A Classification of Carbon Footprint Methods Used by Companies

by

Suzanne L. D. Andrews

M.Sc. Industrial Engineering (Specialty in Quality and Productivity Systems)
Instituto Tecnológico y de Estudios Superiores de Monterrey, 2006

Submitted to the Engineering Systems Division in Partial Fulfillment of the Requirements for the Degree of

Master of Engineering in Logistics

at the

Massachusetts Institute of Technology

June 2009
© 2009
Suzanne Andrews
All rights reserved.

The author hereby grants to MIT permission to reproduce and to distribute publicly paper and electronic copies of this document in whole or in part.

Signature of Author

Master of Engineering in Logistics Program, Engineering Systems Division
May 27, 2009

Certified by.

Dr. Chris Caplice
Executive Director, Center for Transportation and Logistics
Thesis Supervisor

Accepted by...

Prof. Yossi Sheffi
Professor, Engineering Systems Division
Professor, Civil and Environmental Engineering Department
Director, Center for Transportation and Logistics
Director, Engineering Systems Division
Abstract

The percent increase in greenhouse gas (GHG) concentration in the atmosphere can be harmful to the environment. There is no single preferred method for measuring GHG output. How can a company classify and choose an appropriate method? This thesis offers a classification of current methods used by companies to measure their GHG output.
Acknowledgements

I would first like to thank my Lord and Savior, Jesus Christ, for blessing me with the opportunity to study at the Massachusetts Institute of Technology, specifically within the Master of Engineering in Logistics Program (MLOG). I would also like to thank my husband, Laurence Andrews, and my parents Dr. and Mrs. Dennis Minott for being my support network during my time here.

Next, I would like to thank Dr. Chris Caplice, Executive Director of MLOG who, in addition to accepting me into the program, also awarded me an International Logistics Fellowship. Late in the game, he became my thesis advisor and this thesis has benefited greatly from his advice.

Finally, I would like to thank Dr. William Haas for being my unofficial thesis co-advisor. He showed me how to more efficiently self-edit, which I hope is evident in this thesis.
Table of Contents

Abstract ......................................................................................................................... 2

Acknowledgements .................................................................................................... 3

Table of Contents .................................................................................................... 4

List of Tables ............................................................................................................ 7

List of Figures .......................................................................................................... 8

Chapter 1 Introduction ............................................................................................. 9

1.1 Definition of Terms ........................................................................................... 9

1.2 Global Warming: Constraint or Opportunity? ................................................ 11

1.3 Concerns with Carbon Footprint Methods ..................................................... 13

1.4 Motivation of Thesis ......................................................................................... 13

Chapter 2 Literature Review ................................................................................... 14

2.1 Carbon Footprint Methods Used by Companies ............................................. 14

2.2 The Emphasis on the Carbon Footprint of Products ....................................... 15

2.3 Research Question 1: Concerns about Corporate and Product Carbon Footprint Methods ................................................................. 17

Chapter 3 Methodology .......................................................................................... 21

Chapter 4 Data Analysis and Results ........................................................................ 22

4.1 Online Carbon Footprint Calculators .............................................................. 23
Appendices – Carbon Footprint Calculators

A Individual/Household ................................................................. 56
B Features of Individual CF Calculators ........................................... 57
C Industry ...................................................................................... 58
D Corporate/Office .......................................................................... 58
E Product ....................................................................................... 59
List of Tables

Table 2.1: Only Cited ‘Official’ Corporate CF Method......................................................14

Table 2.2: Several Cited Product CF Methods.....................................................................15

Table 4.1: Comparison of “Simple Inputs” vs. “Detailed Inputs”.........................................23

Table 4.2: Approaches to Gathering Data..............................................................................28

Table 4.3: Benefits and Costs of the GHG Protocol and PAS 2050.................................39

Table 4.4: BHD GHG Emissions According to the GHG Protocol....................................41

Table 4.5: BHD GHG Emissions According to PAS 2050..................................................41
List of Figures

Figure 1.1: Projected Changes in Global Temperature.........................................................10
Figure 1.2: Global GHG Emission by Gas (2000).................................................................11
Figure 2.1: Release Dates of Product CF Methods...............................................................16
Figure 2.2: Corporate vs. Product CF Methods.................................................................17
Figure 4.1: Bringing Home the Dough.............................................................................22
Figure 4.2: Organizational and Operational Boundaries of a Company..............................26
Figure 4.3: Overview of Emissions and Scopes across a Supply Chain...............................27
Figure 4.4: GHG Protocol Classification...........................................................................31
Figure 4.5: GHG Emissions across a Supply Chain.........................................................32
Figure 4.6: Comparison of Company-by-Company and Supply Chain Analyses...............34
Figure 4.7: B2C and B2B Boundaries..............................................................................35
Figure 4.8: PAS 2050 Classification.................................................................................38
Figure 4.9: A Loaf of BHD Wheat Bread.....................................................................36
Figure 4.10: Product Emissions across the Supply Chain............................................37
Figure 4.11: Life Cycle Stages of a Mobile Phone.......................................................38
Figure 4.12: Where the GHG Protocol and PAS 2050 Overlap......................................40
Chapter 1 - Introduction

Global warming and the reduction of carbon dioxide emissions are at the top of the environmental policy agenda today (Weidema et al., 2008). From an organizational perspective, some of the trends that have dramatically increased their respective profiles include: science and policy initiatives that have called for more aggressive action in stabilizing carbon dioxide emissions in the future; growing public and media interest in the need for alternative and renewable energy for security and environmental reasons; and increasing concern from financial institutions about the potential risks that an organization may face in a carbon-concerned future (Bennett, 2007). In this chapter, I first define what is meant by the terms carbon footprint, greenhouse gases, greenhouse effect and global warming. I then show how global warming, although initially considered a constraint for companies, is now being viewed as a source of opportunity. In order to realize this opportunity, companies need to first understand how to measure their carbon footprints. Given that some concerns exist with these methods, I conclude this chapter by highlighting these concerns and stating the motivation for this thesis.

1.1 Definition of Terms

In the specific context of organizations, The Carbon Trust (2006) defines a carbon footprint as the total amount of greenhouse gas (GHG) emissions for which an organization is responsible. Gases such as carbon dioxide, methane, nitrous oxide and halocarbons are called greenhouse gases (GHGs). They serve to absorb and reradiate the sun’s energy. This phenomenon is referred to as the greenhouse effect. It serves to keep the earth 33°C (60°F) warmer than it would otherwise be. However, as concentrations of these GHGs increase, this warming effect also increases (Pew Center on Global Climate Change). This warming effect is referred to as global...
warming. Figure 1.1 shows the projected changes in global temperature using estimates from the Intergovernmental Panel on Climate Change (IPCC).

![Projected changes in global temperature: global average 1856-1999 and projection estimates to 2100](image)

**Figure 1.1:** Projected Changes in Global Temperature (Source: United Nations Environment Program)

According to Nordhaus (2008), higher concentrations of GHGs lead to increased surface warming of the land and oceans. Such intense warming is now resulting in climate changes, such as temperature extremes, storm location and frequency. These changes may have profound impacts on biological and human activities that are sensitive to climate. Nordhaus (2008) further adds that global warming is a serious, perhaps even a grave, societal issue. He states that, of all the greenhouse gases, carbon dioxide represents the largest problem because the burning of fossil (or carbon-based fuels) such as coal, oil and natural gas leads to emissions of carbon dioxide at faster
levels and greater accumulation in the earth’s atmosphere than other greenhouse gases. Figure 1.2 illustrates that carbon dioxide is the most concentrated GHG, as of 2000.

![Pie chart showing global GHG emissions by gas (2000)](image_url)

**Figure 1.2:** Global GHG Emissions by Gas (2000) (Source: World Resources Institute)

Hawken et al. (1999) also offer that scientific analysis of bubbles in the Vostok ice core from Antarctica show that carbon dioxide in the atmosphere is at the highest level in 420,000 years and that global temperatures in the next century are expected to exceed a 10,000-year record.

