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Bachelorthesis

Product Carbon Footprinting in the Tourism Industry

Examined Using the Example of a Hotel

vorgelegt von:

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Abbreviations

CO2/ TJ	CO2 emissions on the basis on one tonne
cf.	Confer (latin) – compare
et al.	Et alii (latin) – and others
Mt	Million tonnes
CO2-eq.	Greenhouse gas emissions in CO2 equivalents
PCF	Product carbon footprint
GHG	Greenhouse gases
Ppm	Parts per million
Mg	Mega grams = 106 Mg = 103 kg = 1 t

Introduction

At the United Nations climate conference 2009 in Kopenhagen all involved parties agreed on the existence of the climate change and decided the main aim for the future should be to keep the global warming below two degrees Celsius.[1] Even though there was no compulsive contract, the question was raised, how necessary cuts in greenhouse gas (GHG) emissions might be achieved. Since about 40 percent of the overall emissions are caused by consumers [2] and already 81 percent of all consumers would prefer low carbon products if they had the choice[3], it would be a desirable goal to increase the demand for climate friendly products in addition to regulatory requirements or emission trading systems. One product whereat it would be definite reasonable to choose it by means of carbon content is the hotel stay. Tourism is one of the sectors causing the most emissions with a contribution to the climate change of about five percent.[4] Although this sector does not have a sufficient strategy of reducing its emission [5], the PCF offers the potential to initiate a development towards a low carbon tourism.

However, there is no common standard of carbon assessment and labeling, which is indispensable for the assessment of a carbon footprint. Especially the 'Product Carbon Footprint' (PCF) lacks unity and standardization, even though it draws much attention. [6]
Despite of the difficulties, in recent years many campaigns have developed and pushed the topic. In doing so the carbon footprint has been characterised by a few different organizations like the World Resources Institute (WRI) supported by the World Business Council for Sustainable Development (WBCSD), the British Ministry of the Environment (DEFRA) or the non – profit organization Carbon Trust, whose only common feature is that they are based on the ISO standards series 14040 ff. The two most common methods are the Greenhouse Gas Inventory (WRI/ WBCSD) and the Public Available Specification (PAS) 2050 (DEFRA), which differ because the inventory creates the carbon footprint of a company and the PAS creates a product carbon footprint. Although they consist of similar basic elements.

Nevertheless, in the service sector like tourism these approaches interact because the company is the product in almost the same manner. Therefore, the research will deal with the definition of basics and the question of how to combine the different methodological

[1] cf. http://unfccc.int/resource/docs/2009/cop15/eng/l07.pdf (10.05.2010)
[2] cf. Klockenhoff 2009 {p.1}
[3] cf. www.klimaktiv.de/media/07/10_dokumente/42_Umfragen/sempora_co2studie_kernergebnisse.pdf
[4] cf. Scott et al. 2010 {p.396}
[5] cf. http://www.respect.at/media/pdf/pdf1300.pdf (27.07.2010)
[6] cf. Minx 2007 {p.1}

backgrounds in order to develop a consistent standard in service, especially for tourism. In this topic the main issues are the setting of a sufficient scope and appropriate boundaries, which are not even clarified for the each standards.

The bachelor thesis consist of seven sectors. In the first sector the history and development of the carbon footprint will be described and will give an insight on the origins of the topic. The second sector provides basics, which help to understand the following chapters and outlines main dificulties of the topic. Consecutively, the next two chapters deal with the product carbon footprint (PCF) and the greenhouse gas (GHG) inventory. In the process I will explain methodological and practical approaches. As the PCF is still under development and has priority in the last chapter I will describe it in more detail and will illustrate difficulties with the use of practical examples.

In the fifth sector I will introduce the complex system between tourism and climate change whereafter the carbon management of hotels will be outlined in chapter six. The last sector gives an example for the application of carbon management in hotels, whereby the goal is to create a PCF of ‘One night’s hotel stay’.

1. The History and Development of Carbon Footprinting

The development of the greenhouse gas standards and the following 'product carbon footprint' is based on various stations of different organizations. To give an insight into environmental footprints I will first explain the origin, and explicate why the debate has moved from the organic to a CO_2 footprint. Thereafter, I will illustrate the history of the three most important standardization processes in chronological order, whereby these developmental processes partially overlap in time and depend from each other as shown in figure one.

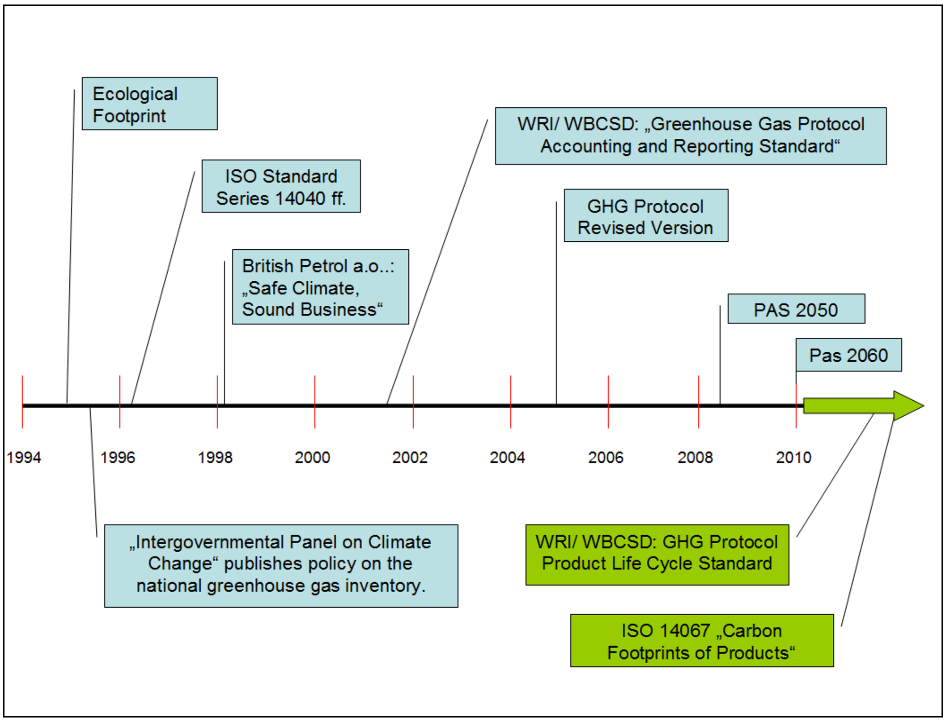

Figure 1: Development of greenhouse gas standards [7]

Besides these standards there are various other projects in Europe as well as in Asia and the USA. For example, 'climatop' in Switzerland, 'Das PCF Pilot Projekt' in Germany, 'Le Grenelle Environnement I & II' in France and others[8]. In 2009 Japan even released an own standard with 'General principles for the assessment and labeling of Carbon Footprint of Products'.[9]

Nevertheless, these projects mostly test possibilities of analysis and communication and rely on existing standards. They do not have the aim to develop a new standard but to gain experience in the process of carbon footprinting or to establish national labels. As these

[7] source: own
[8] cf. http://www.greenpeace.at/uploads/media/Factsheet_CO2-Kennzeichnung_091021.pdf (12.08.2010)
[9] cf. http://www.jemai.or.jp/english/carbonfootprint.cfm (12.08.2010)

projects have not yet seriously influenced the development of carbon footprint standardization yet, they will not be taken into account in this thesis.

1.1 Ecological Footprint

In 1995 Mathis Wackernagel and William Rees published their book ‘Our ecological footprint’ in which they wrote about the ‘ecological footprint’ for the first time to move the issue of sustainability to the fore. However, various other earlier analytic attempts dealt with the issue of measuring human load in order to estimate the dependence of human life on nature.[10]

Wackernagel and Rees’ concept of the ‘ecological footprint’ enables to calculate the required land surface, which is necessary to compensate the energy- and material-flows of industrial processes. They call this surface ‘ecological footprint’. In addition to the scientific claim, it is also important to them to generate the puplic attention to the ecological problem by a clear and vivid way of illustration.[11]

The ‘ecological footprint’ is made up of six categories which are farmland, pastures, fisheries, forests, built-up area, and the required area to absorb the CO_2 emissions. It is possible to calculate the footprint for nations as well as for single individuals.

> *„Of these six, land for carbon absorption is the most significant globally, representing nearly one half of humanity's total Footprint.”* [12] as shown in figure 2.

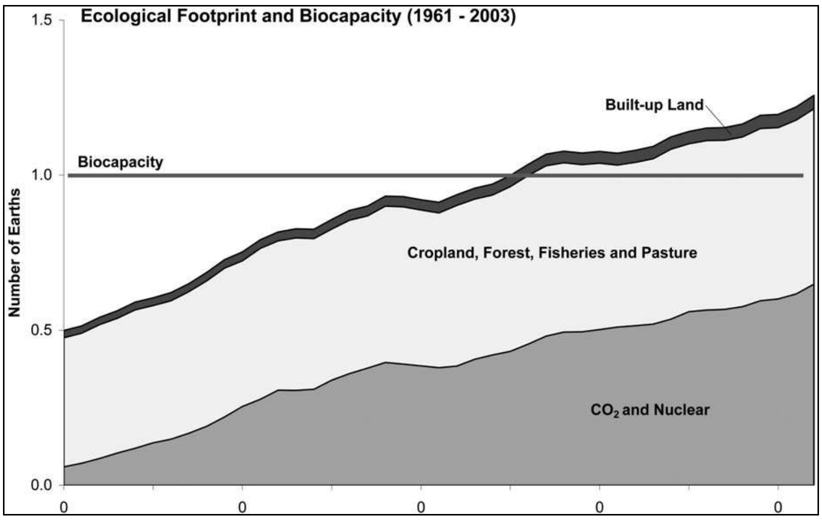

Figure 2: Ecological Footprint and Biocapacity (1961 – 2003)[13]

[10] cf. Holmber et al. 1999 {pp. 3 ff} (see for example Borgstrom 1972 ‘ghost acreage’, Holdren and Ehrlich 1974 ‘IPAT formular’, Meadows 1972 ‘Club of rome report’ a.o.)
[11] cf. Rees/ Wackernagel 1995 {p.3}
[12] Kitzes et al. 2007 {p.1}
[13] Kitzes 2007 {p.2}

There are two facts that are probably responsible for the independent approach of a CO_2 evaluation. First the ecological footprint is strongly caused by the CO_2 emission, which present almost 50 percent of it, and second the issue of the anthropogenic greenhouse effect raised more focus in public over the years. Hence it was only a matter of time until a CF was developed. Moreover, the ecological footprint is limited to CO_2 and does not include other relevant greenhouse gases.[14] Due to the different ways of calculation and presentation and the resulting lack of similarities between the ‘carbon’ and ‘ecological footprint’ they should not be equated or combined.[15] For example, the impact category of the ‘ecological footprint’ is the environmental stress which is represented in hectares, while the ‘carbon footprint’ uses the impact category global warming potential represented in CO_2-equivalents.[16]

1.2 International Organization of Standardization (ISO 14040 ff.)

“The launch of the International Organization of Standardization’s ISO 14001 in 1996 indicated to many businesses that ad hoc environmental management was no longer an option.” [17]

After the ISO 14001 set a new standard in environmental management system the foundation of all developed greenhouse gas standards is the 1996 started ISO-standard series BS EN ISO 14040 ff. (especially BS EN ISO 14044) for Life-Cycle assessment. [18] However, there has been no ISO standard for the creation of a ‘product carbon footprint’ so far. But as the ISO is the most widely adopted voluntary environmental program in the world[19] it has the opportunity to develop uniform guidelines, and since especially in the development of the ‘product carbon footprint’ consistency is lacking, they now take on the topic.

For this they develop the standard ISO 14067 ‘Carbon Footprints of Products’ which will consist of two parts and is supposed to be finished in 2011. One part will handle the analysis and accounting of greenhouse gases, and the second part will deal with the communication of the results.[20] It is very possible that the upcoming ISO standard is based on already existing standards like the ‘GHG protocol’ and particularly the ‘PAS 2050’.

The ISO launched in spring 2006 the ISO 14064 standard, which is a voluntary GHG project accounting standard. The standard consists of three parts and provides the voluntary

[14] cf. Kitzes et al. 2007 {p.6}
[15] cf. Minx 2007 {p. 2}
[16] cf. Grahl 2009 {p.202 ff.}
[17] Grant et al. 2009 {p.1}
[18] cf. Potoski/ Prakash 2006 {p.3}
[19] cf. Potoski 2006 {p.3}
[20] cf. Umweltbundesamt et al. 2004 {p.6}

company with information about the design and development of a GHG inventory, the quantifying and monitoring and the validation and verification.[21]

1.3 World Resources Institute / World Business Council for Sustainable Development (GHG Protocol)

Shortly after the publication of the ISO standard 14001 but a long time before the ISO concerns itself with the topic of carbon footprinting the World Resources Institute dealt with it. In the beginning there was British Petroleum who withdrew 1997 from the ‘Global Climate Coalition’, which denied the climate change and promoted doubts about associated scientific researches [22]. After this BP committed itself, as the first big company, to the reduction of greenhouse gases and established an own commission for the analysis and accounting of greenhouse gases in 1999 which published the first standard ever.[23] Nevertheless, it was even more important that BP generated a lot of attention for the topic and encouraged other companies and organizations to act through their self-commitment. And already in 1998 the companies BP, Monsato and General Motors together with the World Resources Institute published the memorandum ‘Safe Climate, Sound Business: An Action Agenda in October 1998’ in which they called on other companies to measure their emissions and take responsibility. Moreover, they requested a consistent measurement and reporting protocol. [24]

This memorandum laid the foundation for the following work of the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). Together they developed the ‘Greenhouse Gas (GHG) Protocol’ which greatly influenced the ‘carbon footprint’.[25]

In 2001 they published the first edition of the ‘Greenhouse Gas Protocol Accounting and Reporting Standard’ which was the first standard for creating a greenhouse gas protocol and is still applied today. [26]

Thereafter many different editions followed like the service sector guide to greenhouse gas management 'Hot climate, Cool commerce’. [27]

In the published standards the boundaries of the greenhouse gas emissions were always limited to the core businesses (scope 1) and the purchased energy (scope 2). Without,

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[21] cf. http://www.global-greenhouse-warming.com/ISO-14064.html (22.07.2010)
[22] cf. http://www.germanwatch.org/rio/eszvgl.htm (25.05.2010)
[23] cf. http://www.wbcsdcement.org/pdf/tf1/CustomO16C45F41909.pdf (25.05.2010)
[24] cf. http://pdf.wri.org/scsb_action_agenda.pdf {p.6} (26.05.2010)
[25] cf. Green 2009 {S.6}
[26] cf. World Resources Institute/ World Business Council for Sustainable Development 2004 {p.3}
[27] cf. World Resources Institute 2006

nevertheless, taking the resulting emissions of purchased materials, goods or services (scope 3) into account. To meet the trend and need of the ‘product carbon footprint’ which relies on the whole life cycle they will prospectively publish the ‘GHG Protocol Product Life Cycle Standard’ and the ‘Scope 3 Accounting and Reporting Standard’, by the end of 2010 which is based on the ‘GHG Protocol Accounting and Reporting Standard’, giving companies the opportunity to involve scope 3 emissions.[28]

Up to that point the ‘GHG Protocol’ indeed is a helpful guide for the creation of a greenhouse gas inventory, but does not give a comprehensive guide for the LCA of a product.

1.4 British Standards Institution (PAS 2050)

‘Publicly Available Specification (PAS) 2050 : Specification for the assessment of the life cycle greenhouse gas emissions of goods and services’ is the name of the Product Carbon Footprint (PCF) guide sponsored by the non – profit company ‘Carbon Trust’ and the British ‘Department for Environment, Food and Rural Affairs (Defra)’ which is published by the ‘British Standards Institution’.[29] Released in October 2008, it is the first guideline for the analysis of greenhouse gases along the whole life cycle of a product. At the same time the Carbon Trust also published ‘the Code of Good Practice for Product Greenhouse Gas Emissions and Reduction Claims’, which deals with the associated communication of the results. [30]

The process was accompanied and accelerated by the British trading group Tesco which announced in 2008 to create the Carbon Footprint for all their 70.000 products with the use of PAS 2050 and to label them with the Carbon Trust label.[31] Even though they decreased their ambitions in the following years down to about 500 products, which is another sign of the PCF’s magnitude.[32]

[28] cf. World Resources Institute/ World Business Council for Sustainable Development 2004
[29] cf. BSI 2008
[30] cf. Sinden 2009
[31] cf. Öko-Institut e.V. 2009 {p.1}
[32] cf. Watson 2009

2. Carbon Footprint Basics

The basics will present fundamental knowledge about the climate change and more detailed about the ‘carbon footprint’ (CF). The aim is to provide the reader with a good overview about the topic and to remove uncertainties. This chapter begins with a short abstract of the climate change and greenhouse effect to illustrate thereafter information about the ‘carbon footprint’ whereby it deals in the largest part with the definition of it. Towards the end of the chapter general threats and opportunities are discussed.

