thus disregarded the ones made with planes. As for the other subsectors, data from Ecoinvent and the Energy Survey were used for calculating the emissions from operation of infrastructure.

63.21 Supporting and auxiliary land transport activities – 63.22 Supporting and auxiliary water transport activities

As the Energy Survey gives only data for supporting and auxiliary air transport activities, this value was also taken for land transport and water transport. All three categories contain operation of traffic infrastructure and therefore the emissions per employee should be similar.

63.23 Supporting and auxiliary air transport activities

As mentioned above, the supporting and auxiliary air air transport activities were calculated using the Energy Survey. Additionally, we made our own calculations with data from Ecoinvent (2006). Both calculations yield results in the same order of magnitude, thus confirming the validity of data.

71.1 Renting of automobiles

For this category, NOGA considers the renting and operate-leasing of passenger cars and delivery vans without driver, weighing up to 3.5 t. Financial leasing is excluded. We used the Energy Survey and the official BFS (2006) data available.

71.21 Renting of other land transport vehicles

This section includes rail vehicles, lorries > 3.5 t, tractors, trailers, semi-trailers, motorcycles, campers, containers. Automobiles and lorries with driver, bicycles, financial leasing, and renting of mobile homes are excluded.

For hire-cars we were confronted with the problem of allocating the GHG emissions. We had to make the decision whether the GHG emissions from use of hire-cars should be allocated to the hirer, the rental agency or the petrol station. We decided to allocate it to the rental agency as this allows us to take these emissions into the NOGA classification.

The available data derive from the Microcensus (BFS, 2007) for pkm, CO_2 factors from publications, data for private cars from Ecoinvent (2006), as well as data from the Energy Survey.

Private Cars

According to the Microcensus 10 % of car travel accounts for journey with overnight stay. We estimate this as tourism's share of travelled distance by car, although this number also includes journeys within habitual environment e.g. weekly term workers.

The Microcensus gives data about travelled person kilometre by car. These data were extrapolated to the Swiss population and multiplied with CO_2 and GHG factors from Ecoinvent and the tourism share of 10 %. This makes for tourism's emissions of 0.80 million t CO2 or 1.25 million t CO_2-equ, respectively.

Another calculation gives results of similar range: The total amounts of CO_2 and GHG emissions from private cars are published in the Swiss Greenhouse Gases Inventory (BAFU, 2007). Multiplied with the estimated tourism share, that makes 1.11 million t CO_2/a or 1.12 million t CO_2-equ/a, respectively.

Activity services

Emissions for the activity sector were calculated using the Energy Survey. With these data and factors from Ecoinvent (2006) the emissions per employee for each sector were assessed. With numbers of employees from the Employment Survey, the total CO_2 and GHG emissions were extrapolated. As most of these sectors are strongly dependent on buildings, 15 % of emissions from embedded energy were added as described under “accommodation & catering services”.

For four activity sectors, the BFE dataset does not give any data. Therefore, assumptions were necessary. For the sector “other artistic or writing activities and presentations” the emissions per employee were estimated to be the average of the other three sectors in the same NOGA group. For the sector “operation of auxiliary arts facilities” the same value was taken as for the operation of concert and theatre halls. Because no data and no similar sector was available for the sector “fairground entertainment and amusement parks”, the average of all sectors in the NOGA group 92 (i.e. recreational, cultural and sporting activities) were taken as emissions per employee. For ballrooms, discotheques and night clubs the same emissions per employee were taken as for bars.

Travel agencies & tour operators – Cultural services – Recreation and entertainment

Data from the Energy Survey were converted into emission data using GHG and CO_2 emission factors for different energy sources. Emissions per employee were assessed and extrapolated to the whole sectors. Finally, the emissions of the sector were multiplied with the corresponding tourism share.

