JUNE 13

# CHANGE REQUIRES INSIGHT

## Assessing Upstream Scope 3 Emissions by SMEs in the Construction Industry

MASTER THESIS by
PETER MELIS

WZK

UNIVERSITY OF TWENTE.

# CHANGE REQUIRES INSIGHT

## ASSESSING UPSTREAM SCOPE 3 EMISSIONS BY SMEs IN THE CONSTRUCTION INDUSTRY

| | | |
|---|---|---|
| CONTENT: | MASTER THESIS | |
| TITLE: | CHANGE REQUIRES INSIGHT | |
| SUBTITLE: | ASSESSING UPSTREAM SCOPE 3 EMISSIONS BY SMEs IN THE CONSTRUCTION INDUSTRY | |
| NAME: | P.J.W. MELIS | |
| STUDENT NUMBER: | S0138940 | |
| UNIVERSITY: | UNIVERSITY OF TWENTE | |
| MASTER TRACK: | CONSTRUCTION MANAGEMENT & ENGINEERING | |
| INTERNSHIP: | WZK, AMSTERDAM | |
| SUPERVISORS: | DR. IR. A.G. ENTROP | UNIVERSITY OF TWENTE |
| | DR. J.T. VOORDIJK | UNIVERSITY OF TWENTE |
| | T.H.D. MANSCHOT MSC | WZK |
| DATE: | 14-06-2013 | |

## PREFACE

This report is the result of a scientific research carried out to achieve a master degree in the track Construction Management & Engineering at the University of Twente, the Netherlands. The research is executed at WZK in Amsterdam.

The research studies the assessment of emissions. I find it interesting and important to work on the topic of sustainability, since it directly deals with our responsibility for the planet as humankind. We *are* the planet. Organizations become more aware of their responsibility and start to assess the impact of their actions through emissions. During my research I got insight in the complexity of creating a truly sustainable society. Understanding something of the complexity does not make me more optimistic about it; it does however create insight in the joy and meaningfulness I experienced to work on the topic sustainability.

During the research I experienced kindness of a wide variety of people. I would like to thank G. Termeer, D. Hortensius, K. Gemenis, and L. Draucker for their assistance and the valuable information they provided for this research. Due to the cooperation of F. Verbeek and M. Petit dit de la Roche (*De Groene Paal*), and M. van der Holst (*ABLE2 / Ballast Nedam and Omnia)* I was able to retrieve all the required information for the case studies. Without their help it would have been impossible to conduct the case studies, wherefore I would like to express my gratitude. Also, I would like to thank B. Buckley (World Resources Institute) for his valuable input on specific standards and his review of the proposed method in this research. Sam Kin (*SolarSwing*), Sander Leegwater (*Schouten Techniek*), and Jaap Nieuwenhuijse (*Nieuwenhuijse Arends Bouw- en Risicomanagement*) made time for me to gain rich insights on the designed method. Thanks all for your time. If one of you ever needs to interview someone, I owe you.

My special thanks goes out to my supervisors Bram Entrop and Hans Voordijk. They provided their support on behalf of the University of Twente. In the beginning of the research they helped me to find the exact research topic, and later on they provided both valuable inputs as moments of laughter (which is essential in the process of writing a thesis). I would like to express my gratitude to Tim Manschot, my supervisor at WZK. He provided me with essential feedback and insights to assist me in this research. Furthermore, he included me in the team at WZK and let me experience the daily practice of a consultant specialized in sustainability. For me the time at WZK felt as being at the epicentre of the sustainable transition movement of the Netherlands, and sometimes at an even larger scale. I can truly say that this has been a life changing experience. Furthermore I would like to thank Nina Sickenga (WZK) for her invaluable help on the ins and outs of Adobe Illustrator.

The support of my parents during my time at University was perfect. They believed in me and gave me the freedom to create my own path, thank you! Also I would like to thank my sisters for their support. My friends helped me to put things into perspective during a few beers, thanks! And finally, my girlfriend Chantal provided me with more support than any method can assess. Thank you so much!

I hope you enjoy reading this thesis. I had a wonderful time at WZK, and I am proud and satisfied with the result.

Peter Melis
Amsterdam, June 2013

# MANAGEMENT SUMMARY


Sustainability is at the core of WZK's activities. WZK advises organizations in different industries on this topic, including advice on how to assess sustainable performance. Reporting of emissions is a specific aspect of the wider assessment, and is currently mostly done by large organizations. This thesis elaborates on the assessment of upstream scope 3 emissions, which are indirect emissions caused in the upstream supply chain.

**Research motivation**
The construction industry has a high impact on our planet. Before this impact can be decreased, insight in the actual impact of the industry is necessary. Greenhouse gas emissions are linked to global warming, and can be quantified to assess impact. This research will focus on the assessment of these emissions. Furthermore, the focus is on small and medium enterprises (SMEs), since (1) they experience more difficulties when using available standards and (2) they account for 75% of all turnover in the construction industry.

**Research goal**
The goal of this research is to design an efficient and effective method for SMEs in the construction industry to assess upstream scope 3 emissions. This method is based on available standards to assess upstream scope 3 emissions, namely the Scope 3 Standard and the Product Standard. Both standards have been published by the Greenhouse Gas Protocol.

**The research**
The research is structured in four chapters. First underlying theoretic models used to assess upstream scope 3 emissions are discovered. Thereafter available methods to assess the emissions are investigated, in which the Scope 3 Standard and the Product Standard are investigated in detail. These standards are applied on two case studies, followed by the design of a new method for SMEs to assess upstream scope 3 emissions.

Three theoretic models exist to assess upstream scope 3 emissions; the *input-output model* is a large-scale approach, the *lifecycle analysis model* is a fine-scale approach, and the *hybrid model* combines best of both worlds. The Greenhouse Gas Protocol published the *Scope 3 Standard* and the *Product Standard* which both can be used to assess scope 3 emissions. The basis of the former is the *input-output model*, and the *LCA model* of the latter. Both standards are exhaustive documents and very general in their guidance. The generality is especially an obstacle in terms of usability. Additional data needs to be retrieved from third party databases, which creates another obstacle. Overall, the Scope 3 Standard is efficient in quickly gaining insight in emissions with an effective result of category comparison. The Product Standard requires more time and expertise, and is therefore less efficient. The visualizations and insights of the supply chain of products a reporting organization produces is however very effective.

Two case studies have been executed in which both standards are used. In both cases purchased goods and materials caused the majority of upstream scope 3 emissions. The Data Quality Indicators were difficult to use. Also, retrieving good activity data (primary) and emission factors was a challenge. Especially the emission factors needed for lifecycle phases formed a problem, since these factors are often not available free of charge. Emissions calculated with the Scope 3 Standard where mostly within a +/- 20% range compared to the Product Standard.

The new Hybrid US3 Method that is designed starts with an initial step in which basic information, goal-setting and organizational boundaries are provided. Then one to four steps become available. The steps form a clear-cut path for the user, in which less time and expertise is needed compared to the standards themselves. The selection of third party databases is already determined. Each step is preceded by a questionnaire to create a tailor-made step for the user. After each step a short questionnaire is completed to provide information on Data Quality Indicators. In step 2 and 4 a Threshold for Data Quality Improvement creates the opportunity for the user to have influence over required improvement; based on available time/expertise and desired result a percentage can be specified above which categories and/or life cycle phases have to be improved. End visualizations of each step show a combination of emission quantities, data quality, and improvement steps.

**Results and recommendations**

The Hybrid US3 Method developed in this research is a smart combination of the Scope 3 Standard and the Product Standard. It is smart in the sense that the general and exhaustive character of both standards is tackled in this combination, and improvements on efficiency and effectiveness compared to the existing Standards have been realised. The three main improvements on efficiency are (1) the predetermined emission databases and factors, (2) the clear-cut path through the method based on a framework, and (3) the divide of both standards into a more estimation-based step and a deepening insights step. The effective aspects are mostly in the visualizations of the steps: all eight upstream categories can be compared, the size of scope 3 emissions can be compared to the size of scope 1 and 2, and the visualization of the product lifecycle leads to upstream supply chain insights. An improvement that is both efficient and effective is setting the aim in the initial step and determining the percentage of the Threshold for Data Quality Improvement.

It is the first academic research, known by the researcher, in which a method is developed based on the Scope 3 Standard and the Product Standard. The Hybrid US3 Method improves chances on comparability and creates the opportunity for SMEs to assess upstream scope 3 emissions with limited resources, which is acknowledged by potential users.

The Hybrid US3 Method was presented to a researcher working on the Scope 3 Standard and Product Standard, and to three potential users, namely persons working for or owning an SME in the construction industry. This reflection showed that the method does require guidance and explanation to use it on itself, especially for steps focused on lifecycle insights. Potential improvements are to add the *potential* to improve data quality and mitigating emissions. WZK has to alter the Hybrid US3 Method before it can be used on other projects that are not in the construction industry, while strategic partners can help to develop this method further. Academic research can add value to this research field when company assessments by using the Scope 3 Standard and the Product Standard are critically reviewed. Investigation of how an open source network for lifecycle data can be established can speed up the chance on reliable and high quality inventories established by SMEs using this method.

# TABLE OF CONTENTS

# 1 INTRODUCTION

This first chapter will provide background information on the topic of this research, as well as a description of the company at which the research will be executed.

## 1.1 Research background

The world is changing rapidly. The current generation will most probably witness a world that will no longer be a world of abundance. The biodiversity on planet earth is declining rapidly. In the period 1970-2008 the Living Planet Index, a figure to measure earth's biodiversity, declined with 30% (World Wide Fund for Nature, 2012). Sustainable development is seen by many as a hype, but is in fact a necessity to meet the needs of future generations. The UN World Commission on Environment and Development report (or: Brundtland Report) introduced this definition in 1987:

> *"Sustainable development is development that meets the need of the present without compromising the ability of future generations to meet their own needs."*

It is disputable what the needs of future generations will be. It is evident however that there are possibilities to behave in a more sustainable matter. But what is meant with sustainable here? And which part of sustainability will be dealt with in this research? These questions will be answered in this paragraph on the research background.

### 1.1.1 Sustainability

The triple bottom line principle introduced by John Elkington in 1998 provides a good starting point for sustainability in respect to this research. Companies will no longer stick to just measuring profit, but will include environmental protection and social equity as well. His triple bottom line principle is also known as triple 'P': people, planet, profit (Elkington, 1998). The environmental aspect of sustainability does not stand on its own, but is rather closely related to the social and economic performance of an organization. The entire performance of sustainable purchasing (a concept that will be introduced later on) of a company can be seen as a combination of the degrees of emphasis on both economic, social and environmental sustainability (Schneider and Wallenburg, 2012), which is represented in Figure 1.

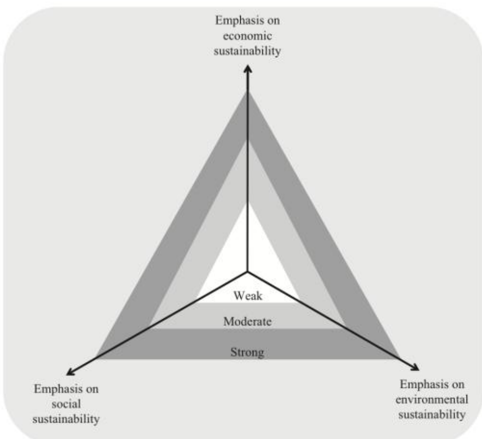



**Figure 1 Three aspects of sustainability leading to sustainable purchasing performance. Source: Schneider, 2012**

### 1.1.2 Sustainability within organizations

Organizations face different pressures and incentives to behave more sustainable, of which the most important ones are legal demands and regulation, customer and stakeholder demands, competitive advantage, environmental and social pressure groups, and reputation loss (Seuring and Müller, 2008).