2.1 Climate Change and Greenhouse Effect

The idea of the CF originates in the issue of the global greenhouse effect. Thereby it needs to be differentiated between the natural and anthropogenic greenhouse gas effect. The natural greenhouse effect is an essential activity making life on earth possible. The earth’s mean temperature on earth is given by the radiation balance, resulting from the composition of the atmosphere and the absorbency of gases. As some gases let the solar radiation through the atmosphere down to earth, however, do not allow the resulting long-wave heat radiation to travel back to the universe, these gases function as a blanket covering the earth and keeping the warmth under it.[33] Without this natural ‘blanket’ the earth would have an average temperature near -18 □ C being much lower than the actual average temperature of about 15 □ C. The event desribed above is similar to the idea of a garden greenhouse, where the glass anables the sun to enter, but the heat does not exit.

Nevertheless, it has to be noted that only some gaseous constituents of the earth’s atmosphere have the ability to absorb thermal radiation and therewith contribute to the greenhouse effect. These are water vapour, carbon dioxide, methane and some other minor gases[34], followin th definition of greenhouse gases given by the IPCC (Intergonernmental Panel on Climate Change) :

> *“those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth’s surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect”* [35]

Among the above-mentioned gases, especially carbon dioxide is important for the greenhouse effect, even though it has only a very small share with 0,038% of all gases in the atmosphere. Carbon dioxide is emitted and absorbed in a cycle process which includes all natural subsystems, like the ocean, the atmosphere and the ground ecosystems. The

[33] cf. Rahmstorf 2007 {p. 31}
[34] cf. Houghton 2004 {p. 16}
[35] cf. Bader 2009 {p.7}

systems are divided between sources, which emit carbon dioxide, and sinks which absorb carbon dioxide. Trees constitute a good example for this natural cycle as they bind carbon dioxide in their wood during their lifetime and release it afterwards in the decaying process or by combustion.

In comparison, the anthropogenic greenhouse effect is human-made and is based on an imbalancing influence on the carbon dioxide cycle. By combustion of fossil fuels, industrial processes, change of land use and agricultural activities the humans have increased the sources emitting carbon dioxide and decreased the sinks, thereby heavily incresing the concentration of carbon dioxide in the atmosphere.[36] While in 1850, the concentration of CO_2 was 280 ppm, it rose by 30% to 385 ppm in 2007 and is predicted to further increase to about 480 ppm in 2050 as shown in figure 3.[37]

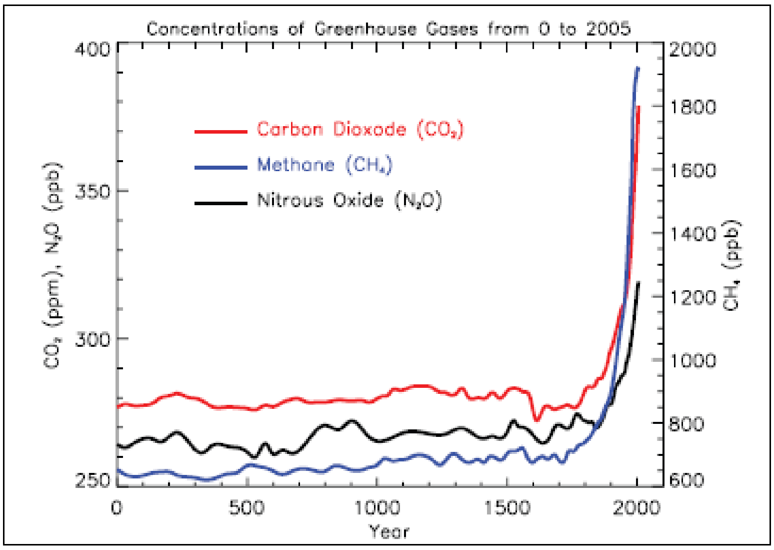

Figure 3: Concentration of Greenhouse Gases from 0 to 2005 [38]

This increase is followed by a temperature rise. Since 1861 the average temperature has risen by 0.6 ° C (-/+ 0.2) and experts fear a further increase between 1.4 and 5.8 ° C until the year 2100. [39] A climate change in such a short time is extraordinary and causes many different problems like higher water levels, devastation, or the displacement of habitats, followed by changes like shift of tourist targets and increased migration.[40] A reduction of greenhouse gas emissions cannot stop the climate change but may reduce the aftereffects.

[36] cf. Germanwatch 2008 {p. 4 ff.}
[37] cf. Buchal 2007 {p. 91}
[38] IPCC 2007 {p.135}
[39] cf. Umwelt Bundes Amt 2004 {p. 4}
[40] cf. Umwelt Bundes Amt 2004 {p. 5}

2.2 Carbon Footprint

The carbon footprint has drawn the attention of many scientists and interested citizen in recent years, whereby it needs to be noted that there is no standard definition yet and even the base is discussed.

> *"It is interesting that carbon footprinting has not been driven by research but rather has been promoted by nongovernmental organizations (NGOs), companies, and various private initiatives. This has resulted in many definitions and suggestions as to how the carbon footprint should be calculated."* [41]

For this reason the thesis will first focus on the methodological fundamentals of the CF. I will describe achieved agreements as well as problematic issues and will point out the most common used solution.

First of all it makes sense to explain the relationship between a 'carbon footprint' and a 'greenhouse gas inventory'. Their relationship is often discussed and there is no clear definition. Some experts list them next to each other, some do not connect them and others behold them as the same.

It seems most reasonable to centralize the 'product carbon footprint' and the 'greenhouse gas inventory' under the colloquial word 'carbon footprint' which provides a basis for both and in the following it will be presented that way.

There is no main definiton of the carbon footprint but most sources define it as follows:

> *"A carbon footprint can be considered to be the total amount of carbon dioxide (CO_2) and other greenhouse gases emitted over the full life cycle of a product or service."* [42]

or

> *"A carbon footprint is the total greenhouse gas (GHG) emissions caused directly and indirectly by an individual, organisation, event or product, and is expressed as a carbon dioxide equivalent (CO_2e)."* [43]

In contrast to the general 'carbon footprint', 'the product carbon footprint' deals with the total emission of a product throughout its life-cycle and the greenhouse gas inventory is a calculation of the greenhouse gases emitted by an individual, or more common, by business activities.

And since it is appropriate to illustrate the emissions of a product as a 'footprint', it seems correct as well to speak about the 'carbon footprint of an organization' whenever it is about the GHG inventory.

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[41] Christensen et al. 2008 {p.3}

[42] Aras et al. 2009 {p.5}

[43] http://www.carbontrust.co.uk/Publications/pages/publicationdetail.aspx?id=CTV043 (05.06.2010)

Moreover, as the following example of Coca Cola shows, many companies handle it that way.

"We calculate our company's carbon footprint — our total annual greenhouse gas emission... according to the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) Greenhouse Gas Protocol, the leading global standard for greenhouse gas accounting." [44]

2.3 Relevant Greenhouse Gases

The designation as 'carbon footprint' as well as the German translation 'CO_2 Fußabdruck' displays a false image of the included gases. The reason is that the carbon footprint typically exists of six different greenhouse gases, and not only of CO_2 or carbon containing compounds as the term suggest. The six gases are named in the Kyoto protocol and are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and the artificial trace gases sulfur hexafluoride (HFCs), hydrofluorocarbons (PFCs) and perfluorinated hydrocarbons (SF_6).[45]

Anyhow, there are definitions which advocate to simply include carbon dioxide, and leave the other gases out in order to get clarity.

"The carbon footprint is a measure of the exclusive <u>total amount of carbon dioxide</u> emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product."[46]

Another reason is that the carbon dioxide emissions cause 56 percent of the anthropological greenhouse effect. However, with the inclusion of all six greenhouse gases almost 100 percent of the harmful gases are covered which is the reason that most definitions rely on them and in it will be treated like that in this thesis. [47]

"A carbon footprint is a measure of the impact human activities have on the environment in terms <u>of the amount of greenhouse gases</u> produced, measured in units of carbon dioxide."[48]

[44] http://crs.cokecce.com/publications/crs-report.php?g=2 (2009) {p.16}
[45] cf. Gabriel 2003 {p.88}
[46] Minx 2007 {p.4}
[47] cf. Schönwiese 2008 {p.11}
[48] Madan 2009 {p.209}

2.4 Global Warming Potential

In the final analysis, even with the implication of various gases, only one weight specification of CO_2 emissions is given. This is because all gases are measured on the basis of their global warming potential and are converted into CO_2-equivalents (CO_2-eq.) to make them comparable and see their single impact.[49] However, besides the absorption efficiency of the solar radiation and the concentration of the gases, the residence time of the gases in the atmosphere play an important role too, in order to construct the global warming potential. Especially the anthropogenic greenhouse gases are long lasting and consequently a very high global warming potential as shown in table 1. Hence, they have a big contribution to the greenhouse effect, even though they appear only in small masses.[50] For example, nitrous oxide (N_20) has a lifespan of 150 years, while methane lingers only ten years in the atmosphere.[51]

The GWP's shown in Table 1 are for a 100-year time horizon and were estimated by the Intergovernmental Panel on Climate Change (IPCC) Second Assessment Report (SAR).[52]

Gas	Shorthand symbol	Source	Global warming potential
Carbon dioxide	CO_2	fossil fuels	1
Methane	CH_4	Extraction of fossil fuels, Landfills, rice cultivation, livestock breeding	21
Nitrous oxide	N_20	fertilizer, combustion, land use change	310
Sulfur hexafluorides	H-FKW/ HFC	Coolant, solvent, extinguishing agent	140 - 11700
Hydrofluorocarbons	FKW/ PFC	Aluminum- and semiconductor-production	6500 - 9200
Perfluorinated hydrocarbons	SF_6	High voltage system, power lines	23900

Table 1: Greenhouse gases [53]

[49] cf. Grahl 2009 {p.202ff.}
[50] cf. Gebauer 1995 {p.53}
[51] cf. Bauer 1993
[52] cf. IPCC 2007 {p.213}
[53] cf. Erling 2008 {p.12}

2.5 Presentation of Carbon Footprint Results

As these gases are presented in CO_2-equivalents weight specifications, and not like the ecological footprint which shaped the carbon footprint in the past in a unit area,[54] the question comes up why it is called carbon footprint and not carbon weight.[55] The reason is probably rooted in the history of the ecological footprint which was invented to address not only scientist, but also the common public through the use of interesting illustrations.[56] Furthermore, it is reasonable to use this presentation in the context of the 'personal carbon footprint' as people can calculate their individual emissions, which are presented as their personal CO_2 footprint.

> *"It is also possible to use CO_2 equivalents per monetary unit,... , or CO_2 equivalents that compare to a reference product."* [57]

Especially for abstract products like consultancy or financial products it may be purposeful to use CO_2 equivalents per monetary unit.

2.6 Scope

Another point which is controversly discussed is the scope of the 'carbon footprint'. Usually the company can determine whether they proceed after the approach of 'the full-scale life cycle', 'the partial life cycle' or only take 'individual stages or processes' into account.[58] Which scope they actually apply depends on the way they want to use the results. For a 'product carbon footprint' a full-scale life scale is necessary, whereas for a greenhouse gas inventory a partial life cycle may be sufficient. Another important point is the exact objetive of the scope which is in the case of a 'carbon footprint' clear - to calculate the greenhouse gas emission and nothing else.

Nevertheless, as the choice of the scope has a immense impact on the result it is a quite a big debate how to, and what to measure.

Sorenson simply describes the main point of the carbon footprint as follows:

> *"The issue revolves around the expansiveness of the carbon footprint – how wide do we throw the net when measuring all the ways in which we can possibly impact the environment?"* [59]

However, there are different categories of emissions that help to provide the users with orientation. Usually these categories are called 'scope' or 'tier' and are divided by three

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[54] cf. Feifel u.a. 2009 {p.42}
[55] cf. Minx 2007 {p.2}
[56] cf. Rees 1996 {p.3}
[57] Christensen 2008 {p. 5}
[58] cf. Ciambrone 1997 {p.17}
[59] Sorenson 2009 {p.62}

different types as shown in figure 4. Scope 1 includes only direct emissions from sources under the company's direct control, like generation of electricity, heat and steam, physical and chemical processes, transportation of materials, products, waste and employees as well as volatile emissions such as HFC emissions from air conditioning. Scope 2 involves GHG emissions of purchased electricity. Generally all standards require the report of scope 1 and 2. [60]

Scope 3 focuses on indirect emissions upstream and downstream of the supply chain which account for further emissions like the extraction and production of purchased materials and fuels, transportations, purchased materials and goods, use of sold products and services, disposal of waste resulting from production activities and fuels as well as waste caused during the use phase of the purchased product.[61]

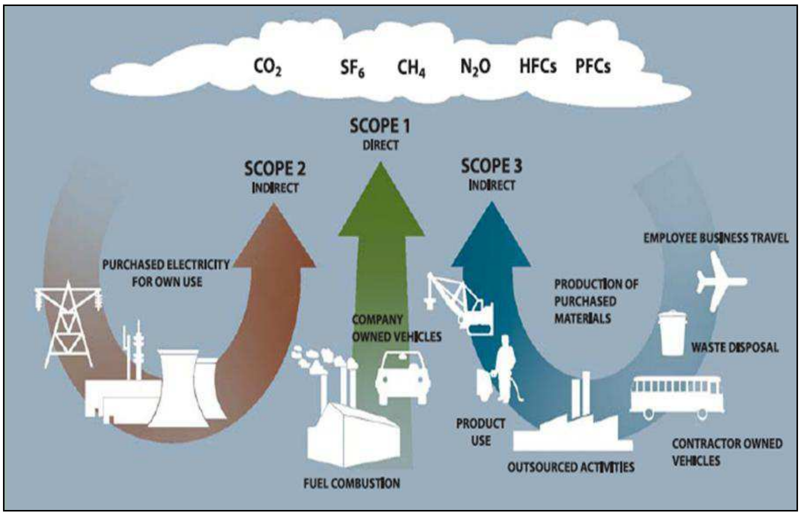

Figure 4: Scopes [62]

But *"Previous estimates have indicated that on average, Scope 1 emissions from an industry are only 14 % of the total upstream supply chain carbon emissions, and the sum of emissions from Scopes 1 and 2, on average, only 26 % of total upstream supply chain emissions, leaving a significant portion of the supply chain emissions in the non-mandatory "Scope 3" category, which combines all non- Scope 1 and 2 sources of emissions."* [63]

Thereby the used scope to measure the emission of a product or a firm is very important. A case study illustrates the distinction between different sectors as shown in figure 5. It uses the examples of a book publisher, power generation and the average sector. Of course the main emissions of the book publishers do not occur in their firm, but in other parts of the

[60] cf. World Resources Institute 2006 {p.24}
[61] cf. Günther 2010 {p.64}
[62] World Resources Institute 2006 {p.23}
[63] Huang 2009

supply chain, e.g. trough the procuremenet of raw materials or printing, while almost all emissions of the power generation belong to the scope 1.