Annex II: Results

Table 1: Tourism's emissions, added value, and climate efficiency in Switzerland according to TSA taxonomy

Economy Branches According To TSA Switzerland		Tourism Share of Added Value	Emissions Sector		Emissions Tourism		Added Value of Tourism	Employment in Tourism	Climate Efficiency Of Tourism		Data Quality
		[%]	Operation: [tCO2]	Total Energy: [tCO2-equ]	Operation: [tCO2]	Total Energy: [tCO2-equ]	[Mio. CHF]		[kgCO2/CHF]	[kgCO2-equ/CHF]	1 = low 2 = medium 3 = high
A	Tourism specific economy sectors	11					12267	160617			
	Characteristic touristic economy sectors without private transport	29	3'767'161	6'314'835	2'307'400	3'648'664	9'911	134'288	0.23	0.37	
A1	**Characteristic touristic economy sectors (with private transport)**	**29**	**11'801'910**	**18'765'629**	**3'110'875**	**4'893'743**	**11'766**	**134'288**	**0.26**	**0.42**	
	Hotel and restaurant industry (accommodation + catering, without use by owners)	48	536'473	1'238'253	337'376	708'216	5'059	86'952	0.07	0.14	2
1	**Accommodation**	**19**	**959'366**	**1'621'817**	**312'123**	**591'326**	**4'001**	**55'696**	**0.08**	**0.15**	**2**
1.1 / 1.2	Hotel and non-hotel accommodation	76	367'486	736'312	288'448	563'473	3'227	55'696	0.09	0.17	2
1.3 / 1.4	Use and renting by owners	4	591'879	885'504	23'675	27'853	773	N/A	0.03	0.04	1
2	**Catering**	**29**	**168'987**	**501'941**	**48'928**	**144'743**	**1'832**	**31'256**	**0.03**	**0.08**	**3**
3	**Passenger transport**	**46**	**2'509'342**	**3'895'771**	**1'917'158**	**2'841'988**	**2'593**	**30'161**	**0.74**	**1.10**	**2**
3.1.a	Railway transport	28	53'796	252'991	15'063	65'225	698	9'756	0.02	0.09	3
3.1.b	Mountain railways and other special railways	92	5'517	30'003	5'075	24'457	385	4'741	0.01	0.06	2
3	Land transport	23	425'816	651'009	122'561	182'200	287	4'020	0.43	0.63	2
3	Water transport	80	30'278	N/A	24'222	N/A	59	897	0.41	N/A	2
3.4 / 3.5	Air transport / Auxiliary transport activities	63	1'984'459	2'947'051	1'743'982	2'560'392	1'068	10'132	1.63	2.40	2
4	Renting of transport vehicles	67	9'477	14'717	6'255	9'713	97	641	0.06	0.10	1
S	**Private transport**	**N/A**	**8'034'749**	**12'450'794**	**803'475**	**1'245'079**	**1'855**	**N/A**	**0.43**	**0.67**	**2**
4	**Travel agencies and tour operators**	**100**	**5'422**	**18'810**	**5'422**	**18'810**	**1'141**	**12'720**	**0.00**	**0.02**	**3**
5	**Culture**	**14**	**23'842**	**59'102**	**3'740**	**10'205**	**108**	**1'400**	**0.03**	**0.09**	**2**
5	Visual arts	11	13'269	25'562	1'460	2'812	55	732	0.03	0.05	2
5	Museums and other cultural activities	23	10'573	33'540	2'281	7'393	54	668	0.04	0.14	3
6	**Sport and entertainment**	**19**	**100'203**	**217'395**	**20'028**	**41'592**	**236**	**3'055**	**0.08**	**0.18**	**2**
6	Sport	21	72'326	147'580	15'188	30'992	116	1'418	0.13	0.27	2
6	Entertainment	17	27'877	69'815	4'839	10'601	121	1'637	0.04	0.09	1

Table 2: Tourism's emissions, added value, and climate efficiency in Switzerland according to NOGA taxonomy