These pressures lead many organizations to start activities on sustainability, in order to improve performance on sustainability. These efforts are often communicated through Corporate Social Responsibility (CSR) reports or Sustainability Reports. On the environmental aspect an organization can report on various topics, such as recycling efforts, energy use, supply chain activities, certification, water waste disposal and Greenhouse Gas emissions (Humphreys, Wong et al., 2003). This research will focus on Greenhouse Gas emissions (GHGE), because this element is one of the most easily quantifiable environmental aspects of sustainability and is linked to the problem of global warming. It is already used in different trading policies on the European level, which means that this environmental aspect is already connected to economic performance in some situations. This trend is likely to continue, in the construction industry as well.

### 1.1.3 Greenhouse Gas Emissions

When referring to GHGE, the definition of the Kyoto Protocol (UNFCC, 1998) is followed in this research. Therefore the following six gases are meant:

- Carbon dioxide ($CO_2$)
- Methane ($CH_4$)
- Nitrous oxide ($N_2O$)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride ($SF_6$)

It is important to note that there are other greenhouse gases, such as chlorofluorocarbons. These are not included when the term greenhouse gas emissions is used throughout this research. The accumulation of GHGE in the atmosphere has been linked to human industrial and agricultural activity. The anticipated effects include increased heat waves, heavy precipitation, cyclone intensity and loss of snow and arctic ice cover (IPCC, 2007). The involvement of business is important since it is both part of the problem and a key part of the solution to climate change (Boiral, Henri et al., 2011). When organizations want to be part of the solution of the climate change issue, GHGE measurement is essential. This is also referred to as carbon footprinting, or carbon accounting (Stechemesser and Guenther, 2012). Although the word 'carbon' suggests that only carbons are included, it often refers to the GHGE in the Kyoto Protocol (in this research this approach is followed).

### 1.1.4 Using scopes to assess Greenhouse Gas Emissions

When assessing GHGE it is essential to divide them into logical parts. This makes the process manageable and improves transparency between organizations. Different standards exist to help in this process. One way to do this is to distinguish between 'direct' and 'indirect' emissions. Direct emissions are caused by sources owned or controlled by the reporting organization. Indirect emissions are a consequence of the activities of the reporting organization, but occur at sources owned or controlled by another organization (WRI and WBCSD, 2011a). The Greenhouse Gas Protocol (WRI and

WBCSD, 2011a) divides indirect emissions in two separate elements, leading to three scopes to assess emissions (see Figure 2):

- scope 1: direct emissions of an organization
    - production on site and own vehicles
- scope 2: indirect emissions of an organization
    - electricity
    - heating and/or cooling, and steam (all purchased for own use)
- scope 3: indirect emissions
    - upstream in the supply chain (or value chain)
    - downstream in the supply chain

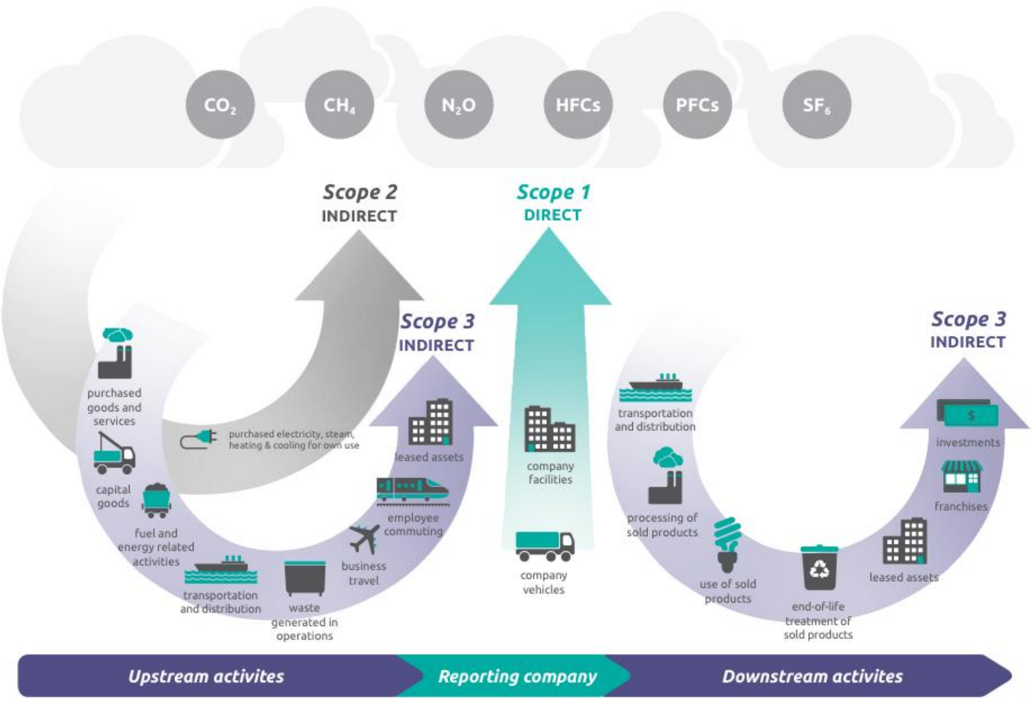



**Figure 2 Scoping of emissions. Source: WRI & WBCSD, 2011**

Scope 1 emissions are the same as direct emissions. It includes gas used by the company, fuels needed in own vehicles, and emissions caused by production on site. Scope 2 emissions, which are indirect emissions, relate to the amount of electricity and other heating and/or cooling purchased by the assessing organization. Scope 1 and 2 emissions are relatively easy to assess, and therefore often a starting point. Information on purchased gas and fuels, energy and electricity can help to create a scope 1 and 2 inventory. Scope 3 emissions are the most difficult to assess since these emissions are not directly caused by the reporting organization. Scope 3 emissions are caused by supply chain activities, both upstream as downstream. Scope 3 emissions account for up to 75% of total direct and indirect emissions of a vast majority of organizations (Huang, Weber et al., 2009a). It is therefore a scope in which huge progress can be made. In this research, the focus will be on *upstream* scope 3 emissions.

#### 1.1.5 Assessing upstream scope 3 emissions

To use the potential of sustainable purchasing to reduce upstream scope 3 emissions requires insight in these emissions. Then the question becomes: how can an organization assess these emissions? As already said, assessing scope 3 emissions is not easy. Currently used methods and data result in huge discrepancies in the number of sources reported and a lack of rigour in determining which sources to include (Downie and Stubbs, 2011). In other words: organizations encounter difficulties when assessing scope 3 emissions. To tackle these difficulties, the Greenhouse Gas Protocol has developed standards. Currently two standards are available to assess scope 3 emissions. These two standards are very extensive, require expertise to use them, and are mainly aimed at large organizations. Furthermore, they are not sector-specific.

### 1.1.6 Assessing upstream scope 3 emissions by an SME in the construction industry

The construction industry is fuel-intensive and has a large share in total GHGE. It could therefore play a pivotal role in carbon reduction and mitigation (Wong, Li et al., 2012). However, scope 3 emissions are not yet widely assessed and/or reported in a consistent way by the construction industry, as became clear during a visit to an event during the Dutch Green Building Week 2012. Large organizations start to assess them, also due to developments on green procurement regarding the $CO_2$ performance ladder (Rietbergen and Blok, 2012). Also smaller organizations start assessing, although for them the obstacles may be higher than for bigger organizations. There is often no specific CSR department or person in the organization, and the time-consuming activity of assessing scope 3 emissions is therefore not executed. The standards provided by the GHG Protocol do tackle problems experienced by small companies since they require specific knowledge and are time-consuming Also, SMEs account for 75% of the turnover in the construction industry (G. Termeer, personal communication, January 8 2013).

## 1.2 Company profile

The research will be carried out at WZK. WZK is a company that helps companies to engage in sustainability. Their portfolio contains companies in different industries. Depending on the needs of the client an approach is chosen, either integral or specified to a certain area of sustainability. The areas depicted by WZK are: 1) Feel – inspiration, 2) Act – innovation, 3) Look – communication (see Figure 3).

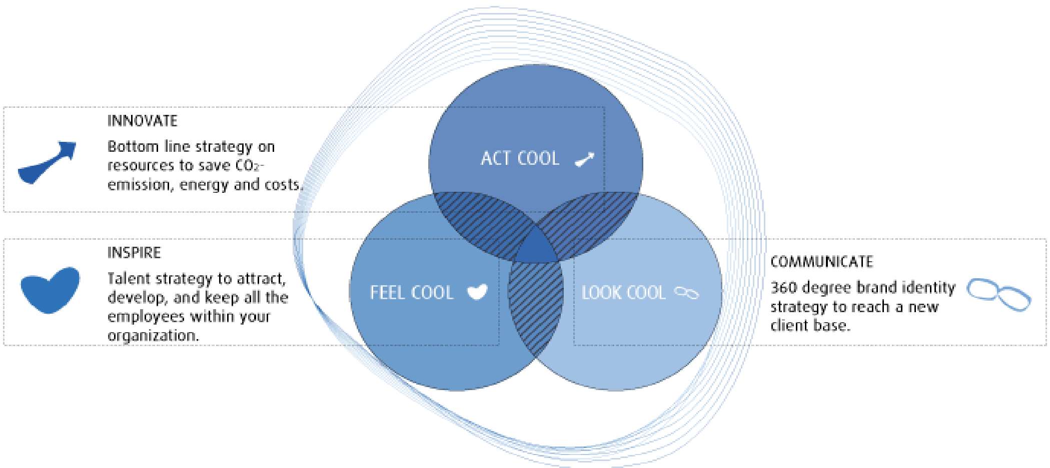



**Figure 3 Approach towards sustainability by WZK. Source: www.wzk.me/what_we_offer**

In WZK's website own words: "Change requires insight" (www.wzk.me). Therefore, WZK developed the Sustainability Navigator. It is a tool that is custom-made for clients, through which emissions can be assessed and monitored over time. Scope 3 emissions can be included in the Sustainability Navigator. The Navigator builds on foot-printing methodology and state-of-the-art sustainability measures.

# 2 RESEARCH DESIGN

This chapter entails the research design, containing the research motive, the problem definition, the research goal, the research questions, and the research methodology. The structure is based on the book by Verschuren and Doorewaard (2005).

## 2.1 Research motive

Organizations' understanding of the positive impact Corporate Social Responsibility (CSR) can have on their sales, customers' perception and competitive advantage is rising. Several pressures lead organizations in this direction (Seuring and Müller, 2008). Assessing, monitoring and reporting Greenhouse Gas Emissions (GHGE) is part of this wider CSR practice. In the quest to assess and monitor GHGE difficulties arise. The motive for this research is to help SMEs in this process and to solve part of the difficulties, thereby speeding up the transition to a more sustainable society.

## 2.2 Problem definition

Paragraph 1.1 provides an extensive background on the problem addressed in this research. The summary of the problem definition will be given here.

The construction industry can play a pivotal role in assessing and minimizing upstream scope 3 emissions. Obstacles exist for small and medium enterprises (SMEs) in the construction industry to start this endeavour. It is often perceived as a difficult, time-consuming activity or even unknown to SMEs. The GHG Protocol developed two standards to assess upstream scope 3 emissions: the Scope 3 Standard and the Product Standard. The standards range from large- to fine-scale, and can be either input-output, hybrid, or process-based life cycle assessment models, see Figure 4.