1.2 Global Warming: Constraint or Opportunity?

With these findings of Nordhaus (2008) and Hawken et al. (1999), it is understandable that discussions of global warming and its effect on organizations have often focused on the downside of carbon dioxide emissions controls, labeling them as constraints. However, today, that perspective is changing (Bennett, 2007 and Lash and Wellington, 2007). According to the
Greenhouse Gas Protocol Corporate Standard, which provides standards and guidance for companies and other organizations preparing a greenhouse gas (GHG) emissions inventory, many businesses, ranging from the automobile to the mining industries are voluntarily participating in GHG emissions inventories.

The Business Standards Institute (BSI) encourages these businesses to undertake inventories of their greenhouse gas emissions in order to improve their corporate image and attract capital investment. Lash and Wellington (2007) also cite the following risks that can be transformed into opportunities: regulatory, product and technology, litigation, physical and supply chain. As companies assess their susceptibility to regulations, with supply chain risk, in particular, Lash and Wellington (2007) recommend that they should evaluate the vulnerability of their suppliers. This could lead to higher component and energy costs as suppliers pass along increasing carbon-related costs to their customers.

For example, auto manufacturing relies heavily on suppliers of steel, aluminum, glass, rubber and plastics, all of which are likely to be seriously affected by emissions regulations, or – as in the case of aluminum manufacturing, a big consumer of energy – by regulations on their supplier’s supplier. Lash and Wellington (2007) further offer that a company should take into account the geographical distribution of its supplier network. Executives should be made aware of how many of their suppliers operate in, say, the European Union, where regulatory structures are already in place. In addition, executives must be mindful that the other aforementioned risks could affect not just their companies, but their suppliers as well. Since a company can only manage what it measures, both Bennett (2007) and Lash and Wellington (2007) urge that any carbon emissions risk management strategy needs to begin with the company measuring its carbon footprint.
1.3 Concerns with Carbon Footprint Methods

In its measurement of the carbon footprint (CF) of an organization, the *Greenhouse Gas Protocol Corporate Standard* notes that it establishes organizational boundaries, in terms of equity share and control and operational boundaries, in terms of processes, products and services. However, authors like Wiedmann and Minx (2007) and Matthews et al. (2008) have raised methodological concerns about these organizational boundaries. They also question the completeness and robustness of these measurements. In particular, Matthews et al. (2008) recommend that an organization should not only measure its own CF, but also the CF that it shares with other companies within a product's supply chain. They caution that to do otherwise could generally lead to large underestimates of greenhouse gas emissions for products and services. They further warn that without a full knowledge of their carbon footprints, companies will be unable to pursue the most cost-effective mitigation strategies.

1.4 Motivation of Thesis

I am therefore motivated in this thesis to review and classify the methods by which companies measure their carbon footprints. In Chapter 2, I explore the literature in order to identify these methods. I then answer the first research question, which is: What are some of the concerns raised in the literature about these CF methods? In Chapter 3, I discuss the methodology by which I classify these methods. In Chapter 4, I present and discuss the classification of these methods and answer the second and third research questions, which are: What are the benefits and costs of using each method? What are the tradeoffs? In Chapter 5, I conclude this thesis and illustrate some of the long-term ramifications for a company, given the particular CF method that it chooses.
Chapter 2 - Literature Review

The recent trends discussed in Chapter 1 have been the basis upon which companies are currently looking for methods that would give them the best indication of their respective carbon footprints. In this chapter, I review the literature to learn some more about these methods. I then answer the first research question which is: What are some of the concerns in the literature concerning these CF methods?

2.1 Carbon Footprint Methods Used by Companies

East (2008) and Wiedmann and Minx (2007) note that the majority of publications that cover the issue of carbon footprint methods is coming from “grey” (popular) rather than scientific literature. This was also my observation. I therefore resorted to entering the keywords “company”, “carbon footprint” and “method” into the Google and Google Scholar search engines. The only method that resulted was the Greenhouse Gas Protocol Corporate Standard (GHG Protocol). In Table 2.1, I list where and how many times this standard was mentioned as the ‘official’ corporate carbon footprint method.

<table>
<thead>
<tr>
<th>Corporate CF Method</th>
<th>Source</th>
<th>Frequency of Citation</th>
</tr>
</thead>
</table>
2. Matthew et al. (2008)  
5. British Standards Institute  
6. www.learnaboutcarbon.net  
7. www.bestfootforward.com | 7 times |

Table 2.1: Only Cited ‘Official’ Corporate CF Method
I use the word ‘official’ since authors like Lash and Wellington (2007) have noted that the GHG Protocol has been taken up by the International Organization of Standardization (ISO) and has been used by several hundred companies to measure and track their greenhouse gas emissions.

2.2 The Emphasis on the Carbon Footprint of Products

From a supply chain management perspective, finding only one ‘official’ CF method used by companies was very surprising. I therefore decided to enter the keywords “supply chain”, “carbon footprint” and “method” into the Google and Google Scholar search engines. I also entered these keywords into ProQuest, which is a database of multiple scientific journals. Several ‘product’ CF methods surfaced. In Table 2.2, I list where and how many times these product CF methods were mentioned.

<table>
<thead>
<tr>
<th>Product CF Method</th>
<th>Source</th>
<th>Frequency of Citation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. <a href="http://www.learnaboutcarbon.net">www.learnaboutcarbon.net</a></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. <a href="http://www.bestfootforward.com">www.bestfootforward.com</a></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. wwwpcf-projekt.de</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. PE International</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. British Standards Institute</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Weidema et al. (2008)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. SETAC Europe (2008)</td>
<td></td>
</tr>
<tr>
<td>GHG Protocol’s Product and Supply Chain Initiative</td>
<td>1. <a href="http://www.learnaboutcarbon.net">www.learnaboutcarbon.net</a></td>
<td>4 times</td>
</tr>
<tr>
<td></td>
<td>2. <a href="http://www.bestfootforward.com">www.bestfootforward.com</a></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. wwwpcf-projekt.de</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. PE International</td>
<td></td>
</tr>
<tr>
<td>ISO 14067 (Carbon Footprint of Products)</td>
<td>1. <a href="http://www.learnaboutcarbon.net">www.learnaboutcarbon.net</a></td>
<td>3 times</td>
</tr>
<tr>
<td></td>
<td>2. wwwpcf-projekt.de</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. PE International</td>
<td></td>
</tr>
<tr>
<td>ISO 14064 (GHG Emissions Inventories and Verification)</td>
<td>1. Weidema et al. (2008)</td>
<td>3 times</td>
</tr>
<tr>
<td></td>
<td>2. British Standards Institute</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. <a href="http://www.bestfootforward.com">www.bestfootforward.com</a></td>
<td></td>
</tr>
<tr>
<td>Project Carbon Footprint (PCF)</td>
<td>1. wwwpcf-projekt.de</td>
<td>2 times</td>
</tr>
<tr>
<td></td>
<td>2. PE International</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.2: Several Cited Product CF Methods
Evidently, there were more methods focused on measuring and reducing greenhouse gas emissions of particular products, as opposed to companies (East, 2008). What was also interesting was that, of these product CF methods, only PAS 2050 was currently available, at the time of writing this thesis (see Figure 2.1).