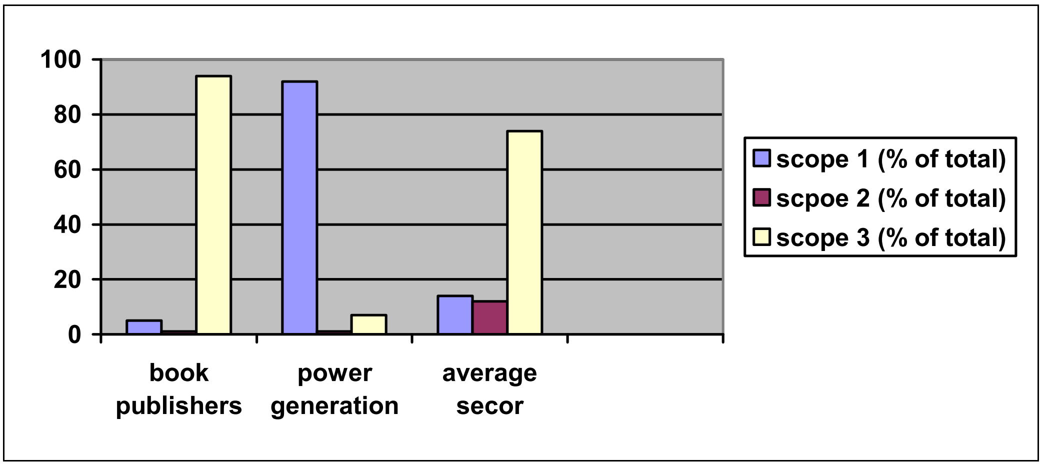

Figure 5: Total emissions divided into three scopes [64]

This study does not only clarify the important role of the scope but also shows that most 'carbon footprints' cannot be exact as long as the companies choose different scopes.
Another example is a research of online based personal carbon footprint calculators which was published in 2007 by the German Umweltbundesamt and the ifeu Institute (Institut für Energie- und Umweltforschung Heidelberg GmbH).
When they compared different online calculators they noticed a deviation by the factor two to three. As a cause they name the different methods of calculation and the application of scopes.[65]

The GHG standards do not bring clarity as long as they are contradictory or unclear. The British Carbon Trust determines:

> *„A carbon footprint is the total greenhouse gas (GHG) emissions caused directly and indirectly by an individual, organisation, event or product, and is expressed as a carbon dioxide equivalent (CO_2e)."* [66]

The World Resources Institute only sees Scope 3 as an option:

> *"Scope 3 is an optional reporting category that allows for the treatment of all other indirect emissions."* [67]

[64] cf. Matthews 2008
[65] Umweltbundesamt 2007 {p.1}
[66] http://www.carbontrust.co.uk/Publications/pages/publicationdetail.aspx?id=CTV043 (05.06.2010)
[67] cf. World Resources Institute 2006 {p.25}

This problem occurs in all carbon footprint types and there are differences to consider. In order to faciliate and clarify the illustration of the issue, each type will be described individually in detail.

2.7 Labels

In recent years a numerous of CO_2 label have been developed worldwide by various institutions, mostly for products. Companies commonly display their emissions and declare which approach they have used. Though some companies, for example in tourism, use compensary payments to be certificated as carbon neutral, whereby different organizations offer such service.

It is a different situation with products. By now there are about 400 different labels, which give the consumer more trouble than help. The variety of labels lead to a sated information level and are therefore mostly ignored with the exception of some established environment labels, like the 'Energy Star' or the 'Blauer Engel', which, however, do not exclusively consider greenhouse gases but also other environmental impact categories.[68] The number of different labels is very high, but they can be divided into five main groups as shown in table 2. These labels distinguish between each other in points like the assessment, the communication and the goal of the labeling. Most known is the carbon reduction label of Tesco, which displays the exact amount of GHG emissions, with the proviso that not the entire life cycle needs to be considered and the company obligates itself to GHG reductions.[69]

Carbon Label	Core message	Central information
„Low“ Carbon Label	Gives product information with respect to climate change and carbon management activities	Life Cycle Information of the product
Carbon Reduction Label	Gives product information with respect to climate change and obligates the company to GHG reducttions	Life Cycle emissions of the product and guarantee of emissions reduction.
Carbon Rating Label	Invitation to purchase products from the highest rating category	Results of the evaluation of a rating, based on emission intensities
Carbon Intensity Label	Call for a comparison of emission intensities of competing products	Life Cycle emissions of a product
Carbon „Neutral“ Label	Buying a carbon offset product	-

Table 2: Carbon Label [70]

[68] cf. Öko-Institut e.V. 2009 {p.24}
[69] cf. Öko-Institut e.V. 2009 {p.24}
[70] cf. Schmidt 2008 {p.176}

2.8 General Threats and Opportunities

Many consumer ask for simplified labels which are easy to handle and help them to make environmentally correct decisions.[71] The CF provides such easy handling but the question is whether the advantages exceed the disadvantages. Since the CF only uses one single indicator, the global warming potential, it should be deliberated whether the 'carbon footprint' is a step in the right direction or rather a step backwards. There are several threats and opportunities of the CF which need to be confronted with each other. In order to ensure objectivity, I do not aim to evaluate the carbon footprint, but to list the main opportunities and threats.

2.8.1 Threats

The 'burden shifting' is probably the biggest threat of greenhouse gas inventories. 'Burden shifting' means that a company does not improve its carbon footprint performance by eliminating a particular impact, but by activities like outsourcing, asking suppliers to take over one of the company's burdens or buying carbon credits. This process is similar to 'carbon leakage' in emission trading, which leads to a relocation of production,[72] with the big difference that there is no relocation of the production at 'burden shifting'. Thereby the company merely changes their measurement boundaries and shifts its burdens to a supplier.[73] This is also known as "greenwashing".

> *"The act of misleading consumers regarding the environmental practices of a company or the environmental benefits of a product or a service."* [74]

Moreover, the questions come up how the production process can be monitored and which data the companies have to present in order to reduce the risk of manipulation of the 'carbon footprint.'

This again makes clear why it is of mayor importence to consider all aspects and scopes as well as to agree on one standard authority in charge. Nevertheless, even the consideration of the entire life cycle does not protect of 'greenwashing'.

The reason is another 'burden shifting' that might be even more difficult to catch and which gives companies the opportunity to mislead their consumers. In this case, the strain is shifted from one natural system to the next.[75] As mentioned before, carbon constitutes half of the

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[71] cf. http://www.klimaktiv.de/media/07/10_dokumente/42_Umfragen/sempora_co2studie_kernergebnisse.pdf (21.07.2010)
[72] cf. DEHST (Deutsche Emissionshandelstelle) et al. 2008 {p.4}
[73] cf. Wirtenberg 2009 {p.280}
[74] Billitteri 2010 {p.87}
[75] cf. Wackernagel 2009 {p.50}

ecological footprint, whereby this does not mean to underestimate the other half. The most common example for this problem is the demand for bio fuel as a substitute for fossil fuels, whereby carbon emissions are reduced, but many other problems like deforestation, eutrophication and even food shortage aroused. Solely looking at the carbon emission can be misleading in many ways. For example, recycled paper has a much higher carbon footprint than virgin paper which causes problems elsewhere. This issue can be well illustrated by the case of Tchibo's sport bag as shown in figure 6. It was calculated that the carbon emissions of one bag almost equal the respective daily emission per capita and that the acidification is much higher in comparison.

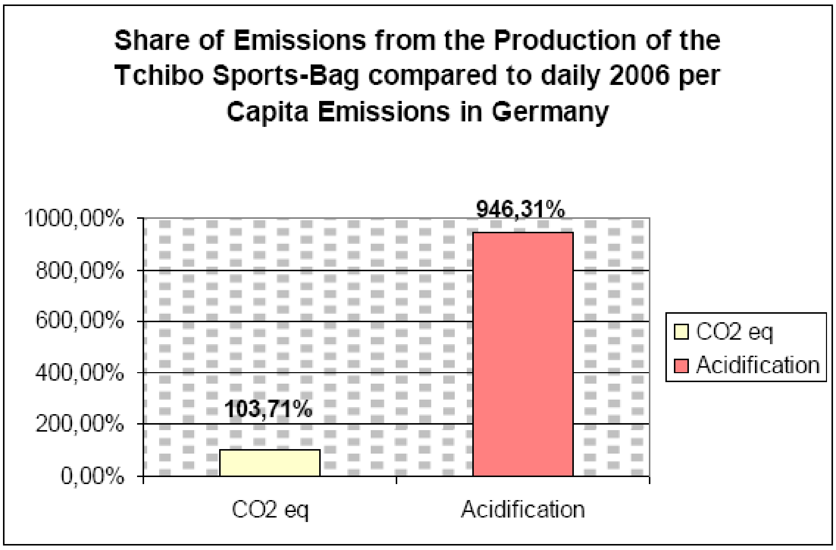

Figure 6: Carbon emission & acidification of a sports bag [76]

Therefore it is very important not to neglect other environmental impact categories and to give the consumer the chance to overview all relevant aspects.

Further minor threats are that the carbon footprint is always only a snap-shot in time. Changes in the procurement of raw materials, the production or the transportation are not shown in the carbon footprint even though they could increase.[77] There is also a debate about double counting, even though it is only a problem when participation in calculating footprints gets to a much higher degree than it already has. A solution for this is a comprehensive regulation.[78]

[76] http://www.pcf-projekt.de/files/1232963036/pcf_tchibo_sports_bag.pdf (21.07.2010) {p.30}
[77] cf. Schmidt 2010 {p.35}
[78] cf. Hendrickson 2008 {p.5841}

Moreover, product category rules and general data might create 'carbon footprints' of generic products and do not show the precise amount of emissions which could mislead the consumer as well.[79]

2.8.2 Opportunities

While reading literature the specialists' doubts and criticism in life-cycle assessment cannot be ignored. Almost everyone sees the CF with scepticalism and tries to recall the achievements of the LCA. However, even though many of them are sceptical they cannot drop the topic because it gives them and the LCA more attention than ever.

> *"In my view, CFP is too bad to love it, but too good to leave it."*[80]

The reason is the huge demand of the market for climate relevant information. Climate change is very contemperary in politics as well as in society. When the SEMPORA Consulting GmbH made a survey study about CO_2 emission and the related consumer behavior in 2007, they figured out that more than 80 percent of the consumers would prefer low carbon products over conventional products. About 12 percent are even willing to pay 5 percent more for those products.[81]

These results again show the power of the CF which is the biggest advantage of it. With a smart use of this power it might be possible to create a new competitive factor which saves carbon emissions and even helps other environmental impact categories to develop new strength. The movement around the CF offers a unique opportunity to help fulfill the climate change targets and should not be dropped because of arousing difficulties.

2.9 Different Carbon Footprints

The range of possible carbon footprints is huge: greenhouse gas inventories of nations and organizations, per-capita-emissions and personal footprints, as well as product carbon footprints - A range of different conceptions which is connected with criticism and ambiguities.

The biggest problem can be described with an example of the global operating company Pepsi. When Pepsi wants to create a 'greenhouse gas inventory' they do not only have to involve the carbon emission which occur during their production, but they are also responsible for the activities of third parties which work for them and emit carbon through

[79] cf. Schmidt 2010 {p.35}
[80] Finkbeiner 2009 {p.94}
[81] cf. http://www.klimaktiv.de/media/07/10_dokumente/42_Umfragen/sempora_co2studie_kernergebnisse.pdf (21.07.2010)

warehouses, manufacturing cartons, transportation and alike. If Pepsi wishes to consider these emissions as well, they leave the ‘greenhouse gas (GHG) inventory’ and enter the ‘product carbon footprint’ (PCF) of the entire supply chain.[82] In principle a complete ‘GHG inventory’ consists of different PCF’s. But since it is up to the companies which scopes they apply there is no standard procedure and the result may be deceiving. This example shows that it is inadvisable to only spotlight one type or one scope since they overlap. This becomes especially evident in the tourism industry, where the hotel is a company and a product at the same time.

For this reason I try to reduce the carbon footprint selection and focus on the most important ones regarding the goal of a PCF in the service sector. Hence, I will describe in the next part the ‘product carbon footprint’ and the ‘GHG inventory’ as shown in table 3, and neglect personal carbon footprints, national carbon emissions and others.

Brief overview	PCF (PAS 2050) [83]	GHG Inventory [84]
Assessment of:	products and services	companies
Scope 1,2,3	All sopes shall be included	1 – shall be included 2 – shall/ should – likely to be shall 3 - should
Methodology	Life-cycle-assessment (LCA) process analysis	economic input-output (EIO) life-cycle-analysis

Table 3: Brief overview PCF – GHG Inventory

[82] cf. Emmet 2010 {p.187}
[83] cf. BSI 2008
[84] cf. World Resources Institute/ World Business Council for Sustainable Development 2004

3. Product Carbon Footprint

The Product Carbon Footprint (PCF) is a further step of the environmental awareness in consumption. Many people set their hope on the PCF while others see it as an impossible task. I will present the basics of the PCF and describe the main stages as well as the difficulties with the ulterior motive of the creation of the PCF of 'One night's hotel stay'. Unfortnately, PCF's in the service sector are seldom and therefore this chapter is based highly on industrial products.

The PCF includes physical products as well as service products, a view which is supported by the following definition of products:

> *"A product is a good, idea, method, information, object, service, etc., that is the end result of a process and serves as a need or satisfier."* [85]

The PCF is only partially new as it is rooted in the life cycle assessment (LCA) and is supposed to indicate the CO_2 emissions generated throughout the whole life cycle of a product. The biggest difference to the general LCA is that it only refers to greenhouse gas emissions.

> *"The term 'product carbon footprint' refers to the GHG emissions of a product across its life cycle, from raw materials through production (or service provision), distribution, consumer use and disposal/ recycling."* [86]

A life cycle assessment is made to study the environmental aspects and potential impact throughout a product's life and consists of three parts: inventory, impact and improvement. Commonly it creates material and energy balances for every stage of the life cycle.[87] The ISO/ EN 14040 defines the LCA as:

> *"compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product's system throughout its life cycle."* [88]

Nevertheless it is doubted by some experts that the PCF provides an improvement and it was even called 'LCA for poor'.[89] The reason is that they see it primarily as a tool for green marketing, and only secondary as a chance of emission-reduction through an optimized production.[90] Nevertheless, there are other opinions that especially see the public contact as the biggest advantage and believe that it does make an improvement in the production

[85] http://www.businessdictionary.com/definition/product.html (07.07.2010)
[86] British Standards Institution (PAS 2050 Guide) {p.2}
[87] cf. Hendrickson et al. 2006 {p.4}
[88] Werner 2005 {p.28}
[89] cf. Feifel a.o. 2009 {p.284}
[90] cf. Feifel a.o. 2009 {p.284}

process simply because the concept is ‘catchy’ and gets attention which is already mentioned in the above section of this thesis.[91]

3.1 Methodology

There are two main methodologies yet to measure the CF. On the one hand the process analysis LCA, and on the other hand the economic input-output (EIO LCA) which I will describe in the GHG inventory part of my thesis.

The process analysis is usually used for the PCF because it is more specific and the input – output analysis is used for bigger inventories, like companies.

The LCA process analysis was invented by the Society of Environmental Toxicology and Chemistry (SETAC) and the U.S. Environmental Protection Agengy (EPA).[92]

The process analysis takes a ‘bottom up’ approach and analyses the environmental impact of single products.[93] It needs technical research to create material and energy balances for every important step of the life-cycle. The idea is to pursue a ‘cradle to grave’ approach of the products’ life cycle. This includes ‘procurement of raw materials’, ‘material preparation’, ‘production’, ‘distribution’, ‘use’ and ‘end of life’.[94] The biggest disadvantage of the process analysis is that it suffers from a system boundary problem. In order to make it assessable it must not be too detailed, without, however, omiting relevant processes. To create appropriate system boundaries is one key factor of a successful carbon footprint.[95]

Furthermore the PCF is divided into two categories as shown in figure 7. On the one hand there is the ‘cradle-to-grave’ approach meaning ‘business-to-customer’ (B2C) and on the other hand there is the ‘gate – to – gate’ approach referring to ‘business-to-business’ (B2B).[96] Thereby, the ‘cradle-to-gate’ approach is controversially discussed since the ‘use phase’ is very difficult to handle. However, a consumer product must contain all stages of the life cycle to be truthfully and comparable, although it would be beneficial to create more ‘gate-to-gate’ analysis.