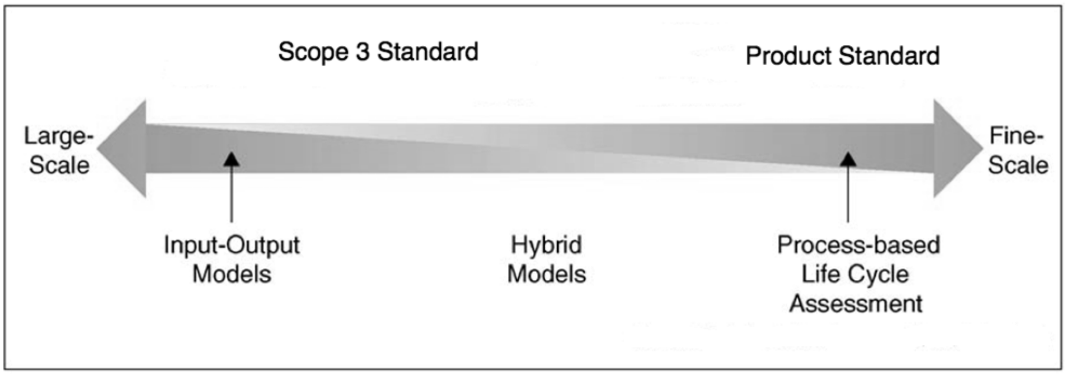



**Figure 4 Range of models to assess scope 3 emissions. Source: Peters, 2010 (figure is edited)**

The standards are however extensive, aimed at large organizations and time-consuming to use. SMEs mostly do not have a CSR department or a person responsible for sustainability to overcome these obstacles. Opportunities for competitive advantage, innovation and changing customer demands therefore stay untouched. WZK acknowledges these difficulties.

Therefore, the problem definition is:

> *SMEs in the construction industry do not know how to combine and use the Scope 3 Standard and the Product Standard to assess upstream scope 3 emissions in an effective and efficient way*

Effectiveness refers to the achievement of the desired or intended result, while efficiency refers to the achievement of maximum productivity with minimum wasted effort or expense. When assessing both effective *and* efficient, effort (in terms of time and expertise) and expense (in terms of money) are at its minimum while achieving the desired result. Each underlined section is commented on more thoroughly in 'Appendix A – Problem definition terms'.

## 2.3 Research goal

The goal of this research is to:

> *Develop a method for SMEs in the construction industry based on the Scope 3 Standard and the Product Standard, to assess upstream scope 3 emissions in an effective and efficient way.*

Every aspect of this research goal has been elaborated on in detail in 'Appendix A – Problem definition terms', except from 'method'. According to Oxford Dictionaries (www.oxforddictionaries.com), a method is *"a particular procedure for accomplishing or approaching something".* In the context of this research, the method that will be developed (1) includes consecutive steps to follow focused on efficiency, (2) includes goal-setting, in order to be effective and (3) provides a practical alternative for extensive methods currently available. With this method SMEs in the construction industry will hopefully be able to overcome the obstacles currently present.

This research is facilitated by WZK. It will provide WZK with a method to work in an effective and efficient way on upstream scope 3 emissions. This method can be used to supplement the Sustainability Navigator.

## 2.4 Research questions

The main research question is based on the problem definition and the research goal:

> *What is an effective and efficient method for a SME in the construction industry to assess upstream scope 3 emissions, by combining the Scope 3 Standard and the Product Standard?*

To find an answer on this research question, several sub-questions are added. The first step is to understand the topic of assessing scope 3 emissions. This can be achieved through investigating the underlying theoretic models of assessment methods. It is essential to understand these models before moving to the further in this research, since the methods can be placed in their theoretical framework. The first question therefore is:

1. What are the underlying theoretic models to assess upstream scope 3 emissions?

After these underlying models have been investigated, the assessment methods that have been developed through these theoretic models can be investigated. The second research question becomes:

2. How are upstream scope 3 emissions assessed in available methods?

Both the academic world as reporting organizations consider the Greenhouse Gas Protocol as leading source on the topic of assessing upstream scope 3 emissions. This research is therefore focused specifically on the Scope 3 Standard and the Product Standard (both published by the GHG Protocol), two sub-questions are added to this second research question, being:

   a. How does the Scope 3 Standard assess upstream scope 3 emissions?
   b. How does the Product Standard assess upstream scope 3 emissions?

The Standards provide guidance to assess scope 3 emissions. However, the Standards are aimed at large organizations and are not sector-specific. Therefore it is necessary to investigate both Standards on their effectiveness and efficiency when used by a construction industry SME. This will give insight in the advantages and disadvantages of these Standards when used in practice. Case studies will be used to answer the third question, which is:

3. How can an SME in the construction industry use the Scope 3 Standard and the Product Standard effectively and efficiently to assess upstream scope 3 emissions?

When insight in effectiveness and efficiency of both Standards is available, a method can be designed that combines both Standards. This method will focus on the effective and efficient elements of both Standards, and add other elements where necessary. The designed method will be aimed at an SME in the construction industry. The fourth question is:

4. Which method can be designed for an SME in the construction industry to assess upstream scope 3 emissions?

To structure the research, these questions will be captured in a methodology.

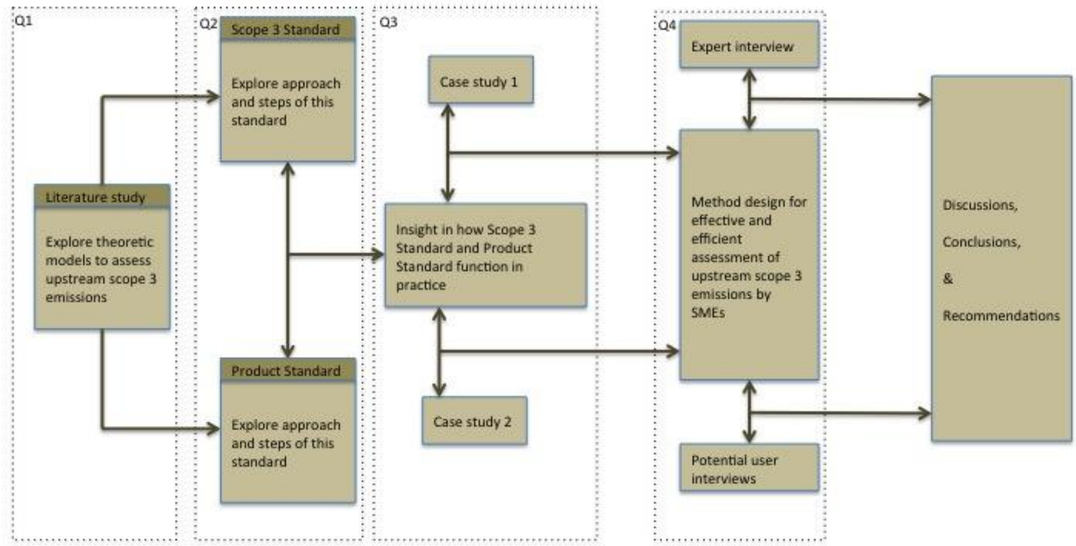
## 2.5 Research methodology

The research is divided into five phases. Each phase is coupled to a research question, while the fifth phase contains conclusions and recommendations. Every research phase also has an approach, depending on the research question that is investigated. Table 1 provides an overview of the different phases.

**Table 1 Research phases**

| Phase | Research question | Description of the approach | Results provided in |
|---|---|---|---|
| 1 | 1 | Literature research | Chapter 3 |
| 2 | 2 | Research on Standards | Chapter 4 |
| 3 | 3 | Case studies | Chapter 5 |
| 4 | 4 | Method development and interviews | Chapter 6 |
| 5 | - | Conclusions and recommendations | Chapter 7 |

The research phases are linked with each other to be able to provide an answer on the main research question. Through confrontations between different elements of phases and/or phases a consecutive order is composed to execute this research. A representation of this research model is visible in Figure 5. Besides the five phases and their elements, also the time frame of these phases is included in the lower part of the figure. Each phase will be described in more detail, except for the fifth phase, since that phase does not need further explanation.




| Phase 1 | Phase 2 | Phase 3 | Phase 4 | Phase 5 |
|---|---|---|---|---|
| Theoretical understanding | Research on Standards | Case studies | Method design, expert interview and potential user interviews | Discussions, conclusions and recommendations |
| Chapter 3 | Chapter 4 | Chapter 5 | Chapter 6 | Chapter 7 |

**Figure 5 Research model**

### 2.5.1 Phase 1

In the first phase the literature on methods to assess upstream scope 3 emissions will be explored. This is an essential starting point, since it is important to know the underlying theories of the Standards that will be investigated in the second phase.

The literature research contains two main elements, namely (1) an existing literature review to select articles and (2) an own literature research to select articles. An existing literature review is used as starting point because it can save a lot of time and is useful to quickly gain more understanding on the topic. Since there is no extensive body of research on scope 3 emissions and therefore no existing literature review, a related concept is chosen to select a literature review. This selected concept is carbon accounting (of which carbon footprinting is used sometimes as synonym or as element), executed by Stechemesser and Guenther (2012). Stechemesser and Guenther divided the literature in four sections of which carbon accounting at the organizational scale was the most relevant. The steps used to select the most relevant articles for this research are:

1. exclude articles not related to carbon accounting at the organizational level
2. review paper-abstracts using inclusion criteria, being:
    a. articles about demarcation of assessing scope 3 emissions
    b. articles about methods for assessing scope 3 emissions
3. review paper-abstracts using exclusion criteria, being:
    a. articles with too much focus on public bodies (this research focuses on non-public organizations)
    b. articles already found in previous search
    c. the article is not free of charge

After this first element of the literature research, an own literature research was executed. For this purpose, the methodology outlined by Moody (2009) is used, but is adjusted for limitations of this research. The exact approach of the literature research methodology is outlined in Chapter 3. The existing literature approach led to four relevant articles, while the own literature research complemented this number with 22, resulting in a total of 26 relevant articles, listed in 'Appendix B – List of articles found in literature research'.

Insights on upstream scope 3 emissions found in literature will be confronted with information found in other relevant sources, leading to the answer on the first research question.

### 2.5.2 Phase 2

In the second phase models used in practice, and more specifically, the Scope 3 Standard and the Product Standard are investigated (WRI & WBCSD, 2011a,b). Both Standards can be used to assess upstream scope 3 emissions, however they have a different approach. The findings of this second phase will lead to a thorough understanding of both Standards to assess upstream scope 3 emissions. This will be used as input for the third phase.

### 2.5.3 Phase 3

The third research question relates to effectiveness and efficiency (see paragraph 2.2 and 'Appendix A – Problem definition terms'). Case studies will be used to test both Standards in practice. The goal of the case studies is to deliver input for the method that will be developed in phase 4. The approach for the case studies will be elaborated in more detail.

Case studies have been captured in a wide variety of definitions. Despite this variety leading to fuzziness around the edges of the definition of a case study, "it does not mean that it is lacking in distinctive characteristics" (Gerring, 2004). Gerring compares the case study design with the cross-unit research design leading to some distinctive characteristics. The main three characteristics why a case study suits the needs of research question 3 are (Gerring, 2004):

- Descriptive inference (opposed to causal inference; *how* question is tried to be answered)
- Exploratory strategy of research (opposed to a theory confirmatory strategy)
- Causal insight is based on causal mechanisms (opposed to causal effects; which method is efficient and/or effective)

These characteristics are not definitive; they do however indicate why a case study is suitable in this respect.

Seawright and Gerring (2008) argue that neither random case selection nor purely pragmatic case selection will be beneficial for the quality of the results of a case study research. They argue that a purposive case selection strategy is the best solution, either quantitative or qualitative. Seawright and Gerring (2008) derived seven case study types from these cross-case characteristics: typical, diverse, extreme, deviant, influential, most similar, and most different. For this research, which is focused on SMEs in the construction industry, most similar cases will be selected. Both case studies are in the construction industry, are preferably a small organization and are focused on a single product.

The template for the case studies in this research is based on Gerring and McDermott (2007). The case studies will be executed to investigate (1) effectiveness and (2) efficiency of the Standards. To investigate the Standards, *both* Standards will be applied on *both* cases. Four different scenarios are created in this way (see Table 2).

**Table 2 Case studies and Standards**

| | Standard used | Case characteristics | Insight in efficiency | Insight in effectiveness |
|---|---|---|---|---|
| Case 1 | Scope 3 | $X_A$ | $Y_A$ | $Z_A$ |
| Case 1 | Product | $X_A$ | $Y_B$ | $Z_B$ |
| Case 2 | Scope 3 | $X_B$ ( $\approx X_A$) | $Y_C$ | $Z_C$ |
| Case 2 | Product | $X_B$ ( $\approx X_A$) | $Y_D$ | $Z_D$ |

Both efficiency and effectiveness will be investigated in the case studies. Regarding efficiency, variables concern which and how much resources (e.g., time, money, expertise) are needed to use the method. Effectiveness concerns achieving the desired result. The variables used for the case studies are listed in Table 3.