Economy Sectors According To NOGA Switzerland		Tourism Share of Added Value	Emissions				Added Value of Tourism	Employment in Tourism	Climate Efficiency		Data Quality
			Sector		Tourism				Of Tourism		
		[%]	Operation: [tCO2]	Total Energy: [tCO2-equ]	Operation: [tCO2]	Total Energy: [tCO2-equ]	[Mio. CHF]		[kgCO2/CHF]	[kgCO2-equ/CHF]	1 = low 2 = medium 3 = high
55	**Accommodation & Catering**		542'075	1'252'294	338'217	716'303	5'113	87'773	0.07	0.14	2
	55.11 Hotels with restaurant	73%	282'990	597'998	206'583	436'539	2'730	47'144	0.08	0.16	3
	55.12 Hotels without restaurant	94%	11'985	20'047	11'266	18'845	150	2'588	0.08	0.13	2
	55.21 Youth hostels, accommodations	98%	2'402	4'018	2'354	3'938	50	861	0.05	0.08	2
	55.22 Campground	90%	2'294	5'264	2'065	4'738	84	1'450	0.02	0.06	2
	55.23A Guest houses and tourist homes	98%	65'764	98'389	64'449	96'422	223	3'854	0.29	0.43	1
	55.23B Group accommodation (without lodges)	85%	1'767	9'775	1'502	8'309	17	296	0.09	0.48	2
	55.23C Other accommodation establishments	81%	283	820	229	664	10	169	0.02	0.07	1
S	**Use and renting of holiday homes by owner**	4%	591'879	885'504	23'675	27'853	773	N/A	0.03	0.04	1
	55.3 Restaurants, tea-rooms, etc.	30%	154'405	457'299	46'321	137'190	1'756	29'897	0.03	0.08	3
	55.4A Bars	20%	10'398	26'061	2'080	5'212	43	739	0.05	0.12	3
	55.40B Discotheques, ballrooms, night clubs	15%	5'602	14'041	840	2'106	17	222	0.05	0.12	1
	55.52 Caterers	10%	4'184	18'581	527	2'341	32	553	0.02	0.07	3
60	**60. Land transport**		485'128	934'003	142'699	271'883	1'370	18'490	0.10	0.20	3
	60.1 Railway transport	28%	53'796	252'991	15'063	65'225	698	9'756	0.02	0.09	3
	60.21C Mountain railways and other special railways	92%	5'517	30'003	5'075	24'457	385	4'714	0.01	0.06	2
	60.21A Passenger transportation, short distance	10%	229'151	360'332	51'495	78'665	72	999	0.72	1.10	3
	60.21B Passenger transportation, long distance	30%	92'827	131'364	21'618	30'383	36	503	0.60	0.84	2
	60.22 Taxi	20%	32'135	52'520	6'427	9'827	35	489	0.18	0.28	2
	60.23 Other passenger land transport	60%	71'701	106'792	43'021	63'326	144	2'012	0.30	0.44	1
61	**61.20A Inland water transport of passengers**	80%	30'278	N/A	24'222	N/A	59	897	0.41	N/A	2
62	**62. Air transport**		1'906'670	2'781'667	1'718'428	2'506'062	404	4'163	4.25	6.20	2
	62.1 Scheduled air transport	90%	1'879'725	2'749'971	1'691'753	2'474'796	N/A	N/A	N/A	N/A	2
	62.2 Non-scheduled air transport	99%	26'945	31'696	26'675	31'266	N/A	N/A	N/A	N/A	1
63	**63. Supporting and auxiliary transport activities, travel agencies**		83'212	184'194	30'977	73'139	1'021	5'996	0.03	0.07	2
	63.21 Supporting and auxiliary land transport activities	9%	20'000	42'521	1'800	3'827	190	176	0.01	0.02	1
	63.22 Supporting and auxiliary water transport activities	20%	2'351	4'998	470	1'000	16	142	0.03	0.06	1
	63.23 Supporting and auxiliary air transport activities	42%	55'439	117'865	23'284	49'503	814	5'678	0.03	0.06	2
	63.3 Travel agencies and tour operators	100%	5'422	18'810	5'422	18'810	1'141	12'720	0.00	0.02	3
71	**71. Renting of mobil devices without operating personnel**		9'477	14'717	6'255	9'713	97	641	0.06	0.10	1
	71.1 Renting of automobiles	66%	6'641	10'313	4'383	6'807	56	367	0.08	0.12	1
	71.21 Renting of other land transport vehicles	66%	2'836	4'403	1'871	2'906	41	274	0.05	0.07	1
92	**92. Entertainment, culture and sport**	14%	118'442	262'456	22'928	49'691	340	4'225	0.07	0.15	2
	92.31A Theatre and dance productions	11%	5'816	10'906	640	1'200	14	192	0.04	0.08	2
	92.31B Orchestras, bands and musicians	11%	500	812	55	89	9	116	0.01	0.01	1
	92.31C Individual fine artists	11%	2'320	3'697	255	407	4	51	0.07	0.11	2
	92.31D Other artistic activities or writing activities and presentations	11%	777	1'349	85	148	2	23	0.05	0.09	1
	92.32A Operation of concert and theatre halls	11%	3'127	7'136	344	785	19	251	0.02	0.04	1
	92.32 B Operation of auxiliary arts facilities	11%	728	1'662	80	183	7	10	0.01	0.02	1
	92.52 Museums	24%	6'904	24'160	1'657	5'798	49	612	0.03	0.12	3
	92.53 Botanical and zoological gardens and nature reserves activities	17%	3'669	9'380	624	1'595	6	72	0.11	0.28	2
	92.61 Operation of facilities for outdoor or indoor sport events	21%	68'857	137'913	14'460	28'962	56	689	0.26	0.51	2
	92.62B Other sport related activities	21%	3'469	9'667	729	2'030	60	729	0.01	0.03	2
	92.13 Cinemas	30%	5'111	8'401	1'533	2'520	34	441	0.05	0.07	1
	92.33 Fairground and amusement parks	30%	1'305	2'951	391	885	1	18	0.29	0.65	1
	92.34 Other cultural and entertainment activities (e.g. Dancing schools)	15%	8'804	16'051	1'321	2'408	9	114	0.15	0.27	2
	92.51 Libraries and archives	2%	2'744	13'021	55	260	1	8	0.09	0.40	2
	92.71 Gambling and betting	15%	1'698	9'442	255	1'416	64	826	0.00	0.02	2
	92.72 Other entertainment/recreation/leisure services	17%	2'612	5'909	444	1'004	6	74	0.08	0.18	1