91 cf. Christensen et al. 2008 {p.3}
92 cf. Hendrickson et al. 2006 {p.4}
93 cf. Bathnagar 2009 {p. 76}
94 cf. Emmett et al. 2009 {p.35}
95 cf. Minx et al.. 2008 {p.3}
96 cf. PAS 2050 Guide {p.10}

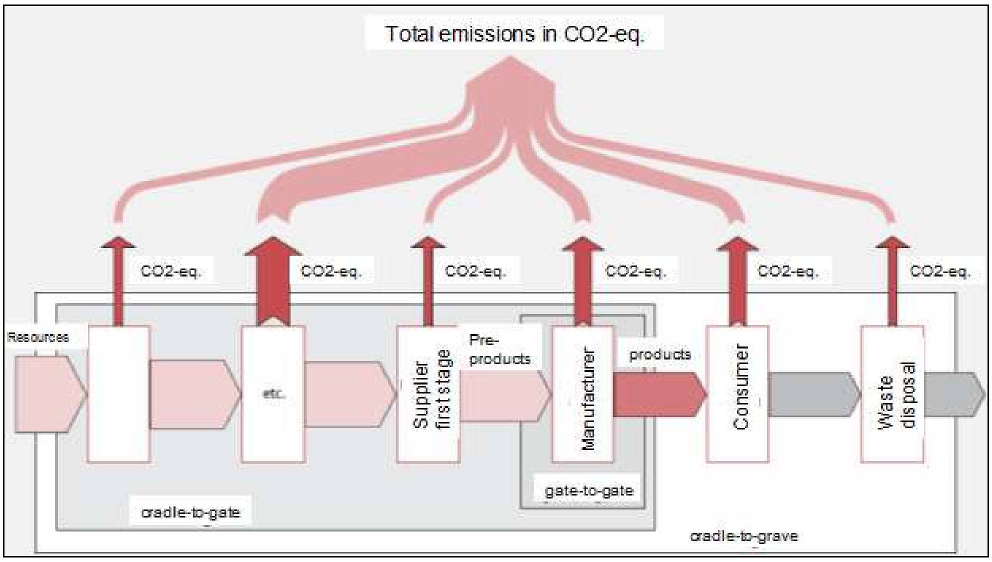

Figure 7: GHG emissions along the supply chain and possible boundaries [97]

The following calculation process is divided into different parts. I will now describe the main stages together with the associated problems.

3.2 Main Stages and Difficulties

The PCF might has a great potential but at the same time shows many difficulties as well. Matthias Finkbeiner lists several problems which occur in the standardization process. Some of them go into detail like the question of how to deal with carbon storage while others deal with fundamentals like the problem whether all stages of the product life cycle shall be included, and if so, how.[98]

Basically, there are three major problems which go along with the most important steps of calculation: The process map, the life cycle stages and the data collection.

To describe these problems I will use practical examples of the German 'PCF Pilotprojekt'. This project was initiated by the WWF Germany, the Öko-Institut, the Potsdam Institute for Climate Impact Research (PIK) and THEMA1. These institutes conducted a study including nine companies to calculate the carbon footprint of one of their products to increase the practical knowledge about carbon footprints.[99]

All of the companies put a lot of effort into this study and calculated the PCF with the 'cradle-to-grave' approach for different products, e.g., washing powder, frozen food, coffee, strawberries and others.

[97] cf. Schmidt 2010 {p.35}
[98] cf. Finkbeiner 2009 {p.92}
[99] cf. http://www.pcf-projekt.de/main/results/results-report/ (9.07.2010)

All practice examples show that the ‘cradle-to-grave’ idea is very difficult to handle. Adding on to this all processes and difficulties merge into each other as well due to the fact that all have a similar basis and cannot be treated separately.

3.2.1 The Process Map

In order to calculate a PCF it is necessary to create a process map first. This map enables the operator to comprehend the life cycle and to calculate the single stages.

To create a process map might be a challenging task and takes a lot of time and human resources. The process map is closely related to the process analysis, which provides information about inputs and outputs of processes. Thereby all processes within the life cycle of a product as well as material and energy flows are illustrated. For the resource flows it is possible to calculate environmental data, like GHG emission. Moreover, the law of conservation of energy and mass does exist, which states that whatever amount of input there is, there must be the same amount of output, even if it is in a different unit or form.[100]

The ‘DM – Drogeriemarkt’ calculated the PCF of their toilet paper ‘Sanft & Sicher’ and named the mapping of the entire process the biggest challenge. As shown in figure 8 their high level process production map consist of many elements, but it is a challenging task to collect all information for the single stages. Since they proceeded on basis of the ‘cradle-to-grave’ approach they also had to add other stages like the procurement of raw materials, the distribution and the use phase.

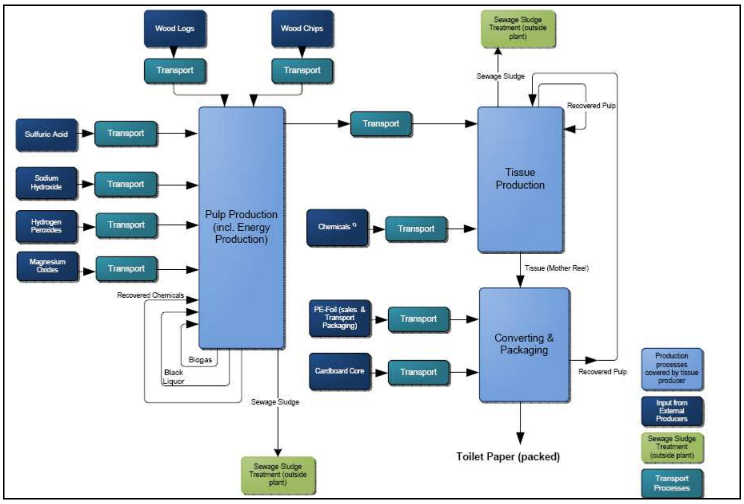

Figure 8: Production Process Map of toilletpapar 'Sanft & Sicher' [101]

Furthermore, Tchibo had great difficulties with mapping their entire supply chain:

> *“The supply chain of coffee, especially in bulk business, is very complex. In consequence the backtracking of coffee products to their origin is in many cases not possible.”* [102]

[100] cf. Creux et al. 2005 {p.10}
[101] http://www.pcf-projekt.de/files/1232962631/pcf_dm_sanft_und_sicher.pdf (13.07.2010)

During the mapping process the result is not the only important factor. Also the communication plays a big role. The mapping process is supposed to be carried out by people from different sections (logistics, production, marketing, transport, supplier, etc.) forming a team. This team has great overview and the chance to discover potentials and opportunities.

However, time remains a problem and it is especially for comlicated procedures very expensive to map the entire process.

> *"Such a study is extremely time and resource consuming. It seems to be not feasible to make such an effort for every product a company might have. Especially for smaller companies this is not possible."* [103]

As a result and to share the work of the 'product carbon footprint' suppliers and subcontractors have to be involved and need to be encouraged to establish their own process maps and calculations. Otherwise, it is not economically reasonable for the main producer to map the entire process of every single product.

3.2.2 Life Cycle Stages

Referring to Werner, a product's life cycle is a theoretical construct, which cannot be seen as a tangible physical object. Therefore, rules have to be determined on what is accounted for the life cycle.[104]

Like I mentioned there are five life cycle stages which are: procurement of raw materials, manufacturing, distribution/retail, consumer use and disposal/recycling.
It is not always possible to transfer the stages one-to-one to the service sector. However,it is supposed to be similar and I will go into detail when I deal with the hotel sector.

Procurement of raw materials:
Raw materials have to be divided into two kinds: primary and secondary raw materials.

> *"Primary raw materials can be produced by cultivation, harvesting, and replenishment such as farm products or some type of wood or can be mines such as fossil fuels, ores, water, air."* [105]

[102] http://www.pcf-projekt.de/files/1232962944/pcf_tchibo_coffee.pdf (13.07.2010)
[103] http://www.pcf-projekt.de/files/1236586248/pcf_henkel_persil-megaperls.pdf (07.07.2010) {p.16}
[104] cf. Werner 2005 {p.32}
[105] Ciambrone 1997 {p.48}

The difference is that secondary raw materials are recycled/ reused and primary raw materials are not. Therefore, the secondary raw materials undergo a different process which results in a difference of emission and environmental impact. As the procurement of raw materials is usually performed by suppliers and contractors it is very important that they take part in the calculation process because many factors have to be involved.

Besides the associated transports other input factors like energy utilization, consumed materials, livestock and infrastructure have to be considered.

Manufacturing:
Manufacturing converts the raw materials into final products ending when the products are transferred to the distribution. Most of the time this process is the easiest to calculate since the companies do most of it on their own and have specific data about it. Though, it takes a lot of time and they have to consider intern recycling, energy utilization, wastes and service trips.[106] Unclear is the consideration of staff trips to work.

> *"The GHG Protocol recommends including commuting to and from work, whiling PAS 2050 state explicitly that it should be excluded."* [107]

Distribution/ Retail:
All products have to be moved to the end-consumer and must contain this stage has to be included in the product's life cycle. To simplify the boundaries, all emissions, which occur during the change of location to the point when the customer buys the product, are considered. Distribution is defined as all non-transportation activities carried out to facilitate the transfer of manufactured products to their ultimate end-user and transportation is defined as the movement of energy or materials between operations at different locations, but only after the manufacturing process.[108]

When Frosta calculated the product carbon footprint of their frozen food 'Tagliatelle Wildlachs' they put a lot of effort in the study and considered all distribution stages. In addition, they had to consider the cooling of the finished product since it is a frozen product.
First they calculated the cooling in the warehouse, where the temperature is always at -28 degree Celsius, which they determined on basis of three factors:
- power consumption
- average capacity utilization (pallets)
- weight of the pallet

[106] cf. Ciambrone 1997 {p.46}
[107] http://gin.confex.com/gin/2009/webprogram/Paper2529.html (2.08.2010) {p.4}
[108] Ciambrone 1997 {p.69}

Later they also have to calculate the cooling in the retailer store, which is based on estimations. This storage time in the retailers refrigerator is very important factor and there should be a general rule.

Distribution FRoSTA 'Wildlachs'	**g CO_2/ FE**
Transport of the finished product	15
Storage at the wholesaler	2
Storage in the central stock	6
Transport to the retailer	6
Storage at the retailer	49
Sum	**78,0**

Table 4: Distribution FRoSTA 'Tagliatelle Wildlachs' [109]

In this context it is worth to mention the problematic field of energy use. When the REWE Group calculated the distribution of their strawberries, they did not consider the cooling phase in the warehouses since they only use 'green energy'.[110] Instead the PAS 2050 recommends the use of a specific renewable energy emission factor and warns of double counting of renewable energy sources.[111] The problem is that many renewable energy sources have been in place for a long time, but now are purchased as 'green energy'. If a company now decides to take the 'green energy' instead of the regular one, the energy mixture stays the same and there is no improvement. Therefore, renewable energy is only an improvement when new sources are developed and used.

Consumer use:
The way the product is bought, used, maintained and reused has an important impact on the environment. Interestingly, many products have the most significant emissions in the consumer use.

For example, the washing powder by Henkel. The 'use phase' is with more than 70 percent the main driver of greenhouse gas emission. It is the phase with the highest demand of energy in the entire life cycle.[112] Especially the 'use phase' is an unclear field because it consists of many unknown parts which have to be estimated.

[109] cf. http://www.pcf-projekt.de/files/1257258154/pcf_frosta_tagliatelle_update.pdf {p.26} (18.07.2010)
[110] cf. http://www.pcf-projekt.de/files/1232962839/pcf_rewe_erdbeeren.pdf {p.21} (18.07.2010)
[111] cf. PAS 2050 Guide {p.31}
[112] http://www.pcf-projekt.de/files/1236586248/pcf_henkel_persil-megaperls.pdf (07.07.2010)

The ‘use phase’ starts with the shopping trip. The PAS 2050 guide recommends not to include the customer shopping trip, but the PCF-Pilotprojekt does include the emission because they see it as an important aspect. Furthermore they show an easy way to implement this approach. The foundation is an assumed shopping distance of five kilometers in an average passenger car. In addition to this, a shopping volume of 20 kilogramme is taken as the basis and the single greenhouse gas emissions for each product are allocated according to the mass of the respective products.[113] By this way the different weights of the products are involved in an easy way.

After the shopping trip, the next problems occur. It deals with the different technical use of the product. For example Henkel’s washing powder as shown in figure 9. They calculated with different times and temperatures of the washing since the decisive parameters are time and temperature of the washing programme as well as the energy efficiency of the washing machine. Thereafter, the CO_2 emissions depend very much on the technique, the soiling and the consumer behavior and less on the product. This amplitude is difficult to illustrate for every product.

	30° C	46° C	60° C	30° C light soiling	90°C heavy soiling
g CO_2-Eq. / Wash load	~ 450	~ 700	~ 930	~ 360	~ 1480
% (Average Temp. = 100 %)	63	100	130	51	209

Figure 9: 'washing powder' different usage[114]

Furthermore, the environmental attitude of the consumer is a parameter, which must not to be underestimated. When Frosta calculated the emissions of their frozen product ‘Tagliatelle Wildlachs’ they even divided the ‘use phase’ into three scenarios from the ‘environmentally conscious-’ to the ‘wasteful-consumer’, because they had difficulties to estimate the consumer behavior.[115]

Since the carbon footprint does not provide an acceptable standard for the ‘use phase’, the product category rules, which I will later describe in this chapter, might be a possibility in the future.

[113] cf. http://www.pcf-projekt.de/main/results/results-report/ {9.15} (16.07.2010)
[114] http://www.pcf-projekt.de/files/1236586248/pcf_henkel_persil-megaperls.pdf (07.07.2010)
[115] cf. http://www.pcf-projekt.de/files/1257258154/pcf_frosta_tagliatelle_update.pdf (13.07.2010)

Disposal/ Recycling:

Waste is defined as

> *"unwanted material left over from a production process, or output which has no marketable value."* [116]

Physically waste often contains the same materials as useful products, but it differs by the lack of value. This lack of value can sometimes be eliminated by separating the waste correctly and therefore, be used again. Although there are many different types of waste this thesis will be limited to household waste which includes organic waste, leaving out hazardous or production specific industrial waste.[117] It can be said that there are three different types of waste management:

- landfills
- combustion
- recycling

Since the 'Kreislaufwirtschafts – und Abfallrecht' was launched in 1996 in Germany there was a development towards waste combustion and in 2005 the use of landfills with untreated waste was discontinued.[118] Landfills emit methane and carbon dioxide through the the chemical and bacterial degradation of organic content of rubbish. Though it is possible to collect the released methane and create energy through the combustion of it, which results in the same problem of consideration as in the direct combustion of waste.[119]

Usually the waste is either recycled or combusted, which makes the calculation easier. The Umweltbundesamt provides average recycling data which can be used by companies to estimate the recycled share of their products.[120] By using this data it is even possible to calculate a CO_2 credit, if the savings are bigger than the demanded energy. Savings may arise since the CO_2-eq. emission in the production of the replaced material could be bigger than through recycling. FRoSTA used the following formula, but there is no common standard, and 'PAS 2050' e.g. does not even take recycling into account.

[116] cf. http://www.businessdictionary.com/definition/waste.html (19.07.2010)
[117] cf. Bilitewski et al. 1997 {p.22}
[118] cf. Meyerholt 2007 {p.296}
[119] cf. http://www.umweltlexikon-online.de/RUBabfall/Deponiegas.php (12.08.2010)
[120] cf. http://www.umweltdaten.de/publikationen/fpdf-l/3865.pdf (20.07.2010)

Formula to calculate the CO_2 credit out of recycling, used by FRoSTA:

Er = - Ep * Rq * Ea [kg CO_2e/kg material][121]

Er:	*Credit out of the recycling (Result with a negative sign)*
Ep:	*CO2e-emission in the production of the replaced material in [kg CO_2e/kg]*
Rq:	*Recycling rate for Germany for the material according to UBA*
Ea:	*Percentage reduction of the yield for the cost of the energy used for the Transport and the recycling, expressed as a number 0-1*

Due to the combustion of waste energy is created as well as emissions. But in the combustion process the CF consideres merely emissions from fossil carbon and excludes plant based carbon emissions in the waste.