**Table 3 Variables on efficiency and effectiveness.**

| | Efficiency | Effectiveness |
|---|---|---|
| Variables | Resources needed<br>- time<br>- money<br>- expertise | Goal attainment:<br>- % of emissions covered<br>- accuracy<br>- insight in proportions and quality |

The first case will be the case of *De Groene Paal*, which is Dutch for The Green Pole. This small company has 5 employees and is based in Amsterdam. It has created an innovative product, being a reinforced concrete foundation with an integrated heat pump. They have a strong focus on sustainability, and can use results of the case study for example for innovation or communication purposes. The second case will be that of *Omnia Plaatvloeren*, a Dutch company producing concrete floor slabs. More information on both cases will be provided in Chapter 6.

### 2.5.4 Phase 4

In this phase the knowledge gathered so far will be used to design a method whereby an SME in the construction industry can effectively and efficiently assess upstream scope 3 emissions. The method that will be developed will be based on (parts of) the two Standards, consists of consecutive steps and includes goal setting. In this phase an expert from the GHG Protocol Initiative will be contacted to discuss the proposed method. Furthermore, potential users of the method will be interviewed. In this way a reflection is possible on the method developed in this phase.

# 3 UNDERLYING THEORETICAL MODELS

This chapter will give a theoretical understanding of underlying theoretical models to assess scope 3 emissions. The research question that will be answered in this chapter is question 1, being:

*What are the underlying theoretic models to assess upstream scope 3 emissions?*

The chapter gives insight in what scope 3 emissions exactly are (paragraph 3.2) and which theoretic framework is the basis for the methods used in practice (paragraph 3.3). It will also be clear where and how these methods are applied, and what the difficulties are (paragraph 3.4). This chapter therefore leads to the choice of the models that will be investigated in Chapter 4, described in the conclusions (paragraph 3.5).

## 3.1 Introduction

In this paragraph the own literature research methodology that was used will be explained, as well as why there is a need for models to assess scope 3 emissions.

### 3.1.1 Literature research methodology

The literature research methodology is based on Moody (2009). The original approach is exhaustive and provides great results, but is also very time-consuming. Moody (2009) states that his methodology is well suited for a dissertation project, but since this research is a master thesis the adjusted approach is acceptable. Both the original approach and the adjusted approach are presented in Table 4.

**Table 4 Literature research methodology, based on Moody (2009)**

| | Step | Original | Adjusted |
|---|---|---|---|
| 1 | Clearly defined and justified choice of search engine. | Determine top-25 relevant journals based on rankings and ensure 100% coverage. Hand search journals not covered by the search engine used. | Assumed that including two main search engines (ScienceDirect and Web of Science) and a complementary Google Scholar search is sufficient. Journals not covered will not be hand-searched. |
| 2 | Clearly defined choice of key words. | Search on a topic using all terms used for that topic and all different ways of spelling them. | Identical approach. |
| 3 | Clearly defined selection criteria. | Review paper-abstracts to include or exclude papers based on inclusion and exclusion criteria. | Apply inclusion and exclusion criteria on paper titles as first step, and on paper-abstracts as second step when title was relevant. |
| 4 | Clearly defined prioritization criteria. | Prioritize papers based on criteria. For instance, based on journal rankings or number of citations. | No prioritization applied due to limited number of articles. |
| 5 | Critical evaluation and synthesis of papers. | Clearly describe which studies make the same claims and which contradict. Evaluate the strength of the arguments used. | Identical approach. Presented in Chapter 3. |

In the first step of this literature research two search engines were selected, ScienceDirect and Web of Science. To check whether relevant articles were missed, a ‘top-of-the-list’ Google Scholar search was executed on the different key words.

Regarding the choice of keywords, the starting point was to search for “scope 3 emissions”. Some hits were similar across these search engines. To limit the possibility of missing relevant articles, different synonyms and search specifications were used, as shown in Table 5. Since the Greenhouse Gas Protocol is very important in this research, this was also used to search for relevant articles.

**Table 5 Literature research in numbers**

| **Search engine key words** | ScienceDirect | Web of Science | After inclusion/excl. |
|---|---|---|---|
| “scope three emissions” | 45 | 9 | 9 |
| “scope 3” emissions | 231 | 14 | 2 |
| “scope 3” boundaries | 364 | 9 | 1 |
| “greenhouse gas protocol” | 3 | 20 | 2 |
| **Subtotal** | 643 | 52 | **14** |
| | | | |
| Google Scholar search | | | 6 |
| Forward citation analysis | | | 2 |
| Existing literature review | | | 4 |
| **Total** | | | **26** |

The inclusion and exclusion rules used for the literature research are identical to the ones used by Stechemesser and Guenther. After applying these first three steps derived from Moody (2009), 14 articles were selected using Science Direct and Web of Science. Six articles were added, which were found through Google Scholar. An additional forward citation analysis applied on one specific article f resulted in three more relevant articles. Of these three, one was not available free of charge and therefore excluded.

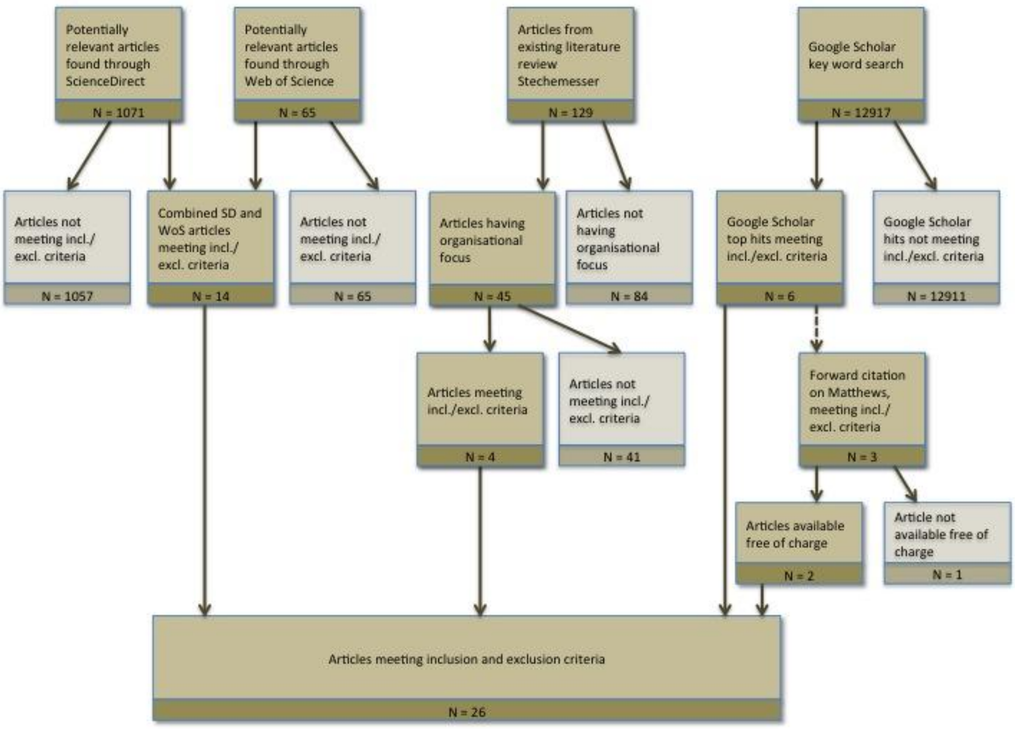



**Figure 6 Literature research flowchart**

Adding the four articles found in the existing literature research, as described in paragraph 2.5.1, an amount of 26 relevant articles was found (see Table 5). On these articles step 4 and 5 of the research methodology presented in Table 4 can be executed. As shown, no specific prioritization will be done. The research synthesis will be presented in paragraph 3.2. The whole process is shown in Figure 6. The articles found through this literature research are listed in 'Appendix B – List of articles found in literature research'.

### 3.1.2 The necessity of modelling

The necessity of modelling upstream scope 3 emissions is most easily explained when visualized. This visualization is presented in Figure 7, representing the leaf of a fern. This leaf relates to the concept of fractals.

**Figure 7 Visualization of upstream scope 3 emissions**

According to Oxford Dictionaries (www.oxforddictionaries.com), a fractal is "*a curve or geometrical figure, each part of which has the same statistical character as the whole. They are useful in modelling structures (such as snowflakes) in which similar patterns recur at progressively smaller scales (...)*". Benoit Mandelbrot introduced the term fractal in 1975, followed by huge popularity in the mathematical world (Ryu, Moon et al., 2012). The recurring element, or self-similarity, is essential to explain the necessity of modelling. To start assessing all relevant scope 3 emissions for the reporting organization, information is required from scope 1, 2 and 3 emissions from tier 1 suppliers. To compose an inventory of the tier 1 supplier, this supplier needs information from its own suppliers as well. This is the moment where the self-similarity comes in; another leaf for the tier 1 supplier can be composed with its own embranchments (smaller embranchment in Figure 7). This self-similarity happens again when assessing the emissions of tier 2 suppliers. This recurring process can go on until raw materials. This process can be very time-consuming or even impossible due to data-availability, wherefore modelling is essential. An optimum has to be found between how much effort it takes to compose the scope 3 inventory (input such as time and money), and how complete the inventory is (output such as completeness and accuracy).

The leaf in Figure 7 can be regarded as the underlying theory; when this is changed into a visualization of the system of upstream scope 3 emissions Figure 8 is the result. In this figure it becomes clear that scope 3 emissions actually 'cascade' through the supply chain. To assess precisely the upstream scope 3 emissions, information from every upstream supplier would be necessary.

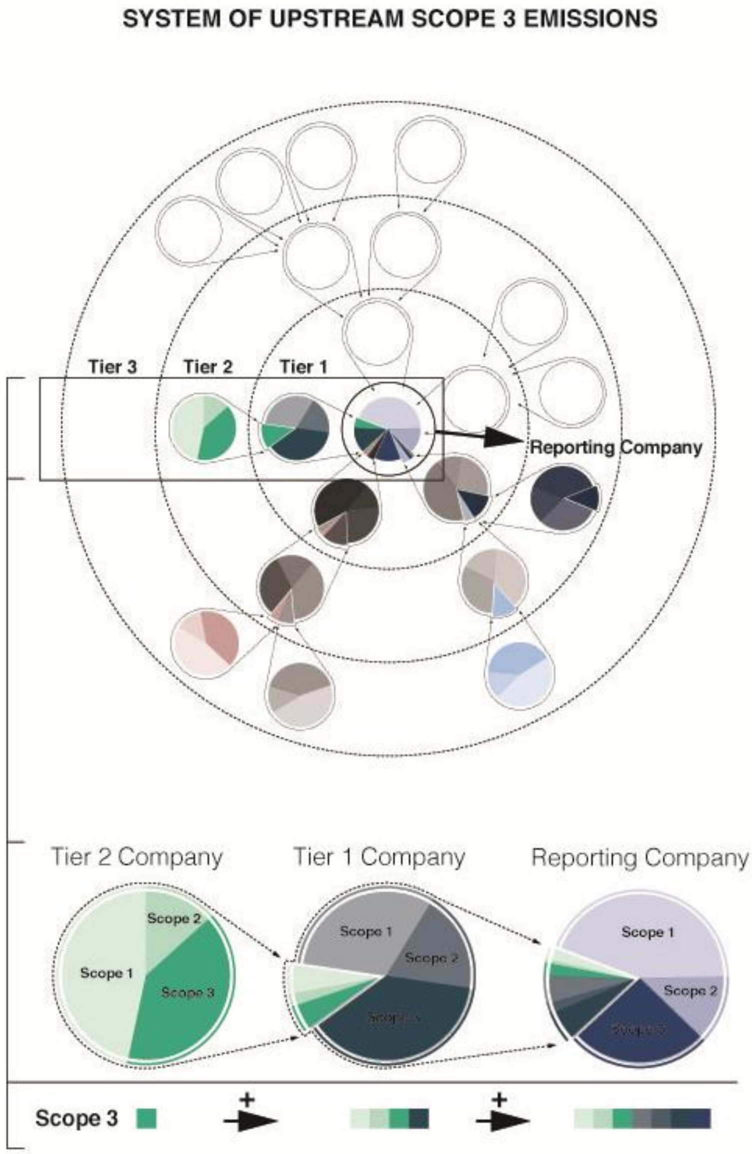



**Figure 8 System of upstream scope 3 emissions**

## 3.2 Insights on scope 3 emissions

In academic literature several insights are available on what scope 3 emissions actually are. These insights are synthesized here. First the general insights will be discussed, then sector wide approaches, concluded by specific cases of organizations assessing upstream scope 3 emissions. In 'Appendix B – List of articles found in literature research' an overview is given of which article is used for which specific subparagraph.