**Figure 2.1:** Release Dates of Product CF Methods (Source: PE International)

The literature review indicates that companies have been using both the GHG Protocol Corporate Standard and the PAS 2050 to measure their carbon footprints. The former has been used to measure the specific footprint of a particular company, while the latter has been used to measure the carbon footprint of a company, in terms of its contribution to the development of a product within a supply chain. Figure 2.2 notes the difference between corporate and product carbon footprint methods.
Corporate footprint:

Product footprint

Product / Service Range

Upstream ➔ Organisation ➔ Downstream ➔ Use, Disposal

Figure 2.2: Corporate vs. Product CF Methods (Source: The Carbon Trust)

2.3 Research Question 1: Concerns about Corporate and Product CF Methods

Finkbeiner (2009), Rich (2008), Matthews et al. (2008), Wiedmann and Minx (2007) and Johnson (2008) are some of the authors expressing concern about corporate and product CF methods. Below, I detail some of their concerns:

Scope of Emissions:

Shall all GHGs specified by the IPCC or only the GHG Gases of the Kyoto Protocol be considered? The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change. The major feature of the Kyoto Protocol is that it sets binding targets for 37 industrialized countries and the European community for reducing greenhouse gas (GHG) emissions. (United Nations Framework Convention on
Climate Change). How would emissions between multiple suppliers, products and companies be allocated?

Life Cycle Stages:

While a general understanding is that CF methods consider all stages of a product, from raw materials to end-of-life, the inclusion of the use phase might be controversial between business-to-business and business-to-consumer perspectives. If included, how can use phase profiles be defined in a meaningful way? How would downstream emissions (e.g. product transport, product use and disposal) be accounted?

System Boundaries:

How would cut-off criteria be specified? How would employee transport be considered? How would time boundaries be considered, especially for agricultural products?

Offsetting:

Shall offsetting be included in the calculation or not? Offsetting provides a mechanism to reduce GHG emissions in the most cost-effective and economically-efficient manner (www.carbonfootprint.com). Is the use of renewable energy a type of offsetting or not?

Data:

Which data sources will be used? What will be the share between primary activity data and secondary data? PAS 2050 defines primary data as direct measurements made internally or by someone else in the supply chain about the specific product’s life cycle. It also defines secondary data as the external measurements that are not specific to the product, but rather represent an
average or general measurement of similar processes or materials (e.g. industry reports or aggregated data from a trade association). Are any operational data quality requirements possible? How much of the supply chain will be considered? Would actual data from suppliers versus generic data be collected? What level of accuracy is needed? For multinational companies, in particular, how would GHG data from suppliers worldwide be collected? How would the issue of confidentiality be handled where data has to be exchanged between suppliers and customers? How would consistent data reporting and verification along the supply chain be ensured?

End-of-life:

How would end-of-life scenarios be defined? This is because some products can be used as inputs to multiple final products with widely divergent use and disposal characteristics (e.g. aluminum can be used in drink cans or airplanes).

Carbon Capture and Storage:

How would carbon capture and storage be treated? Carbon capture and storage, or CCS, involves burying the carbon dioxide deep underground (www.economist.com).

Land Use Change:

Shall emissions arising from direct land use change be included or not? Shall changes in soil carbon be included or not?
Capital Goods:

How will capital goods be treated? Capital goods are goods used for the purpose of producing other goods. They would include items such as industrial buildings, equipment and heavy machinery (www.inverstorglossary.com).

Finkbeiner (2009), SETAC Europe (2008) and Weidema et al. (2008) are concerned that if corporate and CF methods do not address the aforementioned methodological issues, oversimplification may misguide stakeholders on the environmental implications of companies and their products and thereby lead to counterproductive results for the environment. This, they say, is especially true in the case where the evaluation is limited to a single indicator, such as global warming and disregards other potential environmental impacts such as acidification, summer smog and ozone layer depletion. Nevertheless, they all agree that these carbon footprint methods, despite their limitations, are meaningful ways for mitigating global warming, a major environmental concern. Specifically, Weidema et al. (2008) offer that CF methods, more than any other that has been suggested to reduce global warming, have been able to capture the attention of the public and orient it to product life cycle thinking. As a consequence, an overwhelming abundance of websites – some even government-sponsored – exist to calculate a person’s impacts, in terms of what they consume, and offer suggestions for offsetting emissions.

In Chapter 3, I therefore explain the methodology by which I classify the methods used by companies within the supply chain to measure their CF, in order to decipher what these CF methods currently include and exclude. I also go a step further and analyze the carbon footprint methods used by, not only companies, but also individuals, households, industries, offices and products, given their apparent abundance online.
Chapter 3 - Methodology

Based on the review of the literature that was conducted in Chapter 2, I found only two CF methods that companies officially use to measure their carbon footprints: the GHG Protocol Corporate Standard (GHG Protocol) and the British Standards Institute’s PAS 2050. The GHG Protocol contained a suite of calculation tools, whereas PAS 2050 did not. The Industrial Biotechnology Innovation and Growth Team (IB-IGT) defines a carbon footprint method as a guidance manual, and contrasts it with a tool for calculating carbon footprints. With this distinction in mind, I then decided to research these CF calculation tools (calculators), in addition to these CF methods, in order to get a sense of how the methodologies behind these calculators work. This I did, already knowing that the majority of methodologies for these calculators were not standardized (Padgett et al., 2008 and Kenny and Gray, 2008).

Given the lack of standardization, I specifically sought to select calculators that were recommended by one or more of the following: government department, non-governmental organization, state energy agency, state environmental agency, accredited academic institution, leading consulting firm and leading academic/scholarly journal. This is similar to the selection criteria used by Kenny and Gray (2008) and Padgett et al. (2008) in their respective studies on carbon footprint calculators.

I also broadened my search in order to consider all of the methodologies, used by companies, as well as individuals, households, industries, offices and products. I considered these methods over a six-week period. Researching these methods gave me a sense of what carbon footprint methods, in general, are measuring. The differences among these methods are what I used to build the classifications that appear in Chapter 4.
Chapter 4 – Data Analysis and Results

In this chapter, I briefly describe the methods behind the carbon footprint calculators that I found online. I then detail and classify the methods behind, specifically, the carbon footprint calculators used by companies. To aid in the explanation of this classification, I have created a fictional bread manufacturing company, entitled, Bringin’ Home the Dough (BHD). The values used to demonstrate the calculation of BHD’s carbon footprint have been chosen for their simplicity to make the calculation as easy as possible to follow. BHD produces two types of bread: wheat and rye. Wheat bread is its faster-selling product. BHD is located in Wellesley, MA, where it operates out of a two-story building which it owns (see Figure 4.1). Its bread-making facility and storefront are housed on the first floor, while its corporate office is housed on the second floor. BHD employs twelve people: four bakers (who work in the baking facility), two servers and two cashiers (who work in the storefront) and one accountant, two sales representatives and one manager (who work in the office). A year ago, BHD purchased a one-story building in Cambridge, MA, for future expansion purposes. However, in the meantime, it has leased this one-story building to another organization.

![Figure 4.1: Bringin’ Home the Dough (BHD) (Source: Barbados Photo Blog)](image)
Finally, I answer the second and third research questions, which are: What are the benefits and costs of each of these methods? What are the tradeoffs?

4.1 Online Carbon Footprint (Carbon) Calculators

Over a six-week period, I found seventy-six carbon calculators online. Fifty-two were used to calculate the carbon footprints of individuals and households. Twelve were used to calculate the carbon footprints of industries. Ten were used to calculate the carbon footprints of companies and offices. Companies were described as being involved in the manufacturing of a product and offices were described as being service-oriented (GHG Protocol). Finally, two were used to calculate the carbon footprints of products. Lists of carbon calculators by type, and some of their features, appear in the Appendices.

4.1.1 Individual/Household

Typically, these methods asked for two levels of inputs — simple or detailed. For example, Table 4.1 compares Home Energy Saver’s single heating and cooling inputs with its detailed inputs.