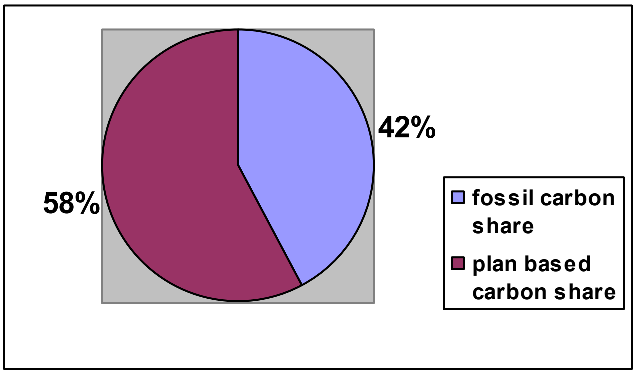

Figure 10: Composition of household waste [122]

The combustion of fossil carbon household waste creates in Germany in average 35,9 Mg (mega grams) CO_2-eq./ TJ, whereas the creation of energy through natural gas (56 Mg CO_2-eq./ TJ) and through anthracite coal (93 Mg CO_2-eq./ TJ) has higher GHG emissions.[123] Therefore, the combustion of waste saves energy in comparison to other fossil fuels. Yet it is not determined how to or even if to consider these greenhouse gas savings in the carbon footprint.

Product Category Rules:

Since there are many questionable points in the consideration of the entire life cycle the need of main product rules exist. To solve this problem various organisations try to define and test environmental product declarations (EPD) and product category rules (PCR) which are supposed to give a clear scope.

121 http://www.pcf-projekt.de/files/1257258154/pcf_frosta_tagliatelle_update.pdf (20.07.2010) {p.30}

122 cf. http://www.umweltbundesamt.de/abfallwirtschaft/nachhaltigkeit/dokumente/energie-aus-abfall-verbrennung.pdf (20.07.2010) {p.5}

123 cf. http://www.umweltbundesamt.de/abfallwirtschaft/nachhaltigkeit/dokumente/energie-aus-abfall-verbrennung.pdf (20.07.2010) {p.7}

> "*Product category rules are a set of specific rules, requirements and guidelines for developing environmental declarations for one or more groups of products that can fulfil equivalent functions.*" [124]

The German 'memorandum Product Carbon Footprint' believes that product category rules are a major factor towards carbon footprints. For example, they think that it is a good idea to determine the shopping trips of product category rules.[125] So far there are only very few existing product category rules and these might be not sufficient. A problem is that these category rules often do not include all life cycle stages. The reason for this is to provide an easier calculation and therefre, focus on the most relevant stages. In the following figure 11 the product category rule of an 'passenger vehicle' is shown.

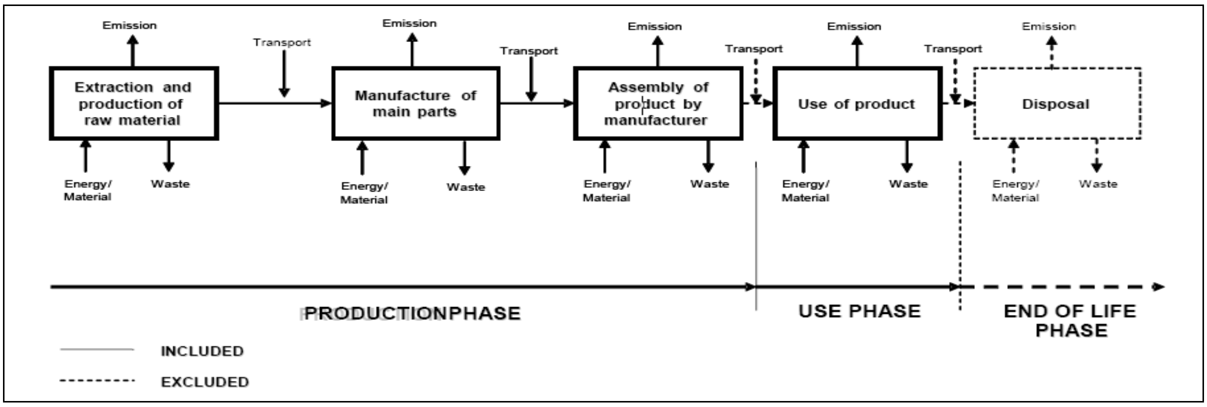

Figure 11: Product Category Rules 'passenger vehicle' [126]

As well shown in the figure the 'end of life' phase is not included. Altough the greenhouse gas emission are much lower in that stage than in the others, they are probably much bigger than the total emissions of other products. Moreover, there are definitely differences between the vehicles, which have to be shown. However, considering the 'cradle-to-grave' approach every stage is supposed to be included.

> *"To calculate the PCF correctly, the entire life cycle of a product must be taken into consideration. Assessing only individual phases can lead to false recommendations for appropriate action."* [127]

Therefore, it is not a sufficient strategy to omit a stage. But in the 'use phase' of the early mentioned 'washing powder' it could definitely be a helpful way to determine the washing temperature and establish, by a product category rule, comparability and clarity. Therefore, Henkel calls for it as well:

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[124] British Standards Institution (PAS 2050 Guide) 2008 {p.13}
[125] cf. Bundesministerium für Umwelt 2009 {p.19}
[126] http://www.environdec.com/pcr/pcr0503_e.pdf (15.07.2010)
[127] http://www.pcf-projekt.de/main/results/results-report/ {p.13} (16.07.2010)

> "Due to the importance of the use phase in case of a detergent a framework of conditions (PCR) is required in order to specify this important life cycle stage. Without a product category rule the comparison of carbon footprints of different detergents is not possible."[128]

Finally it can be said that it is a difficult task to include all stages of the life cycle, but they must be included to calculate a correct product carbon footprint. However, product category rules might be a way in future to increase comparability and decrease effort.

3.2.3 Collection of Data

To collect all data is a difficult and very complex undertaking. The reason is that the available information vary and are not always sufficient. There are three different approaches to gather all data which sources are commonly combined.[129]

- Primary data
- Secondary data
- Assumptions

Primary data are information, where the raw material producer or the manufacturer directly describes how they produce their product while providing as much of the necessary data as possible. These are the best information and if every supplier of a product or a material creates a CF, the following manufacturer would have a much easier task to complete their own PCF. An impediment for this is the withhold of information by the suppliers. Also the Henkel team experienced this:

> *"Typically suppliers don't have the opportunity to convert their original data into non critical data with no confidentiality concern e.g. by aggregation. They don't share any original data e.g. energy data with us because they treat these data as confidential."* [130]

Beside the fact that the data is not always accessable Schmidt identifies three major challenges throughout the Life Cycle of a product. [131]

1. The emissions' data of the suppliers must be easy to convert and have to rely on suitable parameters.
2. The emissions' data must be able to be updated and verified with little effort.
3. The data of the whole supply chain must be able to be simply recorded.

[128] http://www.pcf-projekt.de/files/1236586248/pcf_henkel_persil-megaperls.pdf (07.07.2010)
[129] cf. Ciambrone 1997 {p.64}
[130] http://www.pcf-projekt.de/files/1236586248/pcf_henkel_persil-megaperls.pdf (07.07.2010) {p.16}
[131] cf. Schmidt 2010 {p.35}

To bypass these problems ‘standard’ data were developed to provide the companies with information and to give them the opportunity to calculate and work with generic information. These information are called secondary data and are published data, such as article, studies and surveys.

Most of the companies in the PCF-Pilotprojekt reach back to secondary data and use them for industrial figures, e.g. the transportations with help of TREMOD[132] (Transport Emission Estimation Model). Moreover, there are some data-transfer programmes in development like UNEP/ SETAC or ILCD which will encourage the data transfer and transparency between companies.[133]

Assumptions are of course the least precise data collection. However, gaps in data often exist and sometimes the companies have to take average data to fill these gaps. These data is usually not in detail or the boundaries do not fit. Then, many companies do a best- and worst-case scenario to illustrate the range of possibilities.[134] Though, it is not suitable for the labelling.

	Base case	**Best case**	**Worst case**
Overseas transport	By one ship	By three ships	By one ship
Purchase trip	By car, 5 km, part of total 20 kg purchased	By foot or bicycle	By car, 5 km, part of total 20 kg purchased
Shopping bag	With	Without	With
Brewing methods	Consumption mixed	French press	Automatic coffee machine
Credits	Not considered	1. Electric energy from incineration 2. Recycling paper form carton 3. Pellet thermal energy as a substitute for oil	Not considered
g CO_2-eq. /cup of coffee	59,12	47,75	101,88

Table 5: Carbon Footprin of Tchibo Coffee (best - worst -case) [135]

To avoid such a lack of data Feifel mentiones two main points. First the data transfer between the companies must improve and second different data sources must be included and provided.[136] But sometimes it takes even more, as it can be seen in the example of the Tchibo coffee. Here again we need product category rules to determine the exact boundaries.

[132] cf. http://www.pcf-projekt.de/files/1257258154/pcf_frosta_tagliatelle_update.pdf {p.27} (12.08.2010)
[133] cf. Feifel et al. 2009 {p.49}
[134] cf. Feifel et al. 2009 {p.49}
[135] http://www.pcf-projekt.de/files/1233585232/poster_dsm_claristar.pdf (20.07.2010)
[136] cf. Feifel et al. 2009 {p.50}

4. Greenhouse Gas Inventory

A 'GHG inventory' is used to calculate the CF of a company. In the service sector, however, the boundaries between product and company are fluid and therefore, the 'GHG inventory' is essential as well to create a PCF. This section describes the basics of the 'GHG inventory' and the used methodology.

A very extensive definition of the 'GHG inventory' describes it as

> *"…a compilation of estimates of anthropogenic greenhouse gas emissions, using a stated method, a specified boundary and a particular time period."* [137]

I will limit this definition to the 'GHG inventory' of a company. It is a voluntary act that serves the business in many ways. For example, helping to manage GHG risks and identifiying reduction opportunities, companies get recognition for early voluntary action and it might be possible for companies to participate in GHG markets, e.g. emission trading, 'Joint Implementation' or the 'Clean Development Mechanism'.[138]

Like mentioned earlier in chapter 1, the GHG inventory is based on the ISO 14064 standard and the 'Grennhouse Gas Protocol' of the World Resources Institute.

> *"The ISO standard provides a clear set of verifiable requirements, while the GHG Protocol provides detail guidance on how to prepare a company level inventory, supported by a range of calculation tools."* [139]

As the standard is not clear in every detail and it is a voluntary act, the World Resources Institute published five main principles which shall be followed in the accounting and reporting process.[140]

- Relevance: The GHG inventory is supposed to reflect the greenhouse gas emission in an appropriate way that serves the decision makers, internal and external.
- Completeness: All greenhouse gases within the boundaries of the inventory must be included and if not, justified and disclosed.
- Consistency: Though the inventory needs to be comparable over time, it is important to use consistent methodologies and to report transparently all changes.

[137] Dawson et al. 2009 {p.199}
[138] cf. World Resources Institute/ World Business Council for Sustainable Development 2004 {p.10}
[139] Dawson et al. 2009 {p.204}
[140] cf. World Resources Institute/ World Business Council for Sustainable Development 2004 {p.7}

- Accuracy: The quantification of GHG emissions must be systematically neither over nor under actual emissions, as far as can be judged, and uncertainties need to be reduced as far as practicable.
- Transparency: All relevant issues must be addressed in a factual and coherent manner, based on a clear audit trail. Any relevant assumptions must be disclosed and the used accounting and calculation methodologies must be appropriate.

4.1 Methodology

The methodology used for the 'GHG inventory' is usually based on the economic input-output life-cycle-analysis (EIO LCA).

> *"The Economic Input-Output Life Cycle Assessment (EIO-LCA) method estimates the materials and energy resources required for, and the environmental emissions resulting from, activities in our economy."* [141]

Through the macroeconomic approach of the EIO LCA method it is more suitable for the inventories of companies and organizations, but not for products. However, the EIO LCA has the potential to be more comprehensive than the process analysis since it covers direct and indirect processes. The EIO LCA approach is especially used for companies that have to calculate their own emission and moreover inter-industry effects. On the one hand they use process based information and on the other hand also make use of the standard economic input-output tables and environmental information.[142] Therefore, it is easier to take into account the entire supply chain. For example, if a hotel wants to create a 'GHG inventory' and they have to include the cleanings, which are outsourced, they may take average data of the national sector based input-output table to include the emissions of cleaning.

To assess the process relevant emission of the own company there are different methods, depending on the businesses' activities. For small companies it is advisable to calculate the emissions from fuel use data. Even small users usually know the amount of fuel they use and have access to the carbon emission rates. Furthermore it is the easiest way of calculation.

Whenever emission are emitted through industrial processes, it is not common to measure the flow rate, but to take information based on mass balances or documented emission factors.[143]

[141] http://www.eiolca.net/Method/index.html (24.07.2010)
[142] cf. Suh 2009 {p.220}
[143] cf. World Resources Institute/ World Business Council for Sustainable Development 2004 {p.42}

4.2 Inventory Boundaries

Again the boundaries of the inventory are very important. They decide about comparability, quality and usefulness. Since the standards are voluntary acts it is the companies' responsibility to determine their boundaries.

4.2.1 Temporal Boundaries

Usually the greenhouse gases are measured on an annual bases. But to track emissions over time it is important to set a base year. By using this method it is possible to compare emissions over time and check goals. Since companies undergo significant structural changes such as acquisition and mergers, the base year may need to be recalculated to provide the consistent tracking. Moreover, the base year must have sufficient data about the emission, otherwise it might be useful to use average data of several years.

4.2.2 Organizational Boundaries

Setting the organizational boundaries of a company has a big influence on the greenhouse gas inventory. Especially larger firms have joint ventures, subsidaries, franchises, partnerships or other business units that may, or may not, included.[144] To decide what parts are to be included the GHG Protocol suggest two approaches: The equity share approach and the control approach. However, the companies decide which approach they use and can influence by this the resulting inventory.

> *"Equity share means that the equivalent number of emission for a subsidary, etc. In which the company has an equity stake are included in the inventory."* [145]

For example, if a company owns 100 percent of a joint venture, they have to include 100 percent of the emission. But if they only own 50 percent they only have to include 50 percent. Under the control approach the companies only consider emissions of companies, which they control, financially or operationally. Financial control is defined when a company can direct its financial and operational policies to gain benefit from its activities and operational control when a company is able to implement and direct operating policies.[146]

Considering this two ways the companies have the opportunity to choose the way with the lowest emission. Though a company can only choose one approach and should keep it.

4.2.3 Operational Boundaries

The operational boundaries are divided into three scopes, like described in chapter two. For the Geenhouse Gas Inventory scope 1 and 2 are mandatory. But as companies know about the impact of their scope 3 emissions many of them try to include these.

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[144] cf. Kolk et al. 2009 {p.69}
[145] Wilhelm 2009 {p.13}
[146] cf. Wilhelm 2009 {p.13}

> *"Under the Protocol, reporting Scope 3 emissions is optional; however, we measure and seek to reduce our Scope 3 emissions because they are almost 2.5 times greater than our core emissions."* [147]

To track all scope three emissions might be a difficult task since the companies need information of their supplier and adding on to this the way products and services are used in practice often change. For this reason, the tracking of scope three emission is a trade – off between accuracy and relevance.[148] Companies have to decide which sources to include by relevance and how to deal with missing accuracy.

[147] http://crs.cokecce.com/publications/crs-report.php?g=2 (22.07.2010) {p.16}
[148] cf. Kolk et al. 2009 {p.70}

5. Tourism and Climate Change

In this section I will illustrate the relationship between tourism and climate change to deal with the hotel carbon management afterwards.

The word tourism is a relatively modern term, although nowadays everybody knows what the word means; it became part of our common language. In the beginning the word was associated with trouble and work and its meaning did not develop towards pleasure and happiness until the twentieth century.[149] But to define the term tourism is still complicated, as tourism is everything tourists do. However, most definitions consist of two parts.