### 3.2.1 General insights

The starting point of scope 3 reporting is to set organizational boundaries, which can be based on legal, financial, or business control, as in the GHG Protocol. Expanded boundaries go hand in hand with increased difficulties, which resulted in the voluntary characteristic of assessing scope 3 emissions. The end value of an upstream scope 3 inventory is indicated in $CO_2$ equivalent ($CO_2e$) mass based on 100 years global warming potential (Pandey, Agrawal et al., 2011).

Matthews, Hendrickson et al. (2008) focus on 'carbon footprint estimation boundaries'. The GHG Protocol is a main source of information in their article, which states that scope 3 emissions include the total supply chain up to the production gate, also known as 'cradle-to-gate' emissions. Simplicity in the design of protocols is essential, especially when accounting for scope 3 remains voluntary. Matthews, Hendrickson et al. (2008) state that flexibility and cost-effectiveness can lead to the situation where scope 3 emissions can have higher impact than focussing on scope 1 and/or 2. Including more scope 3 emissions will lead to a higher possibility of effective mitigation strategies than when leaving some emission out (Matthews et al., 2008; Huang et al., 2009a). Good information on the process to report scope 3 emissions is helpful, which makes categorization of emissions a critical element. Another advice for protocol organizations such as the GHG Protocol is to present industry-specific guidelines; it will be a huge improvement to the portion of upstream scope 3 emissions captured. In these guidelines prioritization (e.g., commuting has a higher impact in the service sector than in the industrial sector) is an essential element (Huang, Weber et al. 2009a).

The sector-specific guidelines are also mentioned by Huang, Lenzen et al. (2009c). They also state that scope 3 emissions are difficult to grasp as a percentage of the total scope 3 emissions, "because unless 100% of a footprint is already known, 95% cannot be calculated" (Huang et al., 2009c). This is a valid point, especially in the light of the theory of fractals presented in Figure 7. Downie and Stubbs (2011) add that academic and/or practitioner literature "has not published which or how many scope 3 emission factors constitute a comprehensive assessment". A complete footprint is always desirable, however different levels of accuracy and completeness are necessary to address different needs (Huang, Lenzen et al., 2009c).

In the literature double-counting is mentioned as possible issue. This is the process that several organizations account for the same set of emissions.

### 3.2.2 Insights in different sectors

Information on expenditure is often used as the input for scope 3 emission assessment (Huang, Weber et al., 2009b; Brown, Buettner et al., 2012). Brown, Buettner et al. (2012) investigated emissions of Australian ambulance services, while Huang, Weber et al. (2009b) focused their research on electronics manufacturing and computer services. When no money is spent on something it is not included in the calculation of scope 3 emissions. Employee commuting is an example of an upstream scope 3 emission source, which is not included when one follows this line of reasoning (WRI and WBCSD, 2011a). Huang, Weber et al. (2009b) state that it is not feasible to include every tier 1 supplier, since that would require enormous calculations. Therefore, they select the top 10 tier 1 suppliers, admitting that the number 10 is arbitrary. Increasing the number of suppliers included will increase the carbon footprint that is captured; therefore this decision is causal to the size of the scope 3 inventory. The issue of which and how many suppliers should be included is related to the nature of the organization. Large organizations often have more suppliers than small organizations and therefore experience this issue more often.

**Table 6 Emission sources reported by respondents. Source: Downie & Stubbs, 2011**

| Emission Source | Respondent ID 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | Times Reported |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flights | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● | | 19 |
| Waste | | ● | | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | | ● | | ● | ● | ● | | 16 |
| Paper | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● | | ● | | | ● | ● | | | | | 14 |
| Staff/Contractor Vehicles | | ● | ● | | ● | ● | ● | ● | ● | ● | ● | | | ● | ● | | ● | ● | ● | | | | 14 |
| Fuel, Gas & Electricity Scope 3 | | | ● | ● | ● | ● | ● | ● | | ● | | ● | ● | ● | ● | | | | | | | | 11 |
| Taxis | | | ● | ● | ● | ● | | ● | ● | ● | ● | | ● | | | | | | | | | | 9 |
| Base Building Emissions | ● | ● | ● | ● | | | ● | ● | | | | | | | | | | | | ● | | | 7 |
| Couriers | ● | ● | ● | ● | ● | | ● | | | | | | | | | | | | | | | | 6 |
| Hire Cars | | | | | ● | ● | | | ● | ● | ● | | | | | | | ● | | | | | 6 |
| Public Transport | | ● | | ● | | | ● | | ● | | | ● | | | | | | | | | | | 5 |
| Water Supply & Wastewater Treatment | ● | | ● | ● | ● | ● | | | | | | | | | | | | | | | | | 5 |
| Hotel Accommodation | | | ● | | | ● | | | ● | | | | ● | | | | | | | | | | 4 |
| Computer Equipment | ● | ● | ● | | | | | | | | | | | | | | | | | | | | 3 |
| Employee Commuting | | | | ● | | | | ● | | | | | | | | | | | ● | | | | 3 |
| Freight | ● | | | | | | | | | | | | | | | ● | | | | | | ● | 3 |
| Office Furniture & Fixtures | | ● | ● | | | | | | | | | | | | | | | | | | | | 2 |
| Office Stationary and Consumables | ● | ● | | | | | | | | | | | | | | | | | | | | | 2 |
| Packaging | ● | | | | | | | | | | | | | | | | | | | | | ● | 2 |
| Phones/Internet Usage | ● | ● | | | | | | | | | | | | | | | | | | | | | 2 |
| Postage | | ● | | | | | ● | | | | | | | | | | | | | | | | 2 |
| Printing (if calculated differently to Paper) | | ● | | ● | | | | | | | | | | | | | | | | | | | 2 |
| Catering | | | ● | | | | | | | | | | | | | | | | | | | | 1 |
| Cleaning | ● | | | | | | | | | | | | | | | | | | | | | | 1 |
| Electricity for POS Equipment | | | | | | | | | | | | | | | | ● | | | | | | | 1 |
| Equipment | ● | | | | | | | | | | | | | | | | | | | | | | 1 |
| Events | | | | ● | | | | | | | | | | | | | | | | | | | 1 |
| Fire Extinguishers | | | | | ● | | | | | | | | | | | | | | | | | | 1 |
| Ink & Chemicals | ● | | | | | | | | | | | | | | | | | | | | | | 1 |
| Planting Activities | | | | | | | | ● | | | | | | | | | | | | | | | 1 |
| Product Usage | | | | | | | | | | | | | | | ● | | | | | | | | 1 |
| Livestock | | | | | ● | | | | | | | | | | | | | | | | | | 1 |
| Refrigerant Loss from POS Equipment | | | | | | | | | | | | | | | | ● | | | | | | | 1 |
| Repairs | ● | | | | | | | | | | | | | | | | | | | | | | 1 |
| TOTAL Emission Sources | 13 | 13 | 12 | 12 | 11 | 9 | 9 | 9 | 7 | 6 | 6 | 5 | 5 | 5 | 5 | 4 | 4 | 4 | 3 | 3 | 2 | 2 | |
| Total scope 3 as % of Total Emissions | 65 | * | 59 | 41 | 23 | 28 | 24 | 61 | * | 46 | 83 | 81 | 15 | 9 | 90 | * | 64 | 15 | 9 | 48 | 45 | * | |

*Undisclosed.

Downie and Stubbs (2011) investigated scope 3 reporting practices at a wide range of Australian companies. In total they included 22 respondents, providing interesting insight on scope 3 emission issues. An interesting difference is in who actually determines what to include and what to exclude when reporting scope 3 emissions. Some companies were assisted by external consultants, some left the decision to a single individual within the company and the remaining companies had internal discussions before arriving at their scope 3 inventory (Downie and Stubbs, 2011). After determining who is responsible for this decision, the inclusion rules are the next step. Downie and Stubbs (2011) noticed that half of their respondents (11) were limited by the availability of activity data. Furthermore, a majority of 20 companies had no formal criteria for determining which sources to include. Four companies reported that their decisions were entirely subjective. An overview of sources that were reported by the respondents in the study by Downie and Stubbs (2011) is presented in Table 6. A similar conclusion can be drawn from the work by Pandey, Agrawal et al. (2011) where different tiers are included and excluded by a wide variety of organizations.

It is clear that authors acknowledge the challenges when assessing upstream scope 3 emissions in sectors. Including *all* suppliers is almost impossible, and different approaches exist to compose an inventory. Sometimes this is done using a certain logic (Huang et al., 2009b), sometimes it appears to be done randomly (Downie and Stubbs, 2011).

### 3.2.3 Insights in specific cases

Plambeck (2012) describes the case of Walmart, a company that requests their tier 1 suppliers to assess and report their GHG emissions, and consecutively to report targets to reduce these emissions. When emissions form tier 1 suppliers were evaluated it was evident that many of the high-impact processes happened further upstream in the supply chain. The tier 1 supplier information then helped to identify these sources, and Walmart was able to look further upstream to cut scope 3 emissions (Plambeck, 2012).

Several authors have published about companies or authorities assessing scope 3 emissions by using the GHG Protocol. The Corporate Standard, in which general guidance on scope 3 emissions is given, is used in all cases, since the Scope 3 Standard was not published yet. Ozawa-Meida, Brockway et al. (2011) and Larsen, Pettersen et al. (2011) investigated the emissions of two universities: the De Montfort University (United Kingdom) and the Norwegian University of Technology and Science (NTNU). Both authors use spend information to calculate scope 3 emissions. The main difference between Larsen, Pettersen et al. (2011) and Ozawa-Meida, Brockway et al. (2011) is in the inclusion of emissions from investments by the former, and the focus on travel emissions by the latter. The calculation of travel emissions requires certain assumptions. Table 7 shows an overview of included emission sources by Ozawa-Meida et al. (2011).