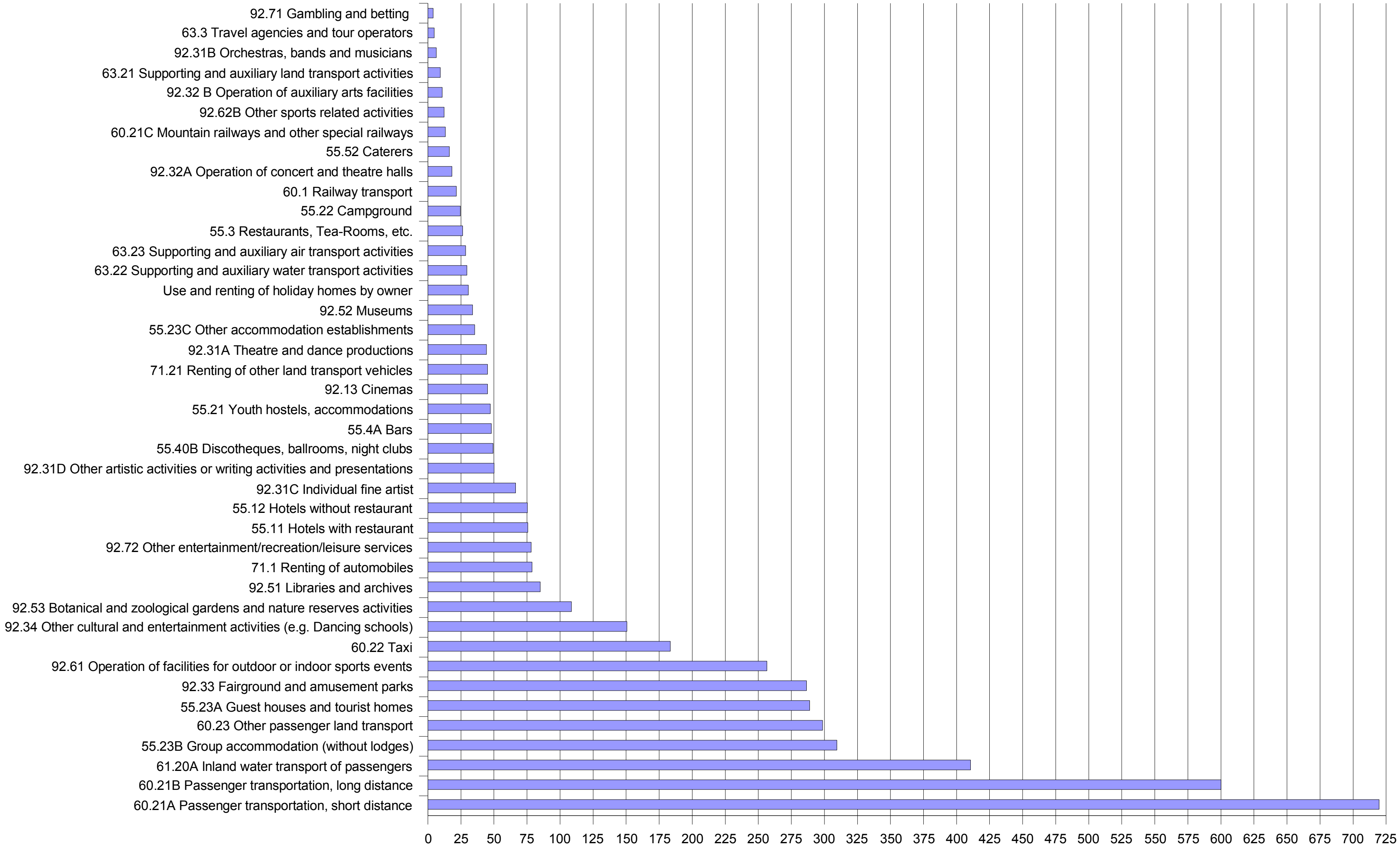


Fig. 1: Climate efficiency ranking of tourism's sectors [10^{-3} kg CO_2/CHF] without air transport

Table 3: CHG and CO_2 emissions connected to tourist single services in Switzerland.

	Tourist single service	GHG emissions	CO2 emissions	Data Quality
		Kg CO2-equ/guest night	Kg CO2/guest night	1 = low 2 = medium 3 = high
Acommodation	Hotel	19.8	9.45	3
	Tourist home	5.50	3.67	2
	Youth hostel	5.02	3.00	1
	Group acommodation	1.40	0.25	2
	Campground	0.74	0.32	2
		Kg CO2-equ/pkm	Kg CO2/pkm	
Transport	Taxi	0.356	0.218	2
	Long-distance traffic (postal bus)	0.334	0.236	2
	Mountain Railway	0.305	0.056	2
	Private Car	0.203	0.131	2
	Plane	0.157	0.108	2
	Short-distance traffic (bus, tram)	0.100	0.063	2
	Railway	0.017	0.004	3
	Ship	N/A	0.246	1
		kg CO2-equ/visit	kg CO2/visit	
Activities	Indoor swimming pool	2.9-4.6	0.0-1.8	2
	Golf	3.3	2.1	1
	Museum	2.0-2.8	0.0-0.8	2
	Theater	0.3-3.9	0.0-2.0	1
	Exhibition	1.5	0.0	2
	Zoo	0.1-1.1	0.1-0.5	2
	Casino	1.1	0.6	1
	Restaurant, Tea-Room etc.	0.9	0.3	1
	Bars, Discotheques etc.	0.8	0.3	1
	Sport indoor	0.7	0.0	2
	Catering	0.1	0.0	1