<table>
<thead>
<tr>
<th>Major End-Use</th>
<th>Simple Inputs Level</th>
<th>Detailed Inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating and Cooling</td>
<td>• City with similar climate&lt;br&gt;• House construction year&lt;br&gt;• Conditioned floor area&lt;br&gt;• Stories above ground level&lt;br&gt;• Orientation&lt;br&gt;• Foundation type&lt;br&gt;• Ceiling/floor/wall insulation&lt;br&gt;• Heating/cooling equipment</td>
<td>Approximately 80 additional questions about house shape and size; exterior shading; airtightness; foundation and floor; walls, doors and windows</td>
</tr>
</tbody>
</table>

Table 4.1: Comparison of “Simple Inputs” vs. “Detailed Inputs” (Source: Home Energy Saver)
As Padgett et al. (2008) note, the major categories for individual/household carbon footprint calculators were *electricity use* and *transportation*. They were also *country-* and *location-* specific.

4.1.2 Industry

Five of the twelve industry CF calculators found were considered adaptable to the vegetable industry. They either employed *static, spreadsheet-based* approaches or *dynamic, process-based* models that captured the flow and stock of carbon dioxide. However, Lisson (2008) notes that, individually, those calculators did not appear suitable for immediate application to the vegetable industry. Furthermore, investment was required to address their scientific, design and operational limitations.

The remaining seven CF industry calculators spanned the aluminum, cement and steel industries and were based on the GHG Protocol. The GHG Protocol required companies within each industry to add up their respective carbon footprints, in order for an industry-wide carbon footprint to be calculated. It was therefore more beneficial to look at the corporate CF calculators and their respective methods.

4.1.3 Corporate/Office

Nine out of the ten corporate/office calculators were based on different methods. These methods were very similar to the individual/household methods and were primarily aimed at calculating the carbon footprints of offices. They enquired about each office’s electricity use and the amount of travel (air, road or rail) made by their employees. However, the sole remaining corporate calculator (a suite of calculators) was based on the GHG Protocol. This suite of calculators was
appplicable to manufacturing companies. In the next sub-section, I present the results of my
analysis of how the GHG Protocol classified what it needed from a manufacturing company (with
a corporate office) in order to measure its carbon footprint.

4.2 GHG Protocol Boundaries

The GHG Protocol first establishes two types of boundaries: organizational and operational. An
organizational boundary is determined based on the extent of an organization’s equity share and
control. The equity share reflects economic interest, which is the extent of rights a company has
to the risks and rewards flowing from it. Under the control approach, a company accounts for
100 percent of the GHG emissions from operations over which it has control. In the case of our
fictional company, BHD owns two buildings. However, in order to measure its particular GHG
output, BHD has decided to only include the two-story building that houses its bread-making
facility and corporate office, since the one-story building houses another organization. With this
organizational boundary established, BHD then considers the ways in which its bread-making
facility and corporate office generate GHG emissions. This would constitute its operational
boundary.

The GHG Protocol determines an operational boundary by identifying emissions associated with
a company’s operations. These emissions are categorized as direct or indirect. Direct GHG
emissions are emissions from sources that are owned or controlled by the company. Indirect
GHG emissions are emissions that are consequences of the activities of the company but occur at
sources owned or controlled by another company. What is classified as direct and indirect
emissions is dependent on the organizational boundaries (determined by either equity or control).
Figure 4.2 shows the relationship between the organizational and operational boundaries of a
company.
Continuing with our example of BHD, its operational boundary includes a natural gas-powered water heater and electricity use in the two-story building and employee business travel via car, train and commuter rail.

4.2.1 Emissions

Direct and indirect emissions are further classified into three scopes: scope 1, scope 2 and scope 3. Scope 1 emissions account for direct GHG emissions that occur from sources that are owned or controlled by the company, for example, emissions from combustion in owned or controlled boilers, heaters, vehicles, etc. Scope 2 emissions account for GHG emissions that are generated by purchased electricity. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organizational boundary of the company. Scope 2 emissions physically occur at the facility where electricity is generated. The GHG Protocol regards scope 3 emissions as optional. These emissions are a consequence of the activities of the company, but occur from sources not owned or controlled by the company. Some examples of scope 3 activities are the extraction and production of purchased materials; transportation of purchased
fuels; and employee business travel. Figure 4.3 gives an overview of the emissions and scopes over a supply chain.

**Figure 4.3**: Overview of Emissions and Scopes across a Supply Chain (Source: GHG Protocol)

BHD therefore has the following emissions: Scope 1 (direct emissions) are emissions from the natural gas-powered water heater in the two-story building that it owns. Scope 2 (indirect emissions) are emissions from purchased electricity use in this two-story building. Scope 3 (other indirect emissions) are emissions from business travel by employees via car, train and commuter rail.

4.2.2 Types of Emissions

Emissions can be further classified into *types of activities* and *sources of emissions*. For example, *fugitive emissions* result from intentional or unintentional releases, e.g. equipment leaks from joints or seals; methane emissions from coal mines and venting; and hydrofluorocarbon emissions during the use of refrigeration and air conditioning equipment. Sources of emissions include *stationary combustion* (the combustion of fuels in stationary equipment such as turbines, heaters and incinerators; *mobile combustion* (the combustion of fuels in transportation devices such as
trucks, trains and ships); and process emissions (the emissions from physical or chemical processes). The GHG Protocol notes that every company has processes, products and services that generate direct and/or indirect emissions from one or more of the above broad categories. It further states that its calculators are based on these categories.

4.2.3 Nature of Companies and Data Collection

Once organizational and operational boundaries have been established, the next step is to identify exactly what data would be needed to measure GHG output. The GHG Protocol notes that there are two basic approaches for gathering data on GHG emissions from a corporation’s facilities: centralized, this is where individual facilities report activity/fuel use data to the corporate level, where GHG emissions are calculated; and decentralized, this is where individual facilities collect activity/fuel use data, directly calculating their GHG emissions, and report this data to the corporate level. The difference between these two approaches is in where the emissions calculations occur. Table 4.2 shows these two approaches to gathering data.

<table>
<thead>
<tr>
<th>SITE LEVEL</th>
<th>CORPORATE LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centralized Activity Data</td>
<td>Sites report activity data (GHG emissions calculated at corporate level: Activity Data x Emissions Factors = Quantity of GHG Emissions)</td>
</tr>
<tr>
<td>Decentralized Activity Data x Emission Factor = Quantity of GHG Emissions</td>
<td>Sites report GHG emissions</td>
</tr>
</tbody>
</table>

Table 4.2: Approaches to Gathering Data (Source: GHG Protocol)
BHD is a centralized company. As depicted in Figure 4.2, BHD needs to find the appropriate *activity data* and *emissions factor*. Activity data quantify an activity in units that will help to measure the amount of emissions generated, for example, the kilowatt hours of electricity used. BHD’s Scope 2 emissions are indirect emissions from electricity use in both the bread-making facility and the corporate office. The activity data that it needs to measure the amount of GHG emissions that it generates is in kilowatt hours (kWh). Suppose that BHD’s annual electricity usage in both the bread-making facility and the corporate office is 47,313 kWh. Once activity data has been collected for each emissions source, emissions factors need to be found. *Emissions factors* convert activity data to emissions values. Emissions factors are published by various entities such as local, state, or national government agencies and intergovernmental agencies.