**Table 7 University's relevant emission sources related to scopes of GHG Protocol. Source: Ozawa-Meida et al., 2011**

| Consumption-based analysis categories | Relevant DMU GHG emission sources | GHG Protocol scopes 1–3 emissions |
|---|---|---|
| Building energy | • On-site natural gas combustion: DMU-owned buildings[a] | • Scope 1 |
| | • Indirect emissions from gas supply: DMU-owned buildings | • Scope 3 |
| | • Natural gas supply and combustion: private halls of residence | • Scope 3 |
| | • On-site biomass combustion: DMU-owned buildings[b] | • Reported separately as a memo item |
| | • Upstream life-cycle emissions from biomass use in DMU-owned buildings[b] | • Scope 3 |
| | • Grid electricity use in DMU-owned buildings[c] | • Scope 2 |
| | • Indirect emissions from grid electricity use in DMU-owned buildings[d] | • Scope 3 |
| | • Direct and indirect emissions from grid electricity use: private halls of residence | • Scope 3 |
| Travel | • DMU-owned fleet diesel consumption[e] | • Scope 1 |
| | • Well-to-wheel emissions from diesel consumption[f] | • Scope 3 |
| | • Staff and student commuting (all modes)[g] | • Scope 3 |
| | • Business travel (all modes) | • Scope 3 |
| | • Students' trips from home to university (UK and international students) | • Scope 3 |
| Procurement | • Purchase of goods and services in the university | • Scope 3 |

[a] Heat generation based on gas natural and biomass is conducted within the University premises, nor external heat or steam is purchased.
[b] Wood pellets are used only in one academic building for heating purposes since 2008/09. Only indirect life-cycle emissions for the logging, processing and transportation of the wood pellets are considered (within the Scope 3 emissions and building energy category). Actual emissions when biomass is combusted were not taken into account as they are considered to be equivalent to the $CO_2$ absorbed in the growth of biomass and there is no net increase in the $CO_2$ atmospheric concentrations (consistent with the GHG Protocol).
[c] Emissions at the point of final electricity consumption, including emissions from generation and from transmission and distribution losses.
[d] Indirect emissions from UK national grid includes GHG emissions associated with the extraction and transport of primary fuels as well as the refining, distribution and storage of finished fuels used in the power stations.
[e] Only includes emissions from combustion in the vehicles.
[f] Only includes emissions from the extraction, transport of primary fuels, refinery, distribution, storage and retail of the final fuels used in the vehicles (from well-to-wheels).
[g] Emission from combustion in the vehicles and from the extraction, transport of primary fuels, refinery, distribution, storage and retail of the final fuels used in the vehicles.

**Table 8 Overview of sources included in UK Central Government study. Source: Wiedmann and Barrett, 2011**

| Category | Description | Included in study |
|---|---|---|
| Purchased goods and services – direct supplier emissions | Scope 1 and 2 emissions of tier 1 suppliers | Yes |
| Purchased good and services – cradle to gate emissions | Extraction and production of inputs (tiers 1, 2, 3, 4, etc.) | Yes[a] |
| Energy-related activities not included in scope 2 | Supply chains impacts of electricity generation | Yes |
| Capital equipment | Manufacturing/construction of capital equipment | No[b] |
| Transport and distribution | External transportation and distribution of inputs | Yes |
| Business travel | Employee business travel | Yes |
| Waste generated in operations | Disposal/treatment of waste generated in operations | Yes |
| Leased assets | Manufacturing/construction and operation of leased assets | Yes |
| Investments | GHG emissions associated with investments | No[b] |
| Transport and distribution | Transportation and distribution of sold products | Yes |
| Use of sold products | Use of sold goods and services (downstream) | No |
| Waste | Disposal of sold products at the end of their life (downstream) | No |
| Employee commuting | Employees commuting to and from work | No |

[a] The footprint of Defence excludes imported products for defence, see Supplementary material B: technical report.
[b] Capital investment (as part of the category 'capital formation' in the final demand section of the National Accounts) has not been included. However, some smaller investments made in whole during the one-year accounting period (e.g. the purchase of office computers) have been included as part of intermediate consumption and the Defence expenditure statistics used to estimate the carbon footprint of defence activities also includes some capital elements (see explanations in Supplementary material B: technical report).

Wiedmann and Barrett (2011) conducted a research into the GHG emissions of the UK central government in the 1990-2008 period. Within scope 3 the main focus was on upstream emissions, see Table 8. Commuting was not included; the exclusion reason is that the government does not pay for it. Emissions related to capital investments were not included either.

Stein and Khare (2009) and Fallaha, Martineau et al. (2009) also used the GHG Protocol as main guidance source. The former conducted a study on how emissions are calculated for a chemical plant, while the latter investigated the case of a waste management plant. Stein and Khare (2009) included purchased utilities, capital projects, purchased raw materials, reagents and maintenance materials, and travel of employees and contractors. Interesting is that annual depreciation is used for capital projects, while the GHG Protocol prescribes *not* to use depreciation. Fallaha, Martineau et al. (2009) present system boundaries first, indicating which activities are included and which are not. Emissions of materials, goods and fuels are categorized as one source, and administrative aspects as the other. In the first source extraction, production and transportation are included, while in the second management and administration, bought services, and commuting and business travels are included (Fallaha et al., 2009).

The findings in the cases presented by the different authors show that the focus may be different in each study, as well as the number of sources and/or categories included. In general, information on procurement (or: spendings) often serves as input.

## 3.3 Theoretical models to assess upstream scope 3 emissions

First the background of available theoretical models will be discussed, then three different theoretical models will be commented on.

### 3.3.1 Background of theoretical models

The central theme around models to assess upstream scope 3 emissions is carbon footprinting. Sometimes a synonym like carbon accounting or GHG accounting is used. A widely adopted definition of 'carbon footprint' does not exist, but the notion of what it encompasses exists (Wiedmann, 2009a). According to Peters (2010) "the 'carbon footprint' of a functional unit is the climate impact under a specified metric that considers all relevant emission sources, sinks, and storage in both consumption and production within the specified spatial and temporal system boundary." It therefore should include all the traces that an activity (or organization) leaves behind. Carbon footprints have gained in popularity in the last few years (Wiedmann, Lenzen et al., 2009b).

The models used to indicate a carbon footprint of an organization can be either consumption-based or production-based. The latter can be used to assess scope 1 emissions, but is not suitable to assess scope 3 emissions (Larsen and Hertwich, 2009). Consumption-based models can be used to assess upstream scope 3 emissions, therefore these will be used for this research. They can allocate all upstream GHG emissions from the production processes to the reporting organization, or even to the final consumer (Larsen and Hertwich, 2009). In general, two distinctive methods exist: input-output analysis (IOA) and life-cycle analysis (LCA). Some authors refer to process analysis (PA), instead of LCA. Between those two a hybrid approach exists, often referred to as hybrid LCA. How these models relate to each is visualized in Figure 9.

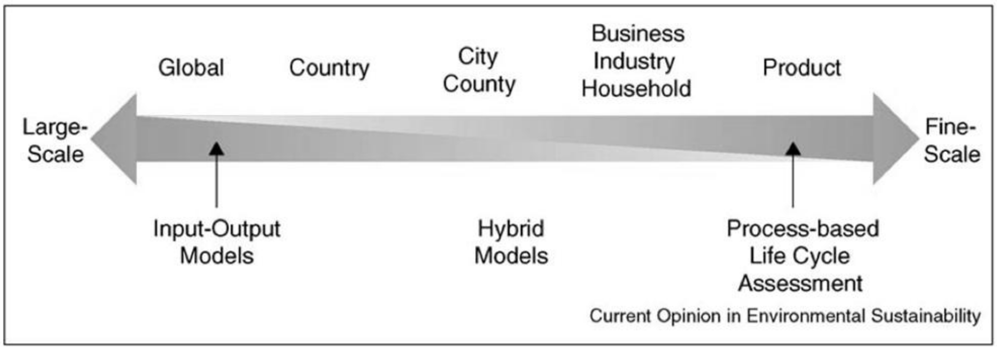



**Figure 9 Schematic overview of GHG emission models. Source: Peters (2010)**

The input-output, hybrid, and process-based life cycle assessment models will be explained more thoroughly in the following paragraphs. In addition some underlying models will be mentioned as well.

### 3.3.2 Input-Output Analysis

Input-Output Analysis (IOA) is a top-down approach, that can be used on a large scale (see Figure 9). "Economic input-output models were first developed by Leontief in 1936 to aid manufacturing planning" (Huang et al., 2009c). Linear algebra is used to trace all transactions throughout the supply-chain network up to the final demand of produced commodities by consumers. The total economic purchases required for a given demand can be calculated with this technique (Huang et al., 2009c). Lenzen wrote that IOA *"is a top-down macroeconomic technique using sectoral monetary transactions (..) to account for the complex interdependencies of industries in modern economies"* (Brown et al., 2012). Opposed to life-cycle analysis (LCA), IOA can also take into account non-physical flows (Larsen, Solli et al., 2012). Leontief showed in 1970 that IOA "could be used to analyze pollutants (as opposed to monetary transactions) as integral components of economic processes, and since then the technique has been used in numerous studies to determine the resource flows and environmental impacts associated with the final consumption of economic sectors" (Brown et al., 2012). In 1978 Bullard already used IOA for scope 3 emission purposes. He suggested using IOA to obtain a first estimate of the upstream supply chain emissions (Huang et al., 2009c). In this way it can be useful in screening for significant sources.

The downside of IOA is that it has "substantial uncertainties related to, for example: sectorial aggregation; price, temporal, and spatial variation; sampling and imputation of the basic data source; assumption of proportionality between monetary and physical flows; and assumptions about international trade" (Huang et al., 2009c). Furthermore, "IOA often neglects the use of capital goods" (Larsen and Hertwich, 2009).

A specific part of IOA is Environmentally Extended Input Output (EEIO) analysis, which derived from adding environmental information to traditional IOA. It provides an alternative, economy-wide approach, making system cut-offs unnecessary. Larger entities can use it for calculations, but it is not suitable for individual products since it assumes homogeneity of prices, outputs and their carbon emissions at a sector level (Wiedmann, 2009a). EEIO analysis is an effective way to provide good quality, timely estimates of reliable accuracy, compared to LCA (Larsen et al., 2012). An EEIO model traces environmental footprints along supply and production chains, which is similar to economic IOA. It is well-suited to attain an overall GHG footprint of an organization, thereby identifying product groups and/or units responsible for it (Ozawa-Meida et al., 2011). It is therefore a resource-efficient way of analysing emissions once a suitable input-output model has been set up (Wiedmann and Barrett, 2011). More specifically, EEIO models combined with financial data have proven to be a possible solution to include scope 3 emissions (Larsen et al., 2011).

The downsides of EEIO are similar to those mentioned for IOA. In addition, Larsen, Pettersen et al. (2011) state that "most EEIO models are a few years old due to the time-consuming construction of increasingly complex models so that changes in production technology from year to year are not sufficiently captured".

### 3.3.3 Life-Cycle Analysis

Life-Cycle Analysis (LCA) is done on a fine scale, as visualized in Figure 9. It is generally used for the assessment of individual products, wherefore 'bottom-up' data of specific processes is needed (Ozawa-Meida et al., 2011). It includes all stages of producing a product, from raw materials, through producing, distribution, consumption/use, to the stages of disposal. Due to this broad approach, it is also referred to as cradle-to-grave analysis (Pandey et al., 2011).

According to Finkbeiner (2009), "the scientific LCA community has been somehow escaping (..) fundamental challenges of how to define a system, how to treat allocation, how to deal with data (..)". Finkbeiner is not trying to devaluate efforts on LCA; he thinks that using LCA for carbon footprints can help to bring more attention to the open issues of LCA. When pursuing this combination of LCA and carbon footprinting, a carbon footprint of an organization can be composed by the sum of every product's LCA (Peters, 2010).

LCA does have downsides. A core problem of LCA is the comparability of different product studies, due to different methods and assumptions. A standardization process can help in this respect (Larsen and Hertwich, 2009; Peters, 2010). Furthermore, it is a time- and resource-consuming method (Larsen and Hertwich, 2009).

### 3.3.4 Hybrid approach

Hybrid methods (or HLCA) combine the strength of both LCA and IOA (or EEIO), and are an active area of research. The method is increasingly being used in practice according to Larsen, Solli et al. (2012). Downie and Stubbs (2011) on the other hand notify in their study that there is a lack of uptake of the HLCA method. According to the authors this may be due to the selection criteria used in their study, which excluded companies that used external consultants.