Annex III: Emission Factors from Literature

Emission Factors For Tourism Sectors

A.1 Characteristic touristic economy sector

UN, WTO, OECD, EUROSTAT (2000)	TSA Switzerland	Economic Sectors According to the NOGA Taxonomy in TSA Switzerland	Becken & Simmons (2002) Energy Use Guest Night [MJ]	Becken & Simmons (2002) MJ/Tourist	Becken & Simmons (2002) [MJ/pkm], [MJ/visitor night], [MJ/visit]	Becken (2002) [MJ/pkm], [L or kg/100km)	Becken (2002) [L or kg/100km]	Becken (2004) MJ/visit, MJ/visitor night	Gössling et. al. (2005) [kgCO2/pkm], [kgCO2/bednight)	Gössling (2002) [MJ/pkm], [gCO2-e/pkm], [MJ/bednight]	Schafer & Victor (1999) [MJ/pkm] 1990 resp. 2050, industr. Country	Becken et. al. (2003a) [MJ/pkm], [MJ/v-night], [MJ/visit]	Becken (2001b) [MJ/pkm],[MJ]	Becken & Simmons (2005) [MJ/pkm], [g CO2/pkm] resp.[MJ/vnight], [g CO2/vnight], resp. [MJ/visit]k [gCO2/visit], NZ	Schmied et. al. (2002).	Müller (2003) [kWh]
1. Accomodation services	1. Acommodation														10 kg GHG/visitor and overnight stay = 26 kWh	
1.1 Hotels and other lodging services	1.1 Hotel Industry	55.11 Hotels with restaurant	183		155 (hotel with restaurant)			151 (Hotel, CH) 200 (Hotel, DE) 260 (Hotel, Zansibar) 94 (Commercial accommodation, DE) 155 (Hotel, NZ)	190 MJ 20.6 kg	130 MJ (global) 155 MJ (NZ) 51 MJ (Majorca) 87 MJ (Cyprus) 11 MJ (Hong Kong) 36-108 MJ (Seychelles) 256 MJ (Zanzibar) 200 MJ (De)		155 hotel, NZ		155 MJ resp. 7895G Hotel/lodge		
		55.12 Hotels without restaurant			32 (Motel without restaurant)											
	1.2 Non-Hotel Acommodation	55.21 Youth hostels, accommodations	48 (Backpacker)		39 (backpacker)			39 (Backpacker, NZ)		39 (Hostel, NZ)		39 backpacker hostel, NZ	39 MJ/night backpacker hostel, NZ 25 MJ/night hut NZ	39 MJ/night resp. 1619g backpacker hostel, NZ 25 MJ/night hut NZ, extrapoliert von backpacker: ca. 1000G		
		55.22 Campground	28		25 (campground)			25 (NZ)	50 MJ 7.9 kg	50 MJ (global) 25 MJ (NZ)		25 campground, NZ	25 MJ/night campground, NZ	25 MJ/night resp. 1364g campground, NZ		
		55.23A Guest houses and tourist homes			41(private or rental)				90 MJ (holiday village) 14.3 kg (holiday village) 100 MJ (Vacation home) 15.9 kg (Vacation home)	91MJ (Holiday village, DE) 100 MJ (vacation home)		41 Home	41 MJ/night home, NZ	41 MJ/night home, NZ		
		55.23B Group accommodation (without lodges)														
		55.23C Other accommodation establishments						110 (B&B, NZ) 32 (Motel, NZ)	25 MJ (Pensions) 4 kg (Pensions) 120 MJ (Self-catering) 19.0 kg (Self-catering)	110 MJ (B&B, NZ)) 32 MJ (Motel, NZ) 25 MJ (Pensions) 120 MJ (Self-catering)		110 B&B, NZ 32 Motel, NZ	110 MJ/night B&B, NZ	110 MJ/night resp. 4142g B&B, 32MJ resp. 1378g Motel		
1.2 Second home services	1.3 Holiday Home Use and Renting by owner	Holyday Home Use and Renting by owner														
2. Food and beverage serving services	2. Catering Industry														0.9 Mio. T GHG 4.1 kg GHG/visitor = 10 kWh 1.7 kg GHG/visitor = 4 kWh	
		55.3 Restaurants, Tea-Rooms, etc.						18.0 (Restaurant meal, CH)								
		55.4A Bars 55.52 Caterers			6.9 MJ/visit											
3. Passenger transport services	3. Passenger Transport															