> *"First it involves travel away from an individual's home environment, and second it involves the exposure of individuals to activities that are different and unusual."* [150]

Tourism is everywhere and has developed to the third biggest economic sector behind the oil and automotive industry. Furthermore, the World Tourism Organization estimated an annual increase of tourism of 4 percent up to the year 2020.[151] However, the tourism industry shrank during the great depression in 2008/ 2009 with exceptions like ferry trips and skiing. And this depression again showed the big dynamics of the tourism sector, in which non-technologically innovations like the optimal utilization of human resources or new forms of organization and management are required more than anywhere else as the competition is huge as well as the economic impact.[152] Worldwide the direct and indirect impact of travel and tourism economy is over ten percent of the world economy and provides direct and indirect over 210 million jobs.[153] Therefore, it is no surprise that the tourism industry has an impact on the climate system, which

> *"consist of the atmosphere, oceans, ice and snow masses, land surfaces, rivers, lakes and the biosphere, as well as mutual interactions,..."* [154]

But tourism relies on a high level on the nature and climate as well. On the one hand, the climate serves as a resource, since most tourists visit places which provide a attractive nature. On the other hand, it is a risk for tourism through storms, water or temperature rise and their consequences.[155] Peeters describes the relationship as a 'two-way-street': tourism impacting on climate change and being impacted by the climate change.[156]

Although both systems are described as very individually operating open systems, which are non-linear and non-deterministic, because of their complex and dynamic relations between

[149] cf. Holden 2000 {p.2}
[150] Franklin 2003 {p.23}
[151] cf. Engels et al. 2009 {p.7}
[152] cf. http://www.oecd.org/dataoecd/21/61/44603973.pdf (27.07.2010) {pp.2-4}
[153] cf. Hall 2005 {p.9}
[154] Becken et al. 2007 {p.16}
[155] cf. Becken et al. 2007 {p.7}
[156] cf. Peeters 2008 {p.12}

and among them and their elements. Consequently it is very difficult to predict, manage or control future changes of the relationship or single elements.[157] However, the next sectiom will describe the present and possible future impacts between the two systems tourism and climate.

5.1 The Impact of Tourism on Climate Change

Like described tourism has developed to one of the biggest economic sectors in the world. Therefore, it is not the question if, but how tourism impacts the climate change. The range of the expected greenhouse gas contribution varies a little in literature. The OECD estimated in 2008 that tourism contributes up to 5.3 percent of the overall global anthropogenic greenhouse gas emission[158], and Scott calculated that only the CO_2 emissions made about 5 percent. Moreover, he noted:

> *"Including the global warming attributable to other GHGs and secondary atmospheric impacts caused by aviation, the contribution of tourism to global climate change is estimated to be between 5.2% and 12.5% in 2005."* [159]

Similar to the estimated 5 percent is a study of the CO_2 emission of a household in the United Kingdom in 2001. The British DERFRA estimated the CO_2 emission caused by recreation, leisure and tourism of about 1.2 tonnes of CO_2, which is about 5 percent of the total emissions (20,7 tonnes) as shown in figure 13.

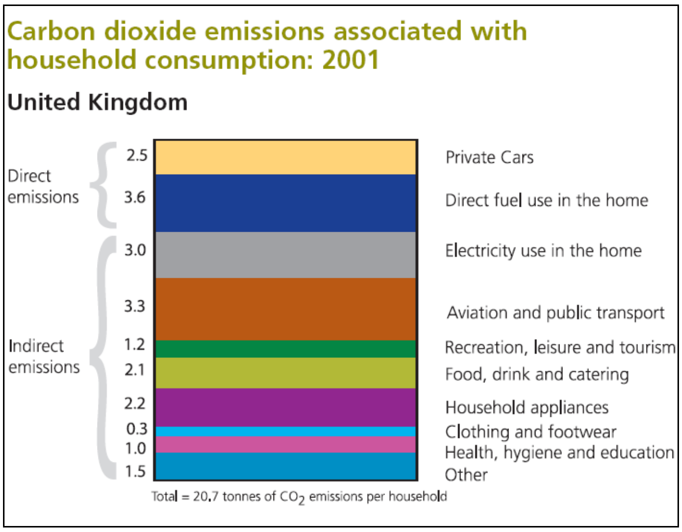

Figure 12: CO2 emission of a UK household in 2001 [160]

According to these data tourism's contribution of anthropogenic greenhouse gases is over 5 percent. This would mean that tourism has a bigger impact on climate change as the entire

[157] cf. Becken et al. 2007 {p.9}
[158] cf. OECD 2008 {p.9}
[159] Scott et al. 2010 {p.396}
[160] DEFRA 2006 {p.16}

middle east and if tourism were a country it would rank fifth after the USA, China, the European Union and Russia.[161]

The emissions of tourism can be divided between the transport of the tourists' homes and their destinations, the accommodations and their activities. The transport of tourists by car, aircraft, ferry or train causes the most amount of emissions, with approximately 75 percent. At this air transport has the biggest share with 40 percent of the total emissions, whereas accommodations make up 21 percent of the total emissions.[162]

Even though there are technological improvements to expect like better fuel efficiency and higher energy standards, the emissions caused by tourism is going to increase since international tourism is expected to expand. In 2008 there were 922 million international arrivals and the UNWTO forecasts that international arrivals are expected to reach nearly 1.6 billion by the year 2020 as shown in figure 14.

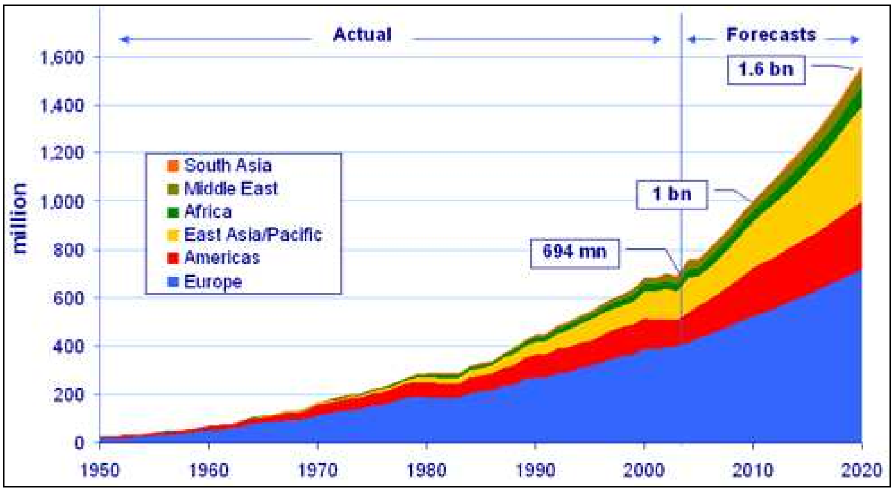

Figure 13: Forecast of tourism development [163]

Scott has illustrated in a business-as-usual scenario that the emission of tourism will increase to over 3000 million tonnes CO_2 (now about 1300 MT) and that aviation will represent more than half of all emissions of CO_2. Furthermore, accommodation is anticipated to increase emissions as well with a share of one quarter of the tourism emissions. This is because accommodation capacity is projected to grow and become more luxurious and energy-intense per bed night.[164]

To take action the WTTC declared the target of minus 50 percent of todays tourism related carbon emissions by the year 2035, which would mean about 600 MT instead of 3000 MT.

[161] cf. http://www.iwr.de/klima/ausstoss_welt.html (27.07.2010)
[162] cf. Scott et al. 2010 {pp.396 ff.}
[163] cf. http://www.unwto.org/facts/eng/vision.htm (27.07.2010)
[164] cf. Scott et al. 2010 {pp.396 ff.}

However, they rather illustrated hopes than to set out a strategy by which this magnitude of emissions reduction could be achieved as shown in figure 15.

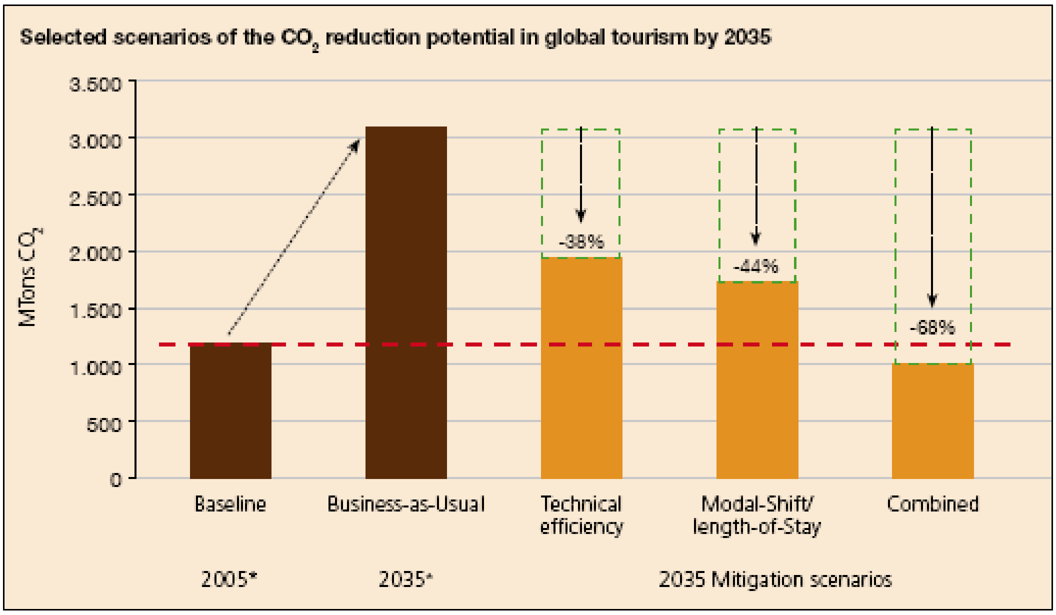

Figure 14: WTTC carbon reduction goals [165]

5.2 The Impact of Climate Change on Tourism

The effects of climate change on tourism will be first of all economically. Some countries will even profit of the changes, but most countries will lose. Especially the Mediterranean countries, island states and distant destinations are threatend. Furthermore, tourism may get an image problem since it is a main driver of climate change and it is one of the few sectors that do not have a proper future strategy. [166]

The majority of tourists choose their destination depending on the climate. They prefer sunshine, but do not like it too hot. In future, tourism places like the Mediterranean countries might get too warm and places like the northwest of Europe get more pleasant, which could lead to a shift of tourist targets. Hamilton et al. describe this as a pull and push scenario. On the one hand the pull effect of international holiday destinations weakens because the weather is not as good as it used to be, and on the other hand, the push factor looses power because tourists can spend the holidays in their home countries and do not have to go abroad.[167] Thereby the amount of spent money will probably not change, but the places where it is spent will. Some experts tried to calculate the shift of calculation and had surprising results.

[165] http://www.respect.at/media/pdf/pdf1300.pdf (27.07.2010)
[166] cf. Engels et al. 2009 {p.36}
[167] cf. Hamilton et al. 2005 {p.246}

> *"The UK, for instance, would see its tourist arrivals fall because, even though its climate improves, its would-be tourists rather stay in their home country where the climate also gets better. As another example, Zimbabwe would see its tourism industry grow because, even though its climate deteriorates, it is still the coolest country in a region where temperatures are rising."* [168]

Several factors and elements will influence the change of tourism targets and it is not possible to predict detail changes. On the one hand a shift towards domestic tourism is possible, but on the other hand international destinations have increased and continue as flights are low prized. Moreover, in domestic as well as international tourism the destinations will change and there will be winner and loser. But the major economic problem is that some countries have focused on tourism and will have big economic losses through a decline in arrivals.[169]

In addition, there are indirect effects of global warming like water rise, devastation or water shortage, which will influence the tourism targets. The following illustration shows the most likely effects on tourism in the world.

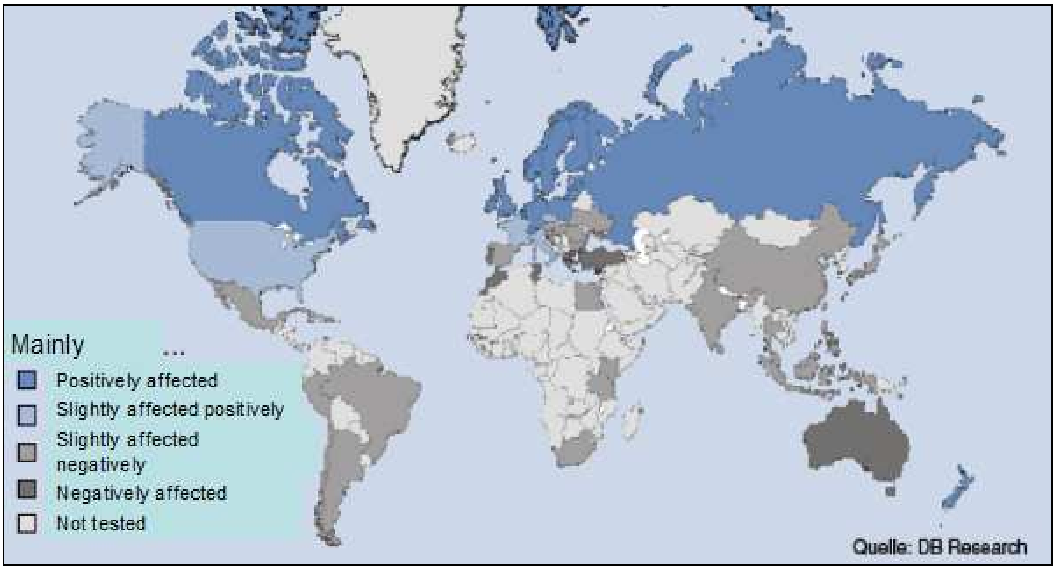

Figure 15: Climate change effects on tourism [170]

Especially the northern countries seem to be affected mainly positive, in contrast to the southern countries, which will suffer more under the climate change, which might be the core message. The 'south' is the smallest emitter of greenhouse gases, but will probably suffer most, economically and environmentally.

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[168] Berrittella et al. 2006 {p.914}
[169] cf. Berrittella et al. 2006 {p.922}
[170] cf. Deutsche Bank Research 2008 {p.1}

6. Hotel Carbon Management

This chapter will introduce the topic of carbon footprinting in hotel management and describes the methodological approach of existing standards as well as the proposed method for future carbon footprinting in the hotel sector.

As described in the previous part tourism has a big impact on climate change and vice versa. Since there is no sufficient top-down strategy to deal with this challenge, the solution might be a bottom-up strategy. Customers in the future will be much more curious about the emissions they cause due to their holidays and since tourism is such a strong competition hotels have to react. The greenhouse gas management of a hotel will be fundamental, wherewith they denote their impact on climate change.

Up till now there is no standard label and calculation tool that informs the customer of the climate impact of the hotel visit. This chapter is primarly concerned with the possibilities of an implementation of a PCF in the hotel sector, wherby practice examples and the connected approach are introduced and discussed. Afterwards the hybrid EIO LCA (HEIO LCA) approach will be suggested as a proper methodology for the issue of a PCF since it seems to be a suitable way to handle the task in the tourism sector, with the goal of a PCF of ‘one night’s hotel stay’.

6.1 Practical Examples

There are various organizations that provide hotels with carbon calculator, labels and certifications. Unfortunately, non of them was willing to give insight in their methods of calculation. However, they do describe it superficially on their internet pages and give some vague information about the process. The most known provider of carbon calculation tools are Viabono in cooperation with CO_2OL, Climate Partner and MyClimate from Switzerland. The calculation approaches of these organzisations are very similar and differ only in detail.

Their approach generally starts with the creation of a ‘GHG inventory’ on basis of the ISO standards and sometimes with help of the ‘GHG protocol guide’.[171] They include all relevant greenhouse gases, but the scope of emissions is not clear and may vary between the organizations. The calculation is executed through the evaluation of a survey paper or internet based survey, which has to be completed by the hotel manager. By means of this information the organization calculates the carbon emission of the hotel and adds recommendations for carbon improvement. Hence, they calculate the CF of a guest.[172]

[171] cf. http://www.climatepartner.com/cp/index.php/de/co2-fussabruck (2.08.2010)
[172] cf. http://www.co2ol.de/Klimaneutrales-Hotel.193.0.html (2.08.2010)

Furthermore, they serve the hotel with a proper holiday flat the hotel can offer to their guests to neutralize their emissions. In connection with the calculation the organization offers the hotel to work on improvements and to coach their personal. Finally, the hotels have the opportunity to convert into a 'carbon neutral' hotel, by compensation payments, which support afforestation programmes or the like.[173] Of course there are organizational distinctions. For instance, Viabono classifies the hotels into climate friendly classes.[174] Though, they all offer the compensation of the emitted greenhouse gases and dispense certificates that rate the hotels as carbon neutral.