The hybrid approach "uses IOA as a screening tool to determine the most significant individual scope 3 emission sources" (Downie and Stubbs, 2011). When necessary, further analysis is possible using LCA. Using only LCA is often too time-consuming, wherefore a mix of both approaches can offer the solution (Huang et al., 2009a). The ratio of IOA versus LCA can vary, thereby finding an optimum between accuracy, precision and cost efficiency (Wiedmann, 2009a; Pandey et al., 2011). By using IOA in this approach it is possible to account for the full upstream supply chain, therefore boundary cut-offs are avoided (Downie and Stubbs, 2011). The hybrid approach has the potential "to improve the validity of the respondents' GHGE assessments by ensuring they are comprehensive in capturing all relevant and material sources of emissions to the organization and removing the current subjectivity in emission source selection" (Downie and Stubbs, 2011). In this respect an accounting standard can be beneficial, although organization-specific scope 3 emissions will always occur. Difficulties of hybrid approaches are mostly in the field of data availability and lack of consistency between data sources (Peters, 2010). Furthermore, when used to assess emissions it often results in the application of IOA for the specific upstream scope 3 part, while LCA is used for scope 1 and/or 2 (Ozawa-Meida et al., 2011; Brown et al., 2012; Larsen et al., 2012).

## 3.4 Models used in practice

Several non-academic sources publish models too. These models are based on the theoretical models described in paragraph 3.3. In this paragraph a selection of available models will be discussed. These models are often published by NGOs, governmental agencies, or charities. Input from companies is often used to improve usability, awareness, and acceptance. First the Greenhouse Gas Protocol Initiative will be discussed, followed by other models and sources.

### 3.4.1 Greenhouse Gas Protocol Initiative

The Greenhouse Gas (GHG) Protocol Initiative is a combination of the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), and other partners. The WRI is an environmental NGO, based in the United States. The WBCSD is a Geneva-based coalition of 170 international companies. The Initiative was launched in 1998 with the mission to develop internationally accepted GHG accounting and reporting standards for business and to promote the adoption of these standards (WRI and WBCSD, 2004). The topic of this research, scope 3 emissions, was actually introduced by the GHG Protocol Initiative in 2001 in the first edition of the *GHG Protocol Corporate Accounting and Reporting Standard.* The standard and guidance were designed with the following objectives in mind (WRI and WBCSD, 2004):

- To help companies prepare a GHG inventory that represents a true and fair account of their emissions, through the use of standardized approaches and principles
- To simplify and reduce the costs of compiling a GHG inventory
- To provide business with information that can be used to build an effective strategy to manage and reduce GHG emissions
- To provide information that facilitates participation in voluntary and mandatory GHG programs
- To increase consistency and transparency in GHG accounting and reporting among various companies and GHG programs

The standard and corresponding tools are consistent with those proposed by the Intergovernmental Panel on Climate Change (IPCC) for compilation of emissions at the national level (WRI and WBCSD, 2004). It is also consistent with the Kyoto protocol, since it uses the same six Kyoto gases already mentioned in 1.1.3.

During time the GHG Protocol Initiative published revised versions of this first standard and complemented it with other documentation and calculation tools. The production of the publications is often done using a multi-stakeholder dialogue, resulting in broad acceptance across industries. Furthermore, it is referred to by different sources in academic literature (Finkbeiner, 2009; Huang et al., 2009a; Downie and Stubbs, 2011). The GHG Protocol Initiative therefore is a relevant source. And as it introduced the concept of scope 3 emissions, it is a good starting point.

In 2004 a revised version of the *GHG Protocol Corporate Accounting and Reporting Standard* was published, in which scope 3 emissions were mentioned again. Scope 3 emissions are “a consequence of the activities of the company, but occur from sources not owned or controlled by the company" (WRI and WBCSD, 2004). The inclusion of scope 3 emissions is voluntary according to this publication in 2004, giving reporting organizations complete freedom. Some examples of categories are given, as well as some general steps how calculations can be done. Since there is complete freedom given to reporting companies, no real demarcation guidelines are given.

In October 2011 the GHG Protocol Initiative published two new standards:

1. Corporate Value Chain (Scope 3) Accounting and Reporting Standard
2. Product Life Cycle Accounting and Reporting Standard

The first publication provides an input-output model approach, combined with some hybrid elements. The second publication chooses an LCA-approach as the basic model (see Figure 4 on page 14).

### 3.4.2 Other organizations

The Carbon Disclosure Project (CDP) is an independent non-profit organization. The organization's aim is to drive greenhouse gas emission reduction and sustainable water use by business and cities (www.cdproject.net). They do not provide own guidance on demarcation of upstream scope 3 emissions. Instead, they refer to the GHG Protocol.

The Global Reporting Initiative (GRI) is a non-profit organization working on the promotion of economic, environmental and social sustainability. In this broad approach is the difference with the GHG Protocol. GRI provides a comprehensive reporting framework, available to all organizations and companies (www.globalreporting.org).

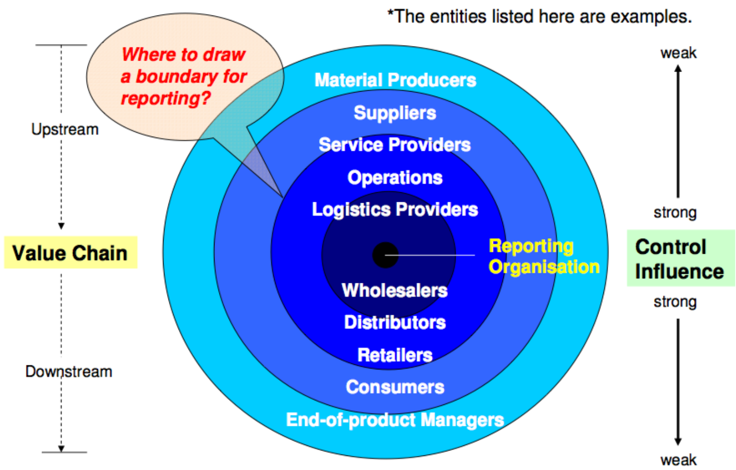



**Figure 10 The boundary issue. Source: GRI, 2005**

The GRI published a report specifically on boundaries: the boundary protocol (GRI, 2005). Although this document is quite old, Figure 10 does provide interesting insight in the boundary issue. It shows the downstream and upstream supply chain on the left side of the figure, while on the upstream side also the level of control is visualized. It shows that the reporting boundary can correlate with the level of control; when no control can be executed on an upstream party, it is questionable if emissions caused in that step should be reported.

The downside is mainly that the boundary protocol does provide insights, lacking a specific model that organizations can use. Furthermore, the other information in the boundary protocol does not give new insights compared to the GHG Protocol.

The Department for Environment, Food & Rural Affairs (or: DEFRA) is a government department of the United Kingdom. They provide a document that is used in reporting scope 3 emissions, the 'Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting'. Compared to the GHG Protocol Standards this document is however less complete and less useful. It is however a valuable source to use as input for the Scope 3 Standard, since it provides values for input output modelling.

In collaboration with the Carbon Trust, DEFRA sponsored the development of the Publicly Available Specification 2050 (PAS 2050); *Specification for the assessment of the life cycle greenhouse gas emissions of goods and services*. It is a response to the risen interest from retailers and other supply chain organizations to understand and/or communicate the carbon footprint of their products. PAS 2050 is "a standardized method for assessing product carbon footprints, providing organizations with a consistent approach to assessing the life cycle GHG emissions of products" (Sinden, 2009). It is based on existing LCA approaches.

The International Organization for Standardization, often referred to as the ISO, published the ISO 14064 standards for GHG accounting and verification. It was published on 1 March 2006 and consists of three parts, of which the first part is focused on the organizational level. It is a GHG programme neutral standard, however the GHG Protocol and the ISO 14064-1 standard have many aspects in common. The same GHG emissions are included, information on organizational boundaries is provided, and indirect emissions are divided into energy indirect emissions (scope 2) and other indirect emissions (scope 3). Furthermore, other indirect emissions (scope 3) are not obligatory. The ISO 140641-1 standard does provide categories, being quite similar to the GHG Protocol categories. Global Warming Potential factors are included to provide guidance on calculation (ISO, 2006). In respect to this research, the GHG Protocol Standards do provide more complete and more specific guidance.

Finally, there is the *CO2 Prestatieladder.* It was first developed by ProRail and is now owned by the *Stichting Klimaatvriendelijk Aanbesteden en Ondernemen* (SKAO, Dutch for: Foundation for Climate Friendly Tendering and Entrepreneurship). It is a tool to motivate organizations to act in an environment friendly way within their own organization and within their projects. It is a tool that can be used to select the most sustainable tender; it also provides information to assess emissions for the own organization (SKAO, 2012). For this information SKAO uses the GHG Protocol as a leading source; however, they slightly altered the scopes.

As can be seen in Figure 11 business travel is not regarded scope 3, it is regarded as a scope 2 emission. As demarcation for this category the following question is used: are costs for travel paid for by the reporting organization? If "yes" is the answer, these are scope 2 emissions. If "no", then these are scope 3 emissions. This different approach is however not used throughout this research; business travel is regarded a scope 3 category. Since SKAO uses the GHG Protocol as main source, it underlines the leading role of that protocol.

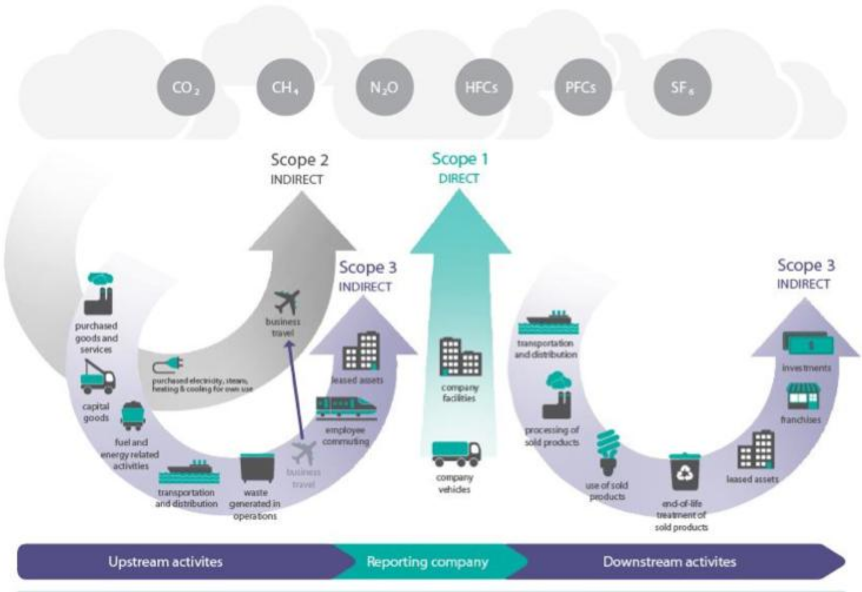



**Figure 11 Scopes according to SKAO. Source: SKAO, 2012**

## 3.5 Preliminary conclusions

The question on which an answer is sought in this chapter is: *What are underlying theoretic models to assess upstream scope 3 emissions?* Before moving to the models this chapter showed that modelling is helpful *and* essential, since a wide variety of sources is reported by different organizations. It is however evident that including more sources improves chances on good mitigation strategies. Various reasons are provided for inclusion and exclusion decisions, sometimes being arbitrary. These various decisions lead to different boundaries, wherefore inventories become incomparable. To be able to overcome difficulties organizations often use financial data to calculate emissions, wherefore availability is automatically the reason of what is included and what is excluded. Setting organizational boundaries is a first and essential step to make upstream scope 3 emissions comparable. Clear communication about these boundaries will make inventories more comparable than without these boundaries.

Double-counting will not be an issue in this research, since the perspective of a single organization is chosen. It is not relevant whether organizations may (partly) account for the same emissions; it is relevant which emissions are caused by the *reporting* organization in the upstream supply chain. When a country for example wants to calculate all emissions of the construction sector, double-counting can become an issue.

Three main theoretical models exist that can be used to assess upstream scope 3 emissions. The *input-output model* is a large-scale model, the *LCA model* is a fine scale approach, and the *hybrid model* combines best of both worlds. These theoretic models are used by various parties as input for methods, guidelines and standards. This chapter showed that the Greenhouse Gas Protocol is the leading organization in this respect. This organization published two standards that can be used to assess upstream scope 3 emissions: the *Scope 3 Standard* and the *Product Standard*. The basis of the former is the *input-output model*, and the *LCA model* of the latter. Both standards will be examined in the next chapter.