As noted in Table 4.2, for a centralized company like BHD, its GHG emissions can be measured by using the following formula:

\[
\text{Activity Data} \times \text{Emissions Factors} = \text{Quantity of GHG Emissions}
\]

Note the activity data and emissions factors must be expressed in the same measurement units. As fictionalized above, BHD’s annual electricity usage in both the bread-making facility and the corporate office is 47,313 kWh. Since this electricity activity data is in kWh, BHD uses an emissions factor, from, say, the E-GRID database from the Environmental Protection Agency (EPA), to convert kWh to pounds (lbs) of carbon dioxide equivalents (CO\(_2\)e). CO\(_2\)e is the unit for comparing the global warming impact of a greenhouse gas expressed in terms of the amount of carbon dioxide that would have an equivalent impact (PAS 2050). The emissions from this database are expressed in lbs of CO\(_2\)e/megawatt hour (MWh). The activity data is in kWh, so the
emissions factor is first converted into CO$_2$e/kWh by dividing by 1,000. Below, the emissions calculation is performed, and then the result is converted to tons (metric tons).

\[
\text{Calculate emissions: } \quad 47,313 \text{ kWh} \times (0.193\text{lbs of CO}_2\text{e/kWh}) = 9,131 \text{ lbs of CO}_2\text{e} \\
\text{Convert to metric tons: } \quad 9,131 \text{ lbs of CO}_2\text{e}/2,205 \text{ lbs/ton} = 4.14 \text{ tons of CO}_2\text{e}
\]

\textbf{Total CO}_2\text{e from electricity} \quad = 4.14 \text{ tons of CO}_2\text{e}

Therefore, BHD’s total GHG emissions from purchased electricity for this year are 4.14 tons of CO$_2$e. This is reported as BHD’s Scope 2 emissions.

Figure 4.4 summarizes how the GHG Protocol classifies what is required from a company in order to measure its carbon footprint.
Figure 4.4: GHG Protocol Classification
4.2.4 Should Scope 3 Emissions be Optional?

As can be seen from Figure 4.4 and noted in sub-section 4.2.2, the GHG Protocol regards scope 3 emissions as optional. This is problematic from a supply chain perspective. Consider Figure 4.5.

Figure 4.5: GHG Emissions across a Supply Chain (Source: World Resources Institute)

According to the World Resources Institute (WRI), which developed the GHG Protocol, corporate GHG management is moving beyond companies' own operations and toward the full supply chain. It notes the following factors that have been driving the creation of a new protocol that addresses product and supply chain GHG accounting and reporting: increasing focus on GHG emissions associated with products; push for supply chain disclosure and risk management; increasing public reporting of scope 3 emissions in product-level GHG emissions; and increasing
business-to-business requests for product-level information. This is why the WRI is currently in the process of developing a new standard for product and supply chain GHG accounting and reporting. However, it will not be available until 2010. In the meantime, companies are using the PAS 2050 to calculate the carbon dioxide emissions of their products and along their supply chains, in order to close this gap. The next sub-section addresses the product carbon footprint method, PAS 2050.

4.3 PAS 2050

As previously discussed in Chapter 2, although there are about five CF methods currently being created, PAS 2050 is the only ‘official’ one. It was therefore not surprising that of the seventy-six calculators found, only two were product-based. Both of these calculators, from Gabi Software and CleanMetrics, said that they were based on PAS 2050. In this sub-section, I present the results of my analysis of how PAS 2050 classified what it needed from a company in order to measure its carbon footprint. To aid in the explanation of this classification, I will again use the example of the bread manufacturer, BHD. Recall that BHD produces two types of bread: wheat and rye. Since wheat bread is its faster-selling product, for the purposes of this classification, I will only focus on BHD’s production of wheat bread.

4.3.1 Boundaries

While the GHG Protocol establishes organizational boundaries and analyzes the operations of a single company or even a single site, PAS 2050 takes a supply chain approach. This approach covers specific processes from multiple companies and multiple sites operating in a single supply chain. This allows the carbon footprint of each product to be measured. Figure 4.6 shows a comparison of company-by-company and supply chain analyses.
PAS 2050 considers two types of boundaries for calculating the CF of products: *business-to-consumer (B2C)* and *business-to-business (B2B)*. B2C involves processes that take place from raw materials, through manufacture, distribution and retail, to consumer use and finally disposal and/or recycling. B2B carbon footprints stop at the point at which the product is delivered to another manufacturer. This is because B2B products can be used as inputs to multiple final products with widely divergent use and disposal characteristics (e.g. aluminum can be used in drink cans or airplanes). B2B therefore captures raw materials through production up to the point where the product arrives to a new organization, including distribution and transport to the customer’s site. It excludes additional manufacturing steps, final product distribution, retail,
consumer use and disposal/recycling. Figure 4.7 illustrates the differences between B2C and B2B boundaries.

![Figure 4.7: B2C and B2B Boundaries (Source: PAS 2050)](image)

Once these boundaries have been established, the materials that are processed and the activities that occur within them are considered. Figure 4.8 summarizes how the GHG Protocol classifies what is required from a company in order to measure its carbon footprint.

![Figure 4.8: PAS 2050 Classification (Source: PAS 2050)](image)
Consider the case of BHD’s wheat bread: 50% of it comprises of flour, 25% comprises of water, 20% comprises of butter and 5% comprises of other ingredients such as yeast. Once the wheat bread is made, it is wrapped in plastic packaging material. The activities involved in producing the wheat bread occur at multiple companies. Where the raw materials such as wheat, milk and butter are concerned, Mega Mills produces and transports wheat and mills it into flour, before transporting the flour to BHD. Daring Dairy produces milk, manufactures butter and transports both to BHD. Once the raw materials have arrived to BHD’s bread-making facility, wheat bread is manufactured and packaged. The finished product is then distributed to BHD’s storefront, as well as to other nearby convenience stores. Customers then eat the wheat bread (see Figure 4.9) and dispose of the waste, in the form of expired bread or the plastic packaging.

![Image of a loaf of bread](image)

**Figure 4.9:** A Loaf of BHD Wheat Bread Ready for Consumption (Source: Real Baking with Rose)

PAS 2050 notes that depending on the company’s aim in measuring it’s product carbon footprint, it could either focus on all of the materials and activities itemized in Figure 4.8 or conduct a high-level carbon footprint (hot spot analysis) whereby the major sources of GHG emissions are
identified or the most important sources that would differentiate a company and its product from its competitors are considered. Figure 4.10 complements Figure 4.8.

![Figure 4.10: Product Emissions across the Supply Chain (Source: World Resources Institute)](image)

4.4 Research Question 2: Benefits and Costs of GHG Protocol and PAS 2050

The GHG Protocol can facilitate public reporting, since it is recognized by the International Organization of Standards (ISO). It can also facilitate participation in voluntary and mandatory GHG programs. It also helps companies to participate in GHG markets. Finally, it helps a company to identify and prioritize GHG hotspots and reduction opportunities at the company level. However, to date, it cannot do this at the product level (GHG Protocol). This appears to be the only cost of the GHG Protocol. Recall that in Chapter 1, Matthews et al. (2008) urged that without a full knowledge of its carbon footprint, a company would be unable to pursue the most cost-effective mitigating strategies.

On the other hand, PAS 2050 can give a company a more complete knowledge of its carbon footprint, where its product is concerned, because it gives a detailed assessment of a product’s life
cycle (BSI). PAS 2050 can also help the company to identify the largest emission sources both within a company’s own operations and across the activities of other companies operating in the supply chain. However, the Climate Change Corp notes that the more intricate the product becomes, the trickier the job. For example, measuring the carbon footprint of an apple is easier than measuring the carbon footprint of a mobile phone. In a study on the life cycle environmental issues of mobile phones, it was found that due to the complex nature of the mobile phone, the potential scope of the data that has to be collected to measure its carbon footprint is immense (Nokia, 2005) (See Figure 4.11).