3.1 Interurban railway transport service	3.1.a Railways	60.1 Railway transport			1.44 (train, NZ)	1.44 (train, NZ)		1.44 (train, NZ)	0.03		0.4 MJ / 0.4 MJ (rail, electric) 3.2 MJ / 1.0 MJ (rail, high speed)	1.44 train, NZ		0.38MJ resp. 26G Train		
	3.1.b Mountain Railways and Other Special Railways	60.21C Mountain railways and other special railways						10 (Gondola ride to Pilatus, CH)								Luftseilbahn (Gondel) 711897 3er Sessellift 385630 2er Skilift (Bügeli) 38988
3.2 Road transport services	3.2 Land Transport	60.21A Passenger transportation, short distance 60.21B Passenger transportation, long distance 60.22 Taxi			1.03 (Private car) 0.59 (shuttle van) 0.75 (scheduled bus) 0.94 (rental car) 2.06 (camper van) 0.87 (motorcycle) 1.03 (hitchhiking) 1.02 (coach, tour bus) 0.58 (backpacker bus) 0 (cycle)	2.06 (camper van) 1.03 (private car) 1.03 (hitchhiking) 1.01 (coach, tour bus) 0.58 (backpacker bus) 0.75 (scheduled bus) 0.59 (shuttle van) 0.94 (rental car) 0.87 (motorcycle)	9,2L (car petrol) 9.5L (car Ex-Overseas-Petrol) 6.7L (car rental-Petrol) 6.6L (car-diesel) 47.9L (Bus petrol) 62.3L (Bus diesel) 3.5L (Motorcycle) 8.2kg (car Compressed Natural Gas) 7.7 kg (car LiquifiedPetroleumGas) 9.0L (taxis-Petrol)	2.06 (camper van) 1.03 (private car) 1.01 (coach, tour bus) 0.58 (backpacker bus) 0.75 (scheduled bus) 0.59 (shuttle van) 0.94 (rental car) 0.87 (motorcycle)	0.075 (car) 0.018 (coach) 0.01 (Cycle, Moped)	1.8 MJ (car) 132 g (car)	2.2 MJ / 2.2 MJ (car) 1.1 MJ / 0.8 MJ (bus)	0.94 Rental car 1.03 Private car 2.06 camper van 1.01 coach 0.58 backpacker bus 0.75 scheduled bus 0.59 shuttle bus 0.87 Motorcycle 0 Cycle 0 tramping	2.27 MJ/pkm camper van 0.75 MJ/pkm scheduled bus 3.25 MJ/pkm private car 1.44 MJ/pkm coach 0 cycle 1.03 MJ/pkm hitchhiking (tramping) 0 trekking 0.805 MJ/pkm shuttle bus	0.94MJ resp. 63g rental car 1.03MJ resp. 69g Private car 0.32MJ resp. 22g Coach 0.51MJ resp. 35g Scheduled coach 2.39MJ resp. 165 Campervan 0.56MJ resp. 36 g Shuttle bus, van 0.87MJ resp. 60G Motorcycle 0.39MJ resp. 27g Backpacker bus		
		60.23 Other passenger land transport														
3.3 Water transport services	2.2 Water Transport	61.20A Inland water transport of passengers			2.40 (Cook Strait ferry 1.75 (Recreational Boat)	8.70 (Steward Island Ferry) 3.53 (Other Ferries) 2.40 (Cook Straight Ferry) 1.75 (Recreational boat)		3.53 (Other Ferries) 2.40 (Cook Straight Ferry) 1.75 (Yacht/ boat)	0.07 (ferry) 0.01 (Cruise ship)				2.40 MJ/pkm (ferry) 271 MJ (recreational boat) 474 MJ (yacht) 237 MJ/activity (boat)	2.63 MJ resp. 181G Ferry		
3.4 Air transport services	3.4 Air Transport	62.1 Scheduled air transport			2.75 (domestic air, NZ)	2.75 (domestic air)		2.75 (domestic air)	0.14 (EU) 0.12 (intercontinental)	2.0 MJ (air travel) 396 g (air travel)		2.7 domestic air	1.75 MJ/pkm international air	2.54 MJ resp. 175 g Domestic air	Fernreisen mit Flugzeug: 5.6 t CO2-equ/person and voyage Mittelmeerreisen mit Flugzeug: 1.4 t CO2-equ/person and voyage	
		62.2 Non-scheduled air transport						4.68 (Helicopter, NZ)								
3.5 Supporting passenger transport services	3.5 Auxiliary Transport Activities	63.21 Supporting and auxiliary land transport activities 63.22 Supporting and auxiliary water transport activities 63.23 Supporting and auxiliary air transport activities														