This procedure has two big advantages; first, it is easy to calculate and second every hotel can implement it without great expense. But on the other hand, there are several disadvantages. First of all, it is debatable whether compensation payments, also called 'carbon offestting', are expedient or not. Presumably these payments will compensate some of the emission, maybe even all. But as soon as the hotel advertises the certification 'carbon neutral', it gives the image of a clean hotel, even though the 'eco-balance' of the hotel turns out to be poor. The German 'Umweltbundesamt' (UBA) and the 'Deutsche Emissionshandelsstelle' (DEHST) call for consideration of the fact that only a minor share of the global warming potential can be eliminated and that the customers might get the wrong image that it is possiple to sell their climate indulgences. For this reason they developed four criteria to secure the responsible use of 'carbon offsetting'.[175]

- Realistic calculation of emissions
- Prevention of GHG emissions has priority over compensation
- A demanding and traceable communication
- Transparency of the compensation offer

Furthermore, some of these organizations charge the emissions of a guest by the division of the greenhouse gas inventory by the number of guests. However, this approach may distort the result and needs to be seen critically. In 7.3.3 this approach is compared to others and highlights the expected perils that could occur.

Finally, this procedure of data assessment and evaluation endows hotels with a big room for greenwashing. The hotels are supposed to fill out the survey sheets by themselves without

[173] cf. http://www.myclimate.org/carbon-management-services/gesamtloesungen/hotelbranche.html (2.08.2010)
[174] cf. http://www.viabono.de/CO2Fussabdruck.aspx (2.08.2010)
[175] cf. DEHST (Deutsche Emissionshandelsstelle) et al. 2008 {p.18}

any examination of the data by thirds. Therefore, one could conclude the results are not reliable.

6.2 Proposed Methodology

In preparation for the hotel carbon management are two necessary goals to consider. On the one hand it is important to create a 'GHG inventory', the 'carbon footprint' of the hotel, and on the other hand a PCF of 'one night's hotel stay' is required.

The 'greenhouse gas inventory' depends strongly on the used scope. Scope 1 and 2 are required and cause a lot of work, but do not create many difficulties. Scope 3 is not mandatory and might cause problems, depending on how detailed it is. The 'GHG inventory' is customary calculated with the environment input-output life cycle analysis (EIO LCA) approach. This approach gives the opportunity to catenate own process data with standard economic input-output tables and environmental information. Instead of that, the PCF is calculated by the life cycle analysis (LCA) approach, whereby every stage of a product's life cycle is assessed individually. The PCF can be very detailed and therefore may be difficult to compile.

Neither a hotel is like any other conventional company nor is the product 'one night's hotel stay' like any other conventional product. The company and the product interact and overlap and it is thus necessary to draw boundaries that clarify where the product ends and where the companies' inventory starts. In this thesis the question of how to create a product carbon footprint of 'one night's hotel stay' will be explored and the topic of a GHG inventory must be neglected.

Due to the hotel's complexity and the difficulty to define the boundaries, the LCA and the EIO LCA approach will be used in combination in order to calculate the PCF with the hybrid EIO process analysis LCA method (HEIO LCA), as Mink et al. suggested as well in 'A Definiton of carbon footprint'. The HEIO LCA model analyses the foreground life cycle processes and supports the calculation with background input-output information.[176] As a matter of fact, the idea is quite new and few studies have been established that would provide new information. But especially for complex systems the approach is appropriate and constitutes an alternative way.

> *"The hybrid EIO process analysis LCA method provides a way to exploit the strenghts and overcome deficiencies in each method."* [177]

[176] cf. Suh 2009 {p.221}
[177] Keoleian et al. 2006 {p.141}

In this way it is possible to utilize the detailed information of a process map and to fill emerging gaps with standard data. Especially for the calculation of a 'product carbon footprint' of 'one night's hotel stay' this idea is suitable, although a 'product category rule' would be useful to supply the hotels with information. To compound both approaches means in this case furthermore to combine parts of the 'GHG inventory' and the PCF. This will make the footprint on the one hand easier to calculate, and on the other hand information of the inventory need to be included in the PCF of a hotel.

In practice, however, only one project using the hybrid approach was traceable. This is when a pilot project was performed in 2008 to assemble a GHG account and a product carbon footprint for Choice Hotels Scandinavia. At that time the authors Rønning and Brekke decided that it was best to use a hybrid LCA.

> *"Thus, a hybrid LCA applied in the hotel case could represent a methodological approach which will facilitate a comprehensive overview over the GHG emissions from those sources where data are lacking without the need for detailed data the management will not be able to produce in real life."* [178]

In the following this approach will be used and the best way of assessment will be determined by a few criteria. This implies that I decide if it is possible and reasonable to gather the data through life cycle assessment or if it is more appropriate to use generic data. However, this is only one question in the creation of the PCF. Others are for instance what scope to use and how to treat special sector emissions.

[178] http://gin.confex.com/gin/2009/webprogram/Paper2529.html (2.08.2010)

7. PCF: 'One Night's Hotel Stay'

The 'product carbon footprint' of one night's hotel stay, as recommended in the 'PAS 2050 Guide'[179] is a complex footprint. Since there is no standard method, I will describe my personal idea of a PCF in the hotel sector in the following. Naturally, there are other possible ways of calculation and the proposed method might not correspond with every hotel. In addition, some aspects are not treated elaborately like the kind of purchased energy or energy feeding input of the hotel.

Some organizations downsize the hotels' carbon footprint to the average amount of visitors and thereby calculate the PCF, e.g. Viabono.[180] Though it has inadequacies since it takes the 'product carbon footprint' in strong addiction to the utilization of the hotel and also uses an inventory scope. This means that many guests in a hotel, and therefore a high utilization, lead to a lower PCF. It seems fair, but it has a disadvantage: A hotel with a high utilization and a low eco-standard could result a better PCF than a hotel with a great eco-standard, but with a few guests. This gives a wrong impression of the environmental impact, even though the utilization should be considered, but with an appropriate impact.

To draw the line between product and company, even though they interact, is an important step towards a PCF of a hotel. A good example is the PCF of a sports bag, which includes all emissions occurring during the entire life cycle except the emissions which accrues when the company gets a new roof or the manager travels by airplane. Even though these emissions should be considered in the 'GHG inventory', the PCF of the product must not be affected thereby.

Moreover, the GHG inventory might only consider scope 1 and 2, but the PCF is supposed to consider all life cycle stages. From my point of view it is necessary to create a GHG inventory as well as a PCF. The GHG inventory should cover up all hotel related emissions like energy consumption and maintenance, but also business travels and employee tours, etc. The result may be rated afterwards on the basis of the hotel's size and the utilization .
Beyond that a Product Carbon Footprint should consider emissions only, which are caused directly by the visit of the guest.

[179] cf. British Standards Institution GUIDE 2008 {p.43}
[180] cf. http://www.co2ol.de/Klimaneutrales-Hotel.193.0.html (20.08.2010)

7.1 Process Map

The process map of 'one night's hotel stay' consists of a process, which is embedded in the system hotel, but also runs out of the system vertically. Therefore, the scope and boundaries have to be defined. In this case, the scope determines where we start and stop to measure and analyse the emissions of the process. The boundaries determine how broad the assessment of emissions should be.

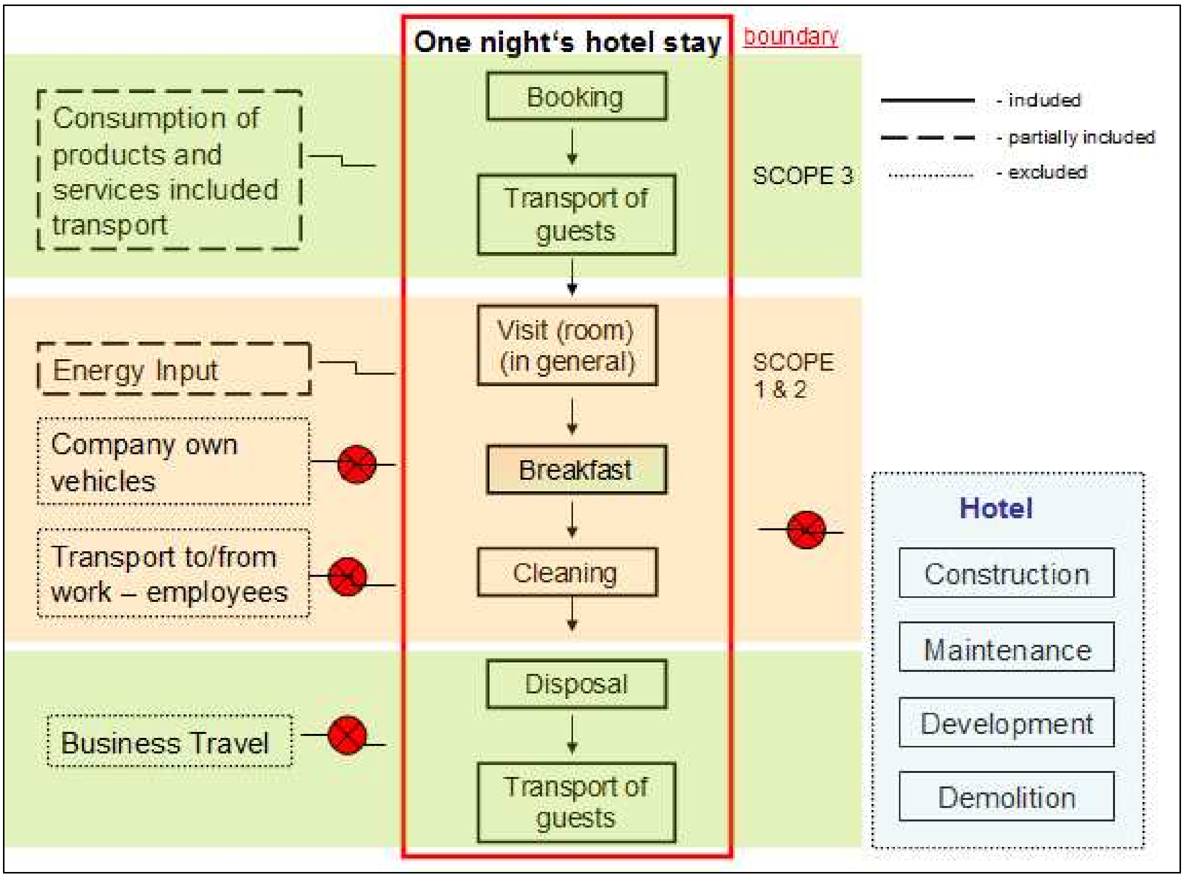

Figure 16: Process map 'One night's hotel stay' [181]

7.1.1 Scope

For the creation of a decent PCF it is necessary to include all stages of the life cycle as shown in figure 16, which consequently mean the scope 1, 2 and 3. The product 'One night's hotel stay' begins in scope 3 with the transportation of the guest. During the hotel stay it takes course over scope 1 and 2 and ends in scope 3 again when the guests travel back home and the waste is disposed . Because the transport is by far the biggest emission source, it is crucial to include scope 3. Most standards disregard this factor because it is variable, even though this variety should not be a problem.

[181] source: own

7.1.2 Boundaries

To determine the boundaries is in the case of a ‘product carbon footprint’ of a hotel more important than usually since the processes interact. In order to reduce complexity the assessment will be done similar to the PCF of other industrial products. This implicates the inclusion of all emissions, which occur in the direct process of ‘One night’s hotel stay’, though it does not include extraordinary hotel emission sources like the construction, maintenance, development and demolition. Furthermore, it is not appropriate to include business travels, company’s own vehicles and the transport of employees to the workplace and back. For instance, if a company, which produces ‘washing powder’ calculates its product carbon footprint, it does not include such emissions either and it only considers direct sources. Of course, indirect emissions are important in the same manner and therefore it is necessary to create a ‘GHG inventory’ next to the PCF.

However, the consumption of products and services inclusive transport should be considered as long as it is used directly for the tourist visit. Moreover, the energy input also has to be included, but only in the correct amount and in dependence of the right energy mix.

7.2 Assessment Criteria

At first it seems like as if the creation of a PCF with a multitude of sources is not possible or at least not economically feasible. Therefore, it is important to decide what information (primary or secondary data, or even assumptions) should or may be used to analyse the different stages and what effort should be undertaken to get these information. The ‘PAS 2050’ suggest five criteria, whereby the decision have to be made.[182]

- Relevance
- Completeness
- Consistency
- Accuracy
- Transparency

From my point of view two of them stand out especially strong in order to decide how to analyse the stages: The relevance and accuray.

<u>Relevance</u> - Most important is the relevance of the emission source. The relevance depends on the amount of emissions created through the source. The more GHG are emitted the more effort should be made.

[182] British Standards Institution 2008 {p.9}

Accuracy - Another important point is the accuracy of the possible data. If secondary data gives evidence to be in detail and to be available it might be a recommendable way to use these data.

In the following all stages of the life cycle will be analysed and it will be decided by the help of the criteria how and if these stages should be considered.

7.3 Life Cycle Stages of 'One Night's Hotel Stay'

7.3.1 Booking

The booking of a hotel room plays a minor role in the overall result. The following survey shows the greenhouse gas share of travel agencies and tour operators, which is below one percent.

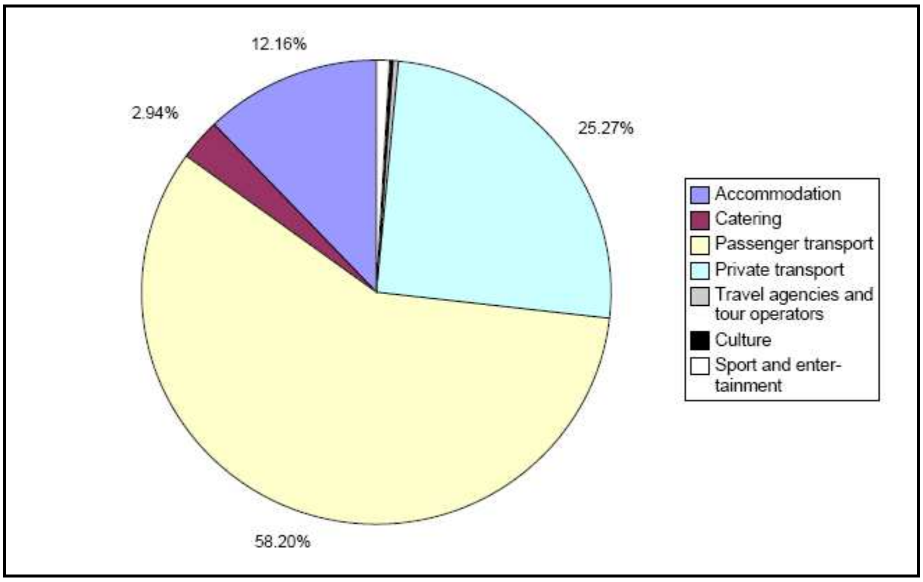

Figure 17: Tourism subsectors' share of greenhouse gas emission in switzerland [183]

It should be considered that many people drive noticeable distances to tourist agencies or spent nights in front of the computer. However, the relevance of this source is low. For a hotelier it is not economically feasible to do a survey about how their customer booked the room, in comparison to the outcome. In this case, standard environmental data would be helpful and could supply all hotels with an average assumption. As long as there are no such data it is advisable not to include this stage.

7.3.2 Transport of Guests

Since the emitted greenhouse gases of the transport of guests have a share of 75 percent or more on the overall emissions of tourism, this source is by far the most relevant.[184] None of

[183] Sesarctic et al. 2007
[184] cf. Scott et al. 2010 {pp.396 ff.}

the described hotel standards include the emissions of transport because they do not feel responsible for these emissions, but some give the customer the chance to calculate the emission and do a compensatory payment.[185]

This source is a sensitive topic. An inclusion of this source would give domestic hotels an advantage and handicap far destination hotels. But to get a real benefit out of the product carbon footprint and not only pretend to look for a solution, it must be included. Moreover, the effort is relatively small. Transport emission calculation tools provide primary data for every guest. They are easy available and it would not be complicated to add such an online tool to the rest of the arising greenhouse gases, whether on the hotel website, in the travel agency or on an independent travel website.

However, with the individual inclusion of this source it is not possible to give an average carbon footprint. For this reason, it would be helpful to illustrate the numbers separately.

7.3.3 Accommodation

The resulting emissions occur mostly through electricity and heating and have to be calculated down to the single guests. From my point of view the total electricity consumption should be divided by the average number of guest and charged that way to the single guest. The reason is that unvisited hotel rooms do not need electricity and therefore the guests only cause energy consumption of which they have a benefit, direct in their room, or indirect, e.g., in the sauna.