![Life Cycle Stages of a Mobile Phone (Nokia, 2005)](image)

**Figure 4.11:** Life Cycle Stages of a Mobile Phone (Nokia, 2005)
Where communicating a product’s carbon footprint is concerned, PAS 2050 states that it is only suitable for internal reporting (PAS 2050). This is a limitation. In order to provide more confidence in its own internal decision-making or as a step towards making external claims, PAS 2050 recommends that the company seek third-party certification by an internationally recognized body. Here, an auditor would review the process used to estimate the carbon footprint, check the data sources and calculations and certify whether PAS 2050 has been used correctly and whether the assessment has achieved conformity. Table 4.3 summarizes the benefits and costs of the GHG Protocol and PAS 2050.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>GHG Protocol</th>
<th>PAS 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company level reporting</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Product level reporting</td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Internal reporting</td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>External reporting</td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Hotspot analysis</td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Detailed analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single company involved</td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Multiple companies involved</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Companies engaged individually</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Companies engaged collaboratively up and down the supply chain</td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Savings from efficiencies within each company’s operation</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Savings from both internal efficiencies and from external process change and reorganization</td>
<td></td>
<td>√</td>
</tr>
</tbody>
</table>

**Table 4.3:** Benefits and Costs of GHG Protocol and PAS 2050

From Table 4.3, we can see that depending on what the company needs a CF method to measure, it will either choose the GHG Protocol or PAS. Neither can be described as the “correct” carbon footprint method for a particular company.
4.5 Where the GHG Protocol and the PAS 2050 Overlap

Consider again Figure 2.2 from Chapter 2, where the corporate and product CF methods overlap (Figure 4.12).

In this overlapping region, it should be noted that the GHG Protocol (the corporate CF method) and the PAS 2050 (the product CF method) do not necessarily measure GHG output in the same way. Using the GHG Protocol, in Table 4.4, the corporate carbon footprint of the bread manufacturer, BHD, was measured as follows:

Figure 4.12: Where the GHG Protocol and PAS 2050 Overlap
Scope | Amount of CO$_2$e
---|---
Scope 1 | 1.25 tons of CO$_2$e (from natural gas-powered water heater)
Scope 2 | 4.14 tons of CO$_2$e (from purchased electricity)
Scope 3 | 0.1 tons of CO$_2$e (from car travel)
| 0.05 tons of CO$_2$e (from train travel)
| 0.02 tons of CO$_2$e (from commuter rail travel)
Total GHG Emissions | 5.56 tons of CO$_2$e

**Table 4.4:** BHD GHG Emissions According to the GHG Protocol

Using the PAS 2050, in Table 4.5, the product carbon footprint of the bread manufacturer, BHD, was measured. In particular, 1 ton of wheat bread was considered.

<table>
<thead>
<tr>
<th>Company</th>
<th>Activity</th>
<th>Amount of CO$_2$e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mega Mills (Raw Materials)</td>
<td>Wheat Farming</td>
<td>0.45 tons of CO$_2$e</td>
</tr>
<tr>
<td></td>
<td>Wheat Transport</td>
<td>0.009 tons of CO$_2$e</td>
</tr>
<tr>
<td></td>
<td>Flour Production</td>
<td>0.045 tons of CO$_2$e</td>
</tr>
<tr>
<td></td>
<td>Flour Transport</td>
<td>0.007 tons of CO$_2$e</td>
</tr>
<tr>
<td></td>
<td>Flour Waste Transport</td>
<td>0.014 tons of CO$_2$e</td>
</tr>
<tr>
<td></td>
<td>Flour Waste Disposal</td>
<td>0.054 tons of CO$_2$e</td>
</tr>
<tr>
<td>Daring Dairy (Raw Materials)</td>
<td>Declined to give information about the butter and milk that it supplied to BHD</td>
<td>Declined to give information about the butter and milk that it supplied to BHD</td>
</tr>
<tr>
<td>Bringin’ Home the Dough (Manufacturing, Distribution and Retail)</td>
<td>Bread-Making</td>
<td>0.3 tons of CO$_2$e</td>
</tr>
<tr>
<td></td>
<td>Packaging</td>
<td>0.04 tons of CO$_2$e</td>
</tr>
</tbody>
</table>
Waste Transport  0.002 tons of CO$_2$e  
Bread Distribution  0.03 tons of CO$_2$e  
Storage  0.0005 tons of CO$_2$e  
Transport to Convenience Stores  0.005 tons of CO$_2$e  
Consumer use (storage)  0.005 tons of CO$_2$e  
Consumer use (heating)  0.036 tons of CO$_2$e  
Disposal of wasted wheat bread  0.0004 tons of CO$_2$e  
Disposal of plastic packaging  0.012 tons of CO$_2$e  
Total GHG Emissions  1.009 tons of CO$_2$e  

Table 4.5: BHD GHG Emissions According to PAS 2050

Comparing the carbon footprint measurements in Tables 4.4 and 4.5, respectively, we see that according to the GHG Protocol, BHD’s corporate carbon footprint is $5.56$ tons of CO$_2$e and according to PAS 2050, BHD’s product carbon footprint is $1.009$ tons of CO$_2$e. By reviewing the inputs of each measurement, one could see that there really was no overlap in terms of what each method measured. There could have been some overlap if the GHG Protocol’s Scope 3 emissions included product-level information, where the wheat bread was concerned. But it was optional to include it. Had it been included, we would see that both the GHG Protocol and the PAS 2050 would have calculated the product-level information, as it related to only BHD, in the same way. However, the GHG Protocol would not have included information from Mega Mills since this would have been outside of its pre-established organizational boundary. Also, PAS 2050 would not have included information that did not pertain to the direct production of the product, such as employee commuter rail information. Further, the carbon footprint that PAS...
2050 calculated could have been larger, if Daring Dairy had participated in the measurement, given that 20% of the wheat bread comprises of butter.

The results from Tables 4.4 and 4.5 show that due to the arbitrary nature of carbon footprint boundaries, different values of carbon footprints can be calculated. For purposes of comparison, however, PAS 2050 cautions that different product footprints are not truly comparable unless the same data sources, boundary conditions and other assumptions are used.

4.6 Research Question 3: Tradeoffs between GHG Protocol and PAS 2050

Despite these variable results, from the point of view of investors and shareholders, it is perhaps better to use GHG Protocol, given its focus on a single company. The GHG Protocol allows a company to address its direct financial and regulatory exposure if the company has high GHG emissions. The company can do so, by addressing the environmental implications of its corporate brand. However, from the perspective of the consumer, it is perhaps better to use PAS 2050. PAS 2050 looks at impacts outside a particular company's boundary and gives a fuller picture from the product-level (The Carbon Trust, 2006). Using both, though, would be the better option, since a fuller picture of a company's carbon footprint, internally and along its product's supply chain is most desirable. Recall, though, that PAS 2050 cannot be publicly reported. In the next and final chapter, I discuss some of the long-term ramifications of using either the GHG Protocol or PAS 2050. For argument's sake, I assume that both the GHG Protocol and the PAS 2050 can be publicly reported.
Chapter 5 - Conclusion

Given my research on the carbon footprint (CF) methods used by companies, I have drawn three key insights. Firstly, a carbon footprint is not simply a measure of carbon dioxide output; it is also a measure of the output of other greenhouse gases, such as nitrous oxide and methane. Secondly, there are a number of methods for measuring the carbon footprints of companies. They fall into two categories: corporate and product. These two categories of CF methods differ significantly from each other. This implies that no single method can be described as the ‘preferred’ method. It was more advisable to make tradeoffs between each of these methods. Finally, methods are chosen according to purpose to be served. I now conclude this thesis by discussing some of the long-term ramifications of choosing a particular method.

5.1 Long-term Ramifications of Using Corporate CF Methods

Consider a company that has measured its GHG output, using the GHG Protocol. Based on the results, the company can either choose to internally reduce its GHG emissions (use internal reduction strategies) or to shift the intensive GHG aspects of the company outside of its responsibility (use outsourcing strategies). How a company chooses to respond will be driven by either regulatory concerns or consumer demand. Consider the case of regulatory concerns, whereby a cap and trade system is in place, along with a tax on a particular greenhouse gas (e.g. carbon dioxide): if a company has reached its limit (its cap) of carbon dioxide, then it will be taxed. The company would then have to decide if it is cheaper to pay this tax, or to reduce the amount of carbon dioxide that it is emitting, by outsourcing its carbon dioxide-intensive activities to lesser environmentally-regulated companies or regions. Here the internal reduction strategy becomes an outsourcing strategy. Such outsourcing strategies are also referred to as carbon leakage.
Reinaud (2008) defines carbon leakage as the increase in emissions outside a region as a direct result of the policy to cap emission in that particular region. Carbon leakage means that the domestic climate mitigation policy is less effective and more costly in containing emission levels, a legitimate concern for policy-makers. In her report, she focuses on the competitiveness leakage channel for manufacturing sectors: immediate loss of market share for carbon-constrained industrial products, to the benefit of non-carbon-constrained countries (i.e. decreases of exports and increases of imports); and relocation of energy-intensive industries to countries with a more favorable climate policy. Changes in trade patterns as a result of uneven carbon constraints are the main indicator of this competitiveness driven-carbon leakage.