3.6 Passenger transport equipment rental	3.6 Renting of Transport Vehicles	71.1 Renting of automobiles 71.21 Renting of other land transport vehicles														
4. Travel ag., tour oper., tourist guide serv.	4. Travel Agencies And Tour Operator															
4.2 Travel Agencies 4.2 Tour Operator 4.3 Tourist information and tourist guide	4.1. Travel Agencies And Tour Operator	63.3 Travel agencies and tour operators		110 (guided Walks????)												
5. Cultural Services	5. Culture	**92. Entertainment, culture and sport**		9.4 (Entertainment)								3.5 buildings 22.4 amusement	4 buildings 22 amusement (gondola cruise, amusement park)	4 MJ resp. 172 g building 22 resp. 1507g amusement		
5.1 Performing Arts	5.1 Visual Arts	92.31A Theatre and dance productions 92.31B Orchestras, bands and musicians 92.31C Individual fine artist 92.31D Other artistic activities or writing activities and presentations 92.32A Operation of concert and theatre halls 92.32 B Operation of auxiliary arts facilities			12 (performance, concert) 12 (performance) 12 (performance, theatre)							12.0 performance 6.0 other entertainment	7 entertainment (shopping) 12 performance	12MJ resp. 589g performance 6MJ resp. 338g other entertainment		
5.2 Museum and other cultural services	5.2 Museums And Other Cultural Activities	92.52 Museums		10 16 (Zoos)	3.5 8.4			10								
		92.53 Botanical and zoological gardens and nature reserves activities										8.4 Parks 8.5 nature attraction	8 botanic garden [MJ/activity] 29 nature attraction (animal observation, water sport, fishing) 9 nature attraction (geothermal, cave)	7 resp. 526g Park 8.5 nature attraction		
6. Recreation and other entertainment services	6 Sport And Entertainment															
6.1 Sports and other recreational sport services	6.1 Sport	92.61 Operation of facilities for outdoor or indoor sports events		95.6 (activity)				46.8-119 (swimming in public pool, CH, FN) 28.8 (indoor ice skating, CH) 90 (Skiing, FN) 12 (Golf, NZ)								Kunsteisbahn I 805245 Kunsteisbahn II 425000 Hallenbad 805000 Skipistenbearbeitung 350000
		92.62B Other sports related activities		36 (Rafting) 57 (adventure activities) 140 (Sailing) 1300 (Heliskiing) 800 (diving) 340 (scene flights)	424.3 (air activity) 236.8 (motorised water activity) 35.1 (adventure activity) 26.5 (nature activity)			36 (Rafting) 1300 (Heliskiing)				424.3 air activity 236.8 motorized water activity 35.1 adventure activity 53.1 nature activity	237 motorized water activity 35 adventure activity 442 air activity	424MJ resp. 27"697g air activity 202MJ resp. 15'312g motorized water activity 43MJ resp. 2241g adventure recreation 8MJ resp. 417g nature recreation		
6.2 Other amusement and recreational services	6.2 Entertainment	92.13 Cinemas			12 (performance,cinema)										4.1 Mio. T CO2-equ	
		92.33 Fairground and amusement parks		29 (experience centers) 4 (visitor centers)	22.4 (experience centre)			29 (experience centers)								
		92.34 Other cultural and entertainment activities (e.g. Dancing schools) 55.40B Discotheques, ballrooms, night clubs 92.51 Libraries and archives 92.71 Gambling and betting 92.72 Other entertainment/recreation/leisure services			6.9 (casino)											
					6.9 MJ/visit (shopping)											