However, the energy consumption through heating should be handled differently. The reason is that a hotel needs to heat all rooms, even though they are not occupied. Therefore, the carbon footprint raises artificially since the heated unoccupied rooms do not offer a benefit to any of the guest, unlike the heated floors, etc. For this reason I suggest to calculate the necessary energy consumption of a single room first and afterwards to calculate the general energy consumption which has to be divided by the average number of guest. But the energy consumption of the untenanted rooms are not considered and do not appear in the PCF. To support this approach I will use an accompanying example.

Room:

The energy input of a room can be estimated almost in detail. First it is possible to calculate the necessary energy to heat a single room. This can easily be done by the total demanded energy calculated down to square meters and the size of the room and the number of people who stay in there.

[185] cf. http://www.co2ol.de/co2calc/schindelbruch/index.php (20.08.2010)

For example, if a hotel with 10 rooms has an annual energy consumption of 9.000 litres of heating oil (24.65 l/day) and a total area of 500 square meters the consumption is about 18l/sqm (if only used for heating and not for the water). A room with 20 sqm thereafter needs about 1.0 litres of heating oil a day, as shown in table four.
The amount of energy used due to bathing and showering has to be taken into account, but can be added to the general energy consumption since empty rooms do not need warm water.

The room calculation is the basis of the energy related emissions of the PCF. Now the general energy demand has to be added to the room-specific-one.

General:
Of course, the guests’ visit has to supply a higher energy demand than the required energy of the hotel room itself. Since the guest moves in the hotel, a lot of energy is used to provide the guests with warm floors, maybe a pool, a sauna, etc. From my point of view, it is the best way to calculate the guest’s share of emission is achieved by using the basis of his room.

In the previous example the room needed about one litre a day and the hotel offers ten rooms and each has to be heated no matter if there is a guest or not. This adds up to about 10 litres a day. The total daily consumption of the hotel is about 25 litres, which subtracts down to 15 litres remaining, which are used for the floors, the lobby, the pool and so on.
Now the heating oil share of the single guest may be calculated by help of the hotel’s average utilization. If the hotel offers ten rooms for ten people, but only four rooms are occupied in average, the remaining 15 litres have to be divided by four, resulting in 3.75 litres per guest. These 3.75 litres must be added to the energy consumption of the single room which leading to 4.75 litres in total, which displays the total amount of heating oil a guest consumes.

Hotel X: 10 rooms, 10 persons, Ø 4 guests

Approach	All rooms are calculated individually and the general energy consumption is divided by Ø number of guests	Standard approach – total energy consumption is divided by Ø number of guests
Daily consumption heating oil	25 litres	25 litres
Visitor’s room needs 1 litre/day	- 1 litre	——
9 more rooms always need to be heated	- 9 l	——
Resuming heating oil that needs to be divided by Ø visitors	15 l : 4 = 3.75 l	25 l : 4 = 6.25 l
Plus energy cons. of the single visitors’ room	+ 1 l	+ 0
Result: One visitor causes the consumption of heating oil of:	4.75 l = 11.4 kg CO_2-eq.[186]	6.25 l = 15 kg CO_2-eq.

Table 6: Hotel calculation example - Consumption of heating oil[187]

This calculation approach is presumably the best concerning fairness and accuracy since only emissions, which the single product is responsible for, are contributed to the ‘product carbon footprint’. Consequently, the utilization is still relevant, but does not shape the footprint merely itself. Moreover, this calculation could be performed twice a year, to distinguish between the summer and winter time.The execution of this method will involve a tolerable amount of time and is feasible for everybody.

In addition, a more detailed calculation example is shown in annex.

7.3.4 Breakfast

The energy usage of the breakfast’s preparation should be simply included in the overall energy consumption of the visit, as introduced above.

Food with about 15 to 20 percent of the per capita emission is a highly relevant factor and should be treated that way, even though it is not possible to calculate the exact product carbon footprint of each food product.[188] But the used food can be downscaled to two climate sensitive characteristics: what food it is and where it is from. The origin of the food is not always clear and it is difficult for the hotelier, who might have bought the food at a

186 1 litre heating oil = 2,4 kg CO_2 cf. Buchal 2007 {p.46}
187 source: own
188 cf. Öko Institut e.V. 2010 {p. 39}

wholesaler, to determine the exact origin. In the case of breakfast this point might be no problem since most products accrue from the region and not from oversee. Therefore, the transport emissions do not vary greatly.[189]

Unlike the origin, the kind of food is easy to secure. Even though about two tonnes CO_2-eq. per capita emissions originate from food consumption, most products only have a PCF of a few gramms since the total emissions are partitioned in many thousand products consumed in a year.[190] Therefore it is suggestive to use generic data. For the hotelier it is economically feasible to calculate the amounts of meat, cheese, eggs, bread, etc. The amounts could be measured for one week hence the average data can be calculated. And since there are scientific data available about the average emissions of the different foods it is possible to calculate the emissions of an average breakfast as shown in annex one. For example, cheese is indicated with 8,35 kg CO_2-eq. per kilogram, meat with 5,05 kg CO_2-eq./ kg and bread with 0,78 kg CO_2-eq./ kg.[191]

Thus, the breakfast can be calculated without too much effort and the accuracy of the result will be adequate. A way to increase the eco – balance of the breakfast would be to purchase biological food, which has a lower PCF of about 7 – 17 percent.[192]

7.3.5 Cleaning

The cleanings like vacuum-cleaning should be simply considered to the general energy consumption. Cleaning supplies do not need to be considered in my opinion since their greenhouse gas relevance is not very high and there are no sufficient environmental data about it. However, the cleaning of towels and bed linen should be included, as well as the clothes of employees and tablecloth, etc. This point might be difficult depending on who performs the cleaning. In case the hotel’s washing everything itself the energy consumption will be considered in the general energy input and is charged to the single guest.
In case that the cleaning is outsourced it is very important to include the emissions nevertheless. Of course, primary data of the subcontractor would be desirable, but maybe secondary data has to be used.

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[189] cf. http://www.esu-services.ch/cms/fileadmin/download/jungbluth-2005-BUWAL-ernaehrung.pdf (5.08.2010)
[190] cf. Öko Institut e.V. 2009 {p.31}
[191] cf. Öko – Institut e.V. 2008 {p.6}
[192] cf. Öko Institut 2010 {p.42}

7.3.6 Water

Water goes through an extensive, energy-consuming purification process before reaching the hotel and afterwards the waste-water and sewage needs to be recycled again.

> *"And for the production of drinking water, and treatment of sewerage and wastewater energy is required and GHG are released."* [193]

Besides, waste-water treatment can produce energy through bio-gas production, which needs to be accounted in the total GHG emissions. The total global warming potential of water for households consists of 'drinking water' (0,36 kg CO_2-eq./m^3), 'sewage' (0,07 kg CO_2-eq./m^3) and 'waste-water' (1,07 kg CO_2-eq./m^3) and is calculated by Frijns et al. to be about 1,5 kg CO_2-eq./m^3 water.[194] Therefore, one liter water causes circa 1,5 g CO_2-eq. The average daily German per capita water consumption is about 126 liter,[195] which results in 189 g CO_2-eq./ day. This amount is relatively low compared to the total GHG emission of 'One night's hotel stay'. For this reason, the use of environmental data is recommended. The most rational approach would be the division of the total water usage by the average utilization.

7.3.7 Disposal

As it is described in the chapter three, the disposal of waste through combustion creates greenhouse gases. However, it creates energy in a way that is more climate friendly than through the combustion of other fossil fuels. Accordingly, the combustion of waste might even give a carbon dioxide credit. This depends on the exact method and the accompanied transports. Since it would be a great expense to calculate the exact emissions and besides the expected revenue is presumably low, it is advisable not to take these emissions or credits into account.

7.4 Conclusion 'One Night's Hotel Stay'

If the PCF includes the main emission sources of the entire life cycle it has the ability to inform the customer in an economically feasible way about the climate impact of the product 'One night's hotel visit'. A disadvantage of the PCF concerns that many other emission sources like the maintenance of the hotel or business trips must be neglected since they would overload the balance. For this reason, it is essential to create also a GHG inventory regarding all three scopes.

During the assessment process the hotel manager should always have the ambition to use primary data and minimize assumptions and estimations. Furthermore, an approach should

[193] Frijns et al. 2010 {p.72}
[194] cf. Frijns et al. 2010 {p.78}
[195] cf. http://www.hydrologie.uni-oldenburg.de/ein-bit/11686.html (20.08.2010)

be applied that does not raise the PCF artificially because it depends too much on the average utilization.

Finally, a check up of an independent inspector would be adjuvant and an annual recalculation is required to secure the transparency of the assessment process and a trustworthy external communication. Moreover, a product category rule is necessary to define the exact boundaries for all hotels since a carbon footprint is much more helpful if it is comparable.

However, other environmental impact categories like eutrophication, land use or acidification should not be neglected.

Conclusion

Global warming will continue to be a leading topic in economy and the significance of the carbon footprint will presumably rise in future as more and more people try to influence the anthropogenic greenhouse effect by their personal behavior.

The carbon footprint derived from the ecological footprint and has been characterized by several organizations, in particular the World Resources Institute and the British British Department for Environment, Food and Rural Affairs as described in chapter 1. By now the 'carbon footprint' is commonly defined as the total GHG emissions caused directly and indirectly by an individual, event or product and is expressed in CO_2-eq. Besides the national GHG inventory, the 'GHG inventory' for companies and the 'product carbon footprint' are the most relevant carbon footrpints in the economy. Like I described in section 2 both footprints are based on the same fundamentals, even though there are still many ambiguities and liberties, e.g., in the scope. The risks associated with carbon footprinting like greenwashing and burden shifting are respectable and should not be disregarded. But on the other hand the carbon footprint gives the opportunity to gather attention throughout the population for environmental awareness.

With the objective to combine the methodological foundations of the 'GHG inventory' and the PCF in order to create a 'product carbon footprint' of a hotel's stay I discussed the different methodologies in chapter 3 and 4. In particular, the PCF was illustrated in a full discreption since this footprint is still under development. The section showed that it is in parts very ambitious to create a detailed PCF and several problems may occur. Moreover, I concluded that 'product category rules' are a necessary tool to achieve the aim, even though a generic footprint poses a risk. The used method is the life cycle analysis (LCA), in which every stage 'from the cradle to the grave' is analysed.

In contrast, the 'GHG inventory' deploys an environmental input-output life cycle analysis (EIO LCA) which uses process based information as well as standard economic input-output tables and environmental information. The greatest uncertainties occur due to the implementation of scopes and boundaries, e.g., the emitted greenhouse gases of scope 3 are in general the highest, but companies are free to decide whether they want to include these emissions in their 'GHG inventory' or not.

In section 5 I introduced the interacting system climate and tourism. We have seen that tourism has a great impact on the climate, especially through transports, but is impacted as well by the climate since the system functions as a ‘two-way-street’.[196] For this reason, and to improve its image, tourism needs to find a sufficient strategy of carbon reduction. One possibility may be the PCF of ‘One night’s hotel stay’. Section 6 took a look on existing projects that create GHG inventories and PCF for hotels. Thereby their approach was examined and the hybrid EIO LCA approach was suggested. This methodology analyses the foreground life cycle processes and supports the calculation with background information, whenever primary data is not available or the data gathering is too time-consuming to be economically feasible.

The example of ‘One night’s hotel stay’ in chapter 7 discussed the practical approach of a PCF in the hotel sector. The example showed that it is possible to create a PCF for a hotel stay, but that some points must be neglected in order to make it practicable. Moreover, it became clear that a ‘product category rule’ is necessary to define the exact boundaries. Next to the PCF a ‘GHG inventory’ is required to include all emission sources.

In conclusion the ‘carbon footprint’ appears to have a high potential but at the same time many difficulties. However, the future launch of the ISO standard 14067 ‘Carbon Footprints of Products’ around March 2011 will presumably help to establish a basis for the uniform quantification of GHG emissions associated with goods and services. Until then it is reasonable to conform to the ‘PAS 2050’ standard or the ‘GHG protocol’, whereby the World Resources Institute will publish a ‘Product Life Cycle Accounting and Reporting Standard’ in December 2010.

For the service sector it is necessary that the ISO standard 14067 will also provide a sufficient basis for GHG accounting in services, which defines the scope and boundaries to establish comparability. In the tourism sector a convincing strategy is needed to deal in an appropriate context and manner with the challenge of climate change. The PCF of ‘One night’s hotel stay’ may be one way towards sustainable tourism, but will only have an influence if the transportation’s of the guests are considered.

Moreover, the CF poses the risk of neglecting other environmental impact categories. This challenge needs to be dealt with to beware the PCF of the reputation as no more than a marketing tool.

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[196] cf. Peeters 2008 {p.12}

Annex – Calculation Example

In the following example the PCF of 'One night's hotel stay' is calculated. The used approach considers merely the guests' room and the general energy consumption. Therefore, the other hotel rooms are pulled out of the calculation and the resuming general consumption is divided by the average utilization.

For the calculation example merely a choice of products are considered and assumptions are used. Moreover, the creation of a serious PCF requires primary data about the energy mix.

Hotel X (rooms: 10, possible guests: 10, total area: 500 sqm)

	Heating Oil		**Electricity**
Annual consumption	9000 litre	Annual consumption	10.000 kWh
Daily consumption	25 litres	Daily consumption	24 kWh
Guest's room needs on a day	- 1 litre	Guests consumes energy through The room: - Light, tv, hairdryer, telephone, radio, etc. In general: - Cleaning (incl. Towels etc.), lights, reception, cooking, tv's, pc's, etc.	
9 more rooms always need to be heated	- 9 l		
Resuming heating oil needs to be divided by Ø no. guests	15 l : 4 = 3,75 l		
Plus energy cons. of the single visitors' room	+ 1 l	electricity needs to be divided by Ø no. guests	24 : 4
Result: One visitor causes the heating oil consumption of:	= 4,75 l	Result: One visitor causes the electricity consumption of:	= 6 kWh
Emissions per guest	**11,4** kg CO_2-eq.[197]	Emissions per guest	**5,93** kg CO_2-eq.[198]

Water

Annual consumption	190.000 litres
Daily consumption	520,5 litres
Water divided be Ø no. guests	520,5 l : 4
Result: One visitor causes the water consumtion of	130,1 litres
Emissions per guest	**0,195** kg CO_2-eq.[199]

[197] 1 litre heating oil = 2,4 kg CO_2 - - cf. Buchal 2007 {p.46}
[198] (e.g. coal-fired power plant)1 kWh = approx. 0,86 kg CO_2 - - cf. Nestmann 2001 {p.105}
[199] 1,5 kg CO_2-eq./m^3 water - - cf. Frijns et al. 2010 {p.78}

Breakfast [200]

Food	Global Warming Potential (CO_2-eq kg/kg)	Kg usage in one week	CO_2-eq kg in one week
Meat	5,05	2,4	12,12
Cheese	8,35	2	16,7
Eggs	1,95	1	1,95
Bread	0,78	4	3,12
Yogurt	1,24	1,4	1,74
Butter	23,6	,4	9,44
Fruits	0,46	2,5	1,15
Jam	1,14	,6	,68
Juice	1,61	10	16,1
Milk	0,89	10	8,9
Total emissions			71,9
Total Ø guests in one week			28
Emissions per guest			2,57 kg CO_2-eq

Average CO_2-eq. emissions per guest without transportation:

Heating oil	11,4 kg
Electricity	5,93 kg
Water	0.2 kg
Breakfast	2,6 kg
Total	20,13 kg

+ [201]

Individual means of transportation	CO_2-eq. emission in kg / km per Guest	Guest total transportation distance	Resulting emissions CO_2-eq.
Airplane	0,38	0	
Car	0,15	240	36
Train	0,04	0	
Bus	0.02	0	

Total guest emissions of 'One night's hotel stay'

20,13 + 36

= **56,13** kg CO_2-eq.

[200] merely some products, based on: Öko – Institut e.V. 2008 {p. 6}
[201] cf. http://www.co2-emissionen-vergleichen.de/verkehr/CO2-PKW-Bus-Bahn.html#CO2-PKW-Flugzeug-Bus-Bahn (8.08.2010)

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Oldenburg, 23.08.2010