Reinaud (2008) offers that since the competitiveness of a company is defined as its ability to maintain profits and market share, a substantial increase in costs for a sector in one region (entailing loss in profits compared to international competitors) would affect a company’s competitiveness (its ability to retain market shares) in different ways: enhanced competition from cheaper competitors on domestic and overseas markets and lower profits leading to lower capacity to invest and expand activities. She gives an example: with or without the carbon dioxide cost component, companies in the European primary smelting industry have de facto lost their position: demand is increasingly met by imports as domestic production is saturated and no investments in additional capacity are in the pipeline.

This means that companies need to be incentivized to look outside of their company’s boundaries and into their supply chain, in order to prevent their own extinction, in light of increasing environmental regulation and its associated costs (tax). This is what OK Petroleum, Sweden’s largest refiner and retailer of gasoline, did. When faced with emissions limits for the carbon dioxide that it produces, it used an internal reduction strategy and lobbied for a higher carbon tax. By fighting for higher carbon taxes, because it no longer wanted to see itself as being in the
petroleum business, it entered the clean energy business. OK Petroleum foresaw two ramifications of its decision. First, an increase in carbon taxes would help them in the long-term by giving them incentives to be innovative. Second, this increase also fostered the creation of cleaner fuels (Hawken et al., 1999).

5.2 Long-term Ramifications of Using Product CF Methods

Rather than wait for carbon dioxide cost components to spell dire effects for its survival, similar to OK Petroleum, Walkers, the UK’s largest snack foods manufacturer with such brands as Doritos and Wotsits was forward-thinking in its approach. It decided to become green, both in response to increasing regulatory pressure, as well increasing consumer pressure for greener products, by looking outside of its company’s boundaries and into its supply chain. That is, instead of becoming a victim of outsourcing strategies and carbon leakage, Walkers used an internal reduction strategy, that involved greener, more energy-efficient production processes, or the use of greener suppliers along its supply chain.

To accomplish this, Walkers worked with the Carbon Trust, the co-creators of PAS 2050 on energy efficiency and carbon management, identifying opportunities that saved more than 2,000 tons of carbon dioxide per annum and reduced their energy bills by approximately £225,000. Through its continuing commitment to reduce its GHG emissions, Walkers was able to boost its profitability through energy savings. One key opportunity related to the water content of the potatoes that Walkers purchases. Since Walkers produced potatoes by weight, it was paying a price per ton of potatoes it purchased from farmers. This excess water in potatoes meant that potato frying time was increased and emissions resulting from the frying stage increased by up to 10%. Instead, Walkers decided to reward farmers who could produce potatoes with a lower water
content. Potatoes with lower water content resulted in an overall supply chain saving of up to 9,200 tons of carbon dioxide and £1.2 million per annum. This in turn led to Walkers reducing the GHG emissions that occurred in the potato frying stage by up to 10% (The Carbon Trust, 2006). Walkers was therefore able to develop a low-carbon product that captured new markets and generated higher profits, thereby giving it larger market share and thus greater competitive advantage.

5.3 The Conundrum Presented by a Tin of Peanuts

This Walkers example points to improving, or better said, ‘greening’ a company’s final product, by using an internal reduction strategy, rather than either using or becoming a victim of outsourcing strategies. Albino et al. (2009) define a green product as a product designed to minimize its environmental impacts during its whole life cycle. In particular, non-renewable resource use is minimized, toxic materials are avoided and renewable resource use takes place in accordance with their rate of replenishment. In order to accomplish the cost savings that it did, Walkers took a supply chain perspective, instead of a single company perspective.

Indeed, low-carbon products allow companies like Walkers to differentiate themselves in the marketplace. In fact, the creators of PAS 2050 have worked with companies like Tesco, a major UK retailer, to put CF labels on products in four different categories: laundry detergent, orange juice, potatoes and light bulbs. The carbon labels tell customers the amount of carbon dioxide and other greenhouse gases produced during the lifetime of the product including use and disposal. However, Schmidt (2009) asks the following question: if a tin of peanuts is labeled to have a load of 85 grams of carbon dioxide, what would this mean to the customer? For a CF label to make sense, Schmidt (2009) offers that all products/product areas and activities have to
be included. Only in this way can consumers become aware of the connections and evaluate the information in order to act appropriately. Regarding the tin of peanuts, Schmidt (2009) asks what would happen if a consumer goes to fetch a tin of peanuts and notices that a tin in one store is labeled to have 85 grams of carbon dioxide, while a tin in another store is labeled to have 90 grams of carbon dioxide? If she chooses to buy the tin with 85 grams of carbon dioxide, she trusts that she is making a contribution to reducing carbon dioxide. However, what sense would it make if the store that sells the tin with 90 grams of carbon dioxide is nearer to where the customer lives? She could end up generating about 200 times more carbon dioxide to get to that store, in order to save 5 grams of carbon dioxide worth of peanuts, and is left confused.

5.4 Other Environmental Effects Apart from Global Warming

This sort of confusion, on the parts of companies, their suppliers and customers, is what has raised many of the methodological questions about the carbon footprint methods used by companies, which have been outlined in this thesis. Underlying these questions is the concern of whether or not companies are really ready to address the observation that while the earth’s resources (natural capital) have been diminishing, companies manufacturing capital has been expanding (Hawken et al., 1999). Hawken et al. (1999) asks if companies have really reached the stage whereby creating production and distribution systems that reverse the loss and eventually increase the supply of natural capital is their only option? Getting to this stage will require more than product design, marketing or competition. It will mean a fundamental reevaluation of companies’ roles and responsibilities amidst this global warming debate.

For example, while increasing labor productivity to improve competitiveness requires huge investments in capital, materials, and energy supplies to sustain its momentum, increasing
resource productivity frees up large amounts of capital that can be invested in strengthening the company, rebuilding human capital and restoring the natural environment. Companies that move toward this sort of advanced resource productively will save energy and money; create competitive advantage; help restore the environment; and save people from the harmful effects of global warming (Hawken et al., 1999).

Finally, research indicates that high GHG emissions levels do not only cause global warming. They also cause other effects such as ocean acidification. According to ScienceDaily (2008), ocean acidification is related to the amount of carbon dioxide we produce. Carbon dioxide dissolves in the ocean, reacts with seawater and decreases the pH levels. Concerns about ocean acidification, and the growing threat of fresh-water shortages, have now led to a new footprint to worry about: water. According to the Wall Street Journal (2009), it takes roughly 20 gallons of water to make a pint of beer, as much as 132 gallons of water to make a 2-liter bottle of soda, and about 500 gallons, including water used to grow, dye and process the cotton, to make a pair of Levi’s stonewashed jeans. Though much of that water is replenished through natural cycles, a handful of companies have started tracking such “water footprints”.