Annex IV: Breakdown to NOGA 5 Level

Annex IV shows on the example of campgrounds, how tourism's added value and share of sectors could be broken from TSA down to the most detailed NOGA level. In order to do so, relations of turnover rates between the sectors from the Turnover Dataset were used. To calculate these relations, the assumption was made that the relation between the turnover rates reflects the relation between the added value.

In the case of campgrounds (see Table 1), this subsector generates a turnover of 119.6 million CHF. Campgrounds belong to the non-hotel accommodation sector that achieves a turnover of 518.8 million CHF. Ergo, campgrounds have a share of 23.1 % on non-hotel accommodation turnover. Since intermediate inputs in similar sectors are of the same order, we assumed that regarding the added value of non-hotel accommodation, this campground share of 23.1 % would stay the same. Multiplying these 23.1 % with non-hotel accommodation's annual added value of 403.1 million CHF, we obtained campground's added value of 93.1 million CHF. To obtain the tourism share of campground added value, its added value must be multiplied with the campground's tourism share. We estimated this tourism share as well as the tourism share of the other non-hotel accommodation sectors with regard to the tourism definition and the system boundaries. The tourism share of various subsectors were tuned, until their aggregated tourism share met the total sectors tourism share. Finally, the estimated tourism shares were verified by an expert from the Swiss Federal Statistical Office.

Table 1: Non-hotel accommodation and its subsectors.

	Turnover [Mio CHF]	Added value [Mio CHF]	Share on non-hotel accommodation	Tourism share
Non-hotel accommodation	**518.8**	**403.1**	**100%**	**95%**
Youth hostels	65.4	50.8	12.6%	98%
Guest houses and tourist homes	292.6	227.3	56.4%	98%
Campground	119.6	93.1	23.1%	90%
Group accommodation	25.7	20.2	5%	85%
Other accommodation establishments	15.5		3%	81%

Example for tuning of the tourism shares:

98% * 12.6% + **95**% * 56.4% + 90% * 23.1% + 85% * 5% + 81% * 3% ≠ 100% * 95%

→ 98% * 12.6% + **98**% * 56.4% + 90% * 23.1% + 85% * 5% + 81% * 3% = 100% * 95%