Today carbon footprints, tomorrow water footprints; what will this all mean for a company aiming for environmental success? A successful company in this new era of heightened environmental awareness will realize that solutions lie in understanding the interconnectedness of the problem, not in confronting them in isolation (Hawken et al., 1999). Carbon footprint methods are therefore only the first steps in this direction, and serve as very good catalysts for system-wide environmental improvement, that involves other aspects than just global warming mitigation.
Bibliography


Appendices – Carbon Footprint Calculators

A Individual/Household

3Degrees
Act on CO₂
Airheads
Alaska Conservation Solutions
American Forests
AOL
Atmosfair
Be Green Now
Best Food Forward
Bonneville Environmental Foundation
BP Calculator
C Level
Carbon Advice Group
Carbon Fund
Carbon Neutral
Carbonfootprint
Chuck Wright
Clear Sky
Clear Water
Climate Care
Climate Path
Climate Friendly
climatecrisis.net

http://www.3degreesinc.com/carbon_calculator/
http://actonco2.direct.gov.uk/index.html
http://airhead.cnt.org/Calculator/?sid=9a83dee4f74cc4544d451dd917ba554d
http://www.alaskaconservationsolutions.com/acs/akcalculator.html
http://www.americanforests.org/resources/ccc/
http://living.aol.co.uk/homes-and-property/go-green/quick-carbon-calculator/09
https://www.atmosfair.de/index.php?id=5&no_cache=1&L=3
http://www.begreennow.com/reduce-offset/carbon-calculator/
http://www.bestfootforward.com/footprintlife.htm
http://www.b-e-f.org/calc
http://www.bp.com/iframe.do?categoryId=9027929&contentId=7050956
http://www.clevel.co.uk/homecalc.html
http://www.carbonfund.org/Calculators
http://www.carbonfootprint.com/calculator1.html
http://chuck-wright.com/calculators/carbon.html
http://www.clearskyclimatesolutions.com/calculator.html
http://www.clearwater.org/carbon.html
http://www.jpmorganclimatecare.com/
http://www.climatepath.org/howitworks/calculatormethodology#
https://climatefriendly.com/personal
http://www.climatecrisis.net/takeaction/carboncalculator/
CO₂ Balance
Colorado Carbon Fund
Combat Climate Change
Conservation International
Cool Climate Calculator (Berkley Institute of the Environment)
Earthlab
Energy Saving Trust
Environmental Defense
EPA Household Emissions Calculator
ICLEI
Low Impact Living
Minnesota Energy Challenge
MSN – Carbon Calculator
National Forest Foundation
Native Energy
Nature Conservancy
Positive Energy
Pure Trust
Resurgence
Safe Climate
StopGlobalWarming.org
Terrapass
The Conservation Fund
The New Hampshire Carbon Challenge
Verteego Carbon
World Land Trust – Carbon Balance
WWF
Yahoo

http://www.co2balance.com/us/co2calculators/household/
http://coloradocarbonfund.com/think_1.cfm
http://www.combatclimatechange.ie/index.asp?locID=4
http://coolclimate.berkeley.edu/
http://www.earthlab.com/carbon-calculator.html
http://www.energysavingtrust.org.uk/calculator/start
http://www.fightglobalwarming.com/carboncalculator.cfm
http://www.epa.gov/climatechange/emissions/ind_calculator2.html
http://www3.iclei.org/co2/co2calc.htm
http://www.mnenergychallenge.org/carbonfootprint/
http://environment.uk.msn.com/tools/
http://www.nationalforests.org/carbon/
http://www.nativeenergy.com/pages/offset_now/473.php
http://www.nature.org/initiatives/climatechange/calculator/
http://calc.positiveenergyusa.com/calculator
http://www.puretrust.org.uk/personal.jsp
http://www.resurgence.org/resources/quickcalc.html
http://www.safeclimate.net/calculator/
http://www.stopglobalwarming.org/carboncalculator.asp
http://www.terrapass.com/carbon-footprint-calculator/
https://gozero.conservationfund.org/calculator/household
http://carbonchallenge.sr.unh.edu/calculator.jsp?cookieCheck=1
http://www.verteegocarbon.com/en
http://www.carbonbalanced.org/calculator/household.asp
http://green.yahoo.com/calculator
http://green.yahoo.com/calculator/
# Features of Individual Carbon Footprint Calculators

(Source: http://hes.lbl.gov/hes/carbon-calculators.html)

<table>
<thead>
<tr>
<th>Name</th>
<th>Provider</th>
<th>Geographical Coverage</th>
<th>Household</th>
<th>Transportation</th>
<th>Public</th>
<th>Food</th>
<th>Goods</th>
<th>Waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Act On CO2 Calculator</td>
<td>DEFRA</td>
<td>United Kingdom</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airhead's Emissions Calculator</td>
<td>Center for Neighborhood Technology</td>
<td>United States</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>America Online's Personal Impact Calculator</td>
<td>AOL</td>
<td>United States</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>California Carbon Calculator</td>
<td>California Air Resources Board</td>
<td>California</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Calculator</td>
<td>Bonnevile Environmental Foundation</td>
<td>United States</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Calculator</td>
<td>CarbonFund.org</td>
<td>non-specific</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Calculator</td>
<td>Air Inconvenient Truth</td>
<td>United States</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Calculator</td>
<td>Pure</td>
<td>United Kingdom</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Calculator</td>
<td>GreenTaxes USA</td>
<td>United States</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Counter</td>
<td>The Climate Trust</td>
<td>(national average)</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Footprint Calculator</td>
<td>BP</td>
<td>3 Countries</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Footprint Calculator</td>
<td>The Nature Conservancy</td>
<td>United States</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CarbonFootprint Calculator</td>
<td>Pacific Gas &amp; Electric Company</td>
<td>non-specific</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earth Conservation Profile</td>
<td>EarthLab</td>
<td>International</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enervad</td>
<td>LBIL</td>
<td>United States</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exaratu</td>
<td></td>
<td>(under dev)</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fortis Investments Footprint Calculator</td>
<td>Fortis Investments</td>
<td>Europe</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home Energy Saver</td>
<td>LBIL</td>
<td>United States</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home Energy Taxstick</td>
<td>USEPA</td>
<td>United States</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LBNL's Personal CO2 Calculator</td>
<td>UC Berkeley</td>
<td>United States</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LiveGreen Carbon Offset Program</td>
<td>Sacramento Municipal Utility District</td>
<td>United States Service Territory</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My Green Lifestyle</td>
<td>Yahoo! GREEN</td>
<td>United States</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partial Emissions Calculator</td>
<td>USEPA</td>
<td>United States</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partial Carbon Calculator</td>
<td>RacStuff</td>
<td>United States</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SafeClimate Carbon Offset Footprint Calculator</td>
<td>World Resources Institute</td>
<td>non-specific</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>See Planet</td>
<td>Tandberg</td>
<td>United States</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stop Global Warming Calculator</td>
<td>Koglobalwarming.org</td>
<td>non-specific</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Travel Matters Emissions Calculators</td>
<td>Center for Neighborhood Technology</td>
<td>United States</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Web Carbon Calculator</td>
<td>WeBx</td>
<td>International</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><a href="http://www.fueleconomy.gov">www.fueleconomy.gov</a></td>
<td>USDA &amp; USEPA</td>
<td>(by vehicle make, model, and year)</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zerofootprint Carbon Calculator</td>
<td>Zerofootprint Inc.</td>
<td>Canada &amp; United States</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
C Industry

Aluminum
Cement
Iron and Steel
Lime
Ammonia
Nitric Acid
Paper
Grains Greenhouse Calculator
Agriculture and Horticulture Carbon Calculator
National Carbon Accounting Toolbox (NCAT/FullICAM)
Agricultural Production Systems Simulator (APSIM)
Furniture Footprinter

D Corporate/Office

GHG Protocol Corporate Calculator
Carbon Trust
The Green Office
The Carbon Neutral Company
Office Footprinter
C Level
Pure Trust
National Energy Foundation
Terrapass
Climatecare.org

E Product

Gabi
CleanMetrics

http://www.terrapass.com/business/email.html
http://www.jpmorganclimatecare.com/business/

http://www.pe-international.com/consulting/carbon-footprint