# 4 ASSESSMENT OF UPSTREAM SCOPE 3 EMISSIONS

In this chapter the assessment of upstream scope 3 emissions will be investigated. This chapter will answer the second research question:

*How are upstream scope 3 emissions assessed in available methods?*

As stated in the conclusion of Chapter 3, the Scope 3 Standard and the Product Standard will be used to answer this question. Therefore two sub-questions are added, being (a) *how does the Scope 3 Standard assess upstream scope 3 emissions?* and (b) *how does the Product Standard assess upstream scope 3 emissions?*

After an introduction on the assessment of upstream scope 3 emissions in paragraph 4.1, the Scope 3 Standard will be dealt with in paragraph 4.2. In paragraph 4.3 the Product Standard will be discussed. At the end of this chapter, it is clear what the steps of both standards are and what their advantages and disadvantages are; this will be presented in the conclusion in paragraph 4.4.

## 4.1 Introduction

Chapter 3 showed the theoretical background of assessing upstream scope 3 emissions. Different underlying theoretical models lead to different methods that help organizations to assess these emissions. It is a difficult task, in which guidance is essential to trigger organizations to start this activity. Chapter 3 showed that the GHG Protocol Initiative is the leading organization in this field. In respect to upstream scope 3 emissions, two standards provide useful insights: the Scope 3 Standard and the Product Standard.

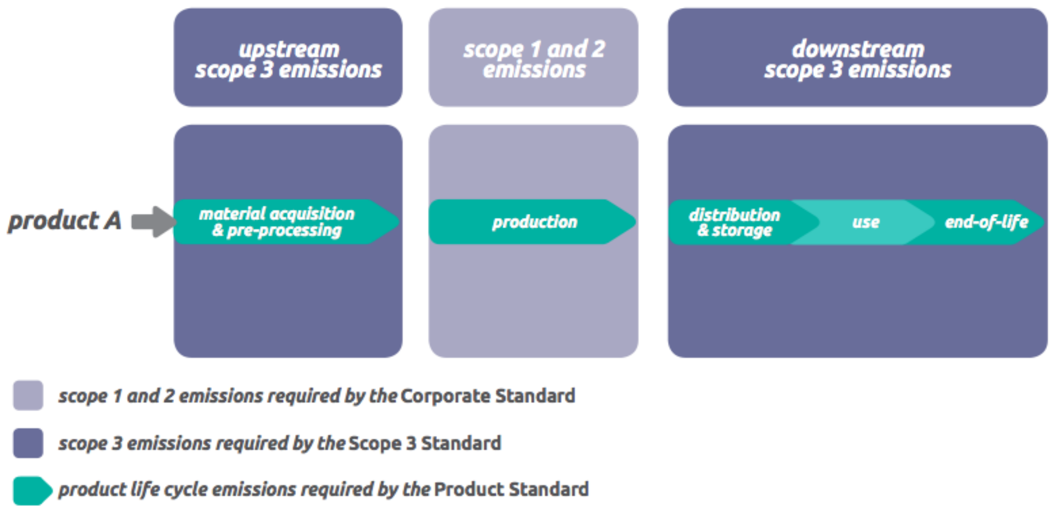



**Figure 12 Relation between Scope 3 Standard and Product Standard. Source: WRI & WBCSD, 2011a**

The relation between the Scope 3 Standard and the Product Standard is visualized in Figure 12. The Corporate Standard will not be discussed, since the Standard is only used to assess scope 1 and 2 emissions.

Although the standards can be used independently, they also can be combined to compose a scope 3 GHG inventory. The combined approach can be (WRI and WBCSD, 2011b):

1. Use the Scope 3 Standard for the first impression, then use the Product Standard to dive further into the product life cycle of selected products
2. Use the Product Standard for the organizations' products, and thereby composing a scope 3 inventory
3. Use the standards simultaneously to compose a scope 3 inventory.

The Scope 3 Standard resembles a hybrid or large-scale approach (input-output model) and the Product Standard a fine-scale approach (LCA model), see Figure 4 on page 14. The combination of both is certainly a hybrid approach.

## 4.2 The Scope 3 Standard

The Scope 3 Standard is a very extensive document, consisting of 11 chapters. The most essential elements in respect to this research will be explained in this paragraph to gain insight in it. The included elements are focused on assessing upstream scope 3 emissions; elements such as assurance are left out. First the identification of upstream scope 3 emissions will be explained, followed by how data can be collected. The next step is then to allocate the data, and finally to report and set reduction targets.

### 4.2.1 Identification of emissions

Scoping of emissions is a first step to categorize emissions. This research focuses on the upstream side of scope 3 emissions. To identify which emissions need to be accounted for and why, organizational boundaries, scope 3 categories, the dimension of time, and other boundaries all need to be investigated. This paragraph will discuss these aspects.

#### *4.2.1.1 Organizational boundaries*

The conclusion of Chapter 3 showed that defining the organizational boundary is an essential first step when reporting emissions. In the Scope 3 Standard this element is considered a first step. There are three consolidation approaches possible, which are described in Table 9.

**Table 9 Consolidation approaches. Source: WRI & WBCSD, 2011a**

| Consolidation approach | Description |
|---|---|
| **Equity share** | Under the equity share approach, a company accounts for GHG emissions from operations according to its share of equity in the operation. The equity share reflects economic interest, which is the extent of rights a company has to the risks and rewards flowing from an operation. |
| **Financial control** | Under the financial control approach, a company accounts for 100% of the GHG emissions over which it has financial control. It does not account for GHG emissions from operations in which it owns an interest but does not have financial control. |
| **Operational control** | Under the operational control approach, a company accounts for 100% of the GHG emissions over which it has operational control. It does not account for GHG emissions from operations in which it owns an interest but does not have operational control |

The approach chosen by an organization can influence the assessment of upstream scope 3 emissions. When an organization has an equity share in three entities and has operational control over two of these entities, the entity over which it has no operational control will account for the difference. In the equity share approach the emissions from operations from all entities are accounted for in scope 1. In the operational control approach, the emissions from operations of the entity over which there is no operational control are not accounted for under scope 1. These emissions are then accounted for under scope 3 and are seen as an investment. The total amount depends on the share of equity in that entity (WRI and WBCSD, 2011a).

#### *4.2.1.2 Upstream scope 3 categories*

The WRI and WBCSD (2011a) use eight categories for upstream scope 3 emissions to create a systematic framework:

1) **purchased goods and services**; extraction, production, and transportation of goods and services, not otherwise included in categories 2-8
2) **capital goods**; extraction, production, and transportation of capital goods
3) **fuel and energy related activities**; extraction, production, and transportation of fuels and energy not already accounted for in scope 1 or scope 2
4) **transportation and distribution**; between a tier 1 suppliers and own operations (in vehicles and facilities not owned or controlled), and purchased inbound logistics, outbound logistics and between own facilities
5) **waste generated in operations**; disposal and treatment of waste
6) **business travel**; employees traveling business-related, in vehicles not owned
7) **employee commuting**; employees traveling between their homes and their worksites
8) **leased assets**; operation of assets leased, not included in scope 1 and scope 2

These categories and their supply chain position are visible in Figure 13. In 'Appendix C – Upstream scope 3 emission categories' an explanation is given on these categories.

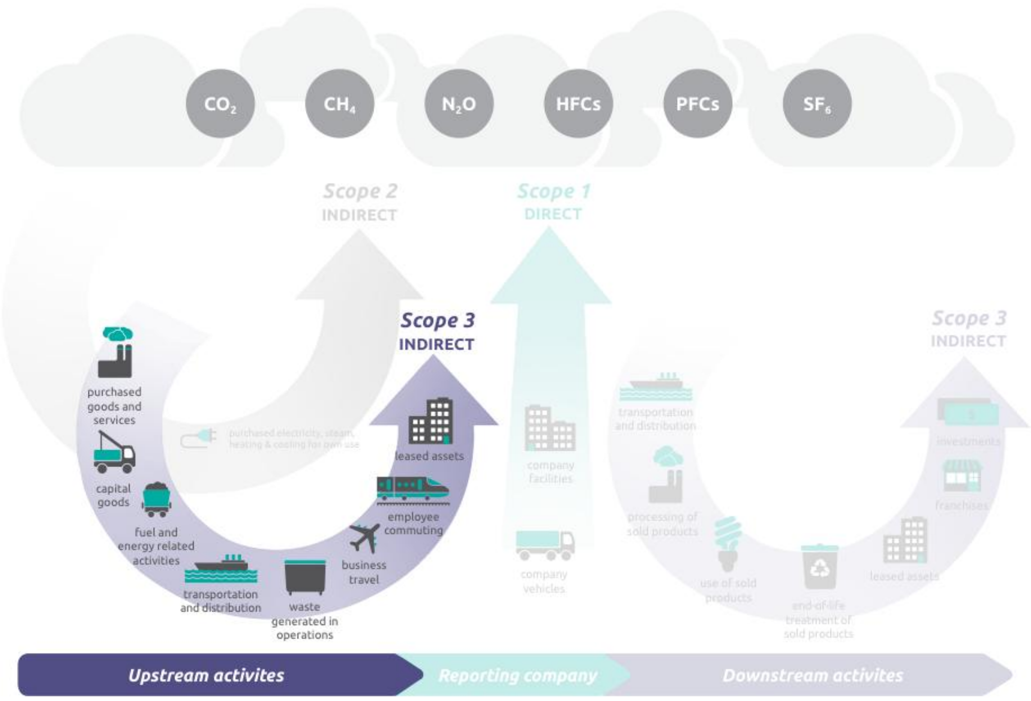



**Figure 13 Categories of upstream scope 3 emissions in the value chain**

#### *4.2.1.3 Dimension of time*

An important element of assessing emissions is time. Emissions are assessed over a reporting year (most commonly a calendar year), when the standard by the WRI and WBCSD (2011a) is used. For some upstream scope 3 categories, emissions occur in the same period of time (or: in the same year as the reporting year). Other emissions might have occurred in previous years, or even in coming years. The time boundaries for upstream scope 3 emissions can be found in Table 10.

**Table 10 Time boundaries of upstream scope 3 emissions**

| Upstream scope 3 category | Past years | Reporting year | Future years |
|---|---|---|---|
| Purchased goods and services | x | x | |
| Capital goods | x | x | |
| Fuel- and energy-related activities | x | x | |
| Upstream transportation & distribution | x | x | |
| Waste generated in operations | | x | x |
| Business travel | | x | |
| Employee commuting | | x | |
| Upstream leased assets | | x | |

These boundaries suggest that it is necessary to draw a line somewhere in history or in the future. This is however not the case; it merely states that emissions reported for waste could happen in future years, but are reported for in the reporting year.

#### *4.2.1.4 Setting the boundaries*

100% completeness can be very time-consuming or will result in poor accuracy when data with poor quality is used to achieve a complete inventory. Therefore 100% completeness does not have to be regarded as the main goal when assessing upstream scope 3 emissions (WRI and WBCSD, 2011a). The WRI and WBCSD (2011) do provide minimal boundaries for each category within upstream scope 3 emissions. The reason for this is twofold:

1. to ensure that major activities are included
2. to clarify that organizations need not account for each entity in the supply chain, ad infinitum (see paragraph 3.1)

Besides these boundaries, organizations may report optional emissions. Organizations may also exclude emissions that are included in the minimal boundaries, only when exclusions are explained and justified (WRI and WBCSD, 2011a). An overview of these minimal boundaries, optional emissions and a short description of the upstream categories is included in 'Appendix D – Description & boundaries of upstream scope 3 emissions'.

The principles on which exclusions are based are relevance, completeness, accuracy, consistency and transparency (WRI and WBCSD, 2011a). Relevance is in particular important when setting boundaries, since excluding relevant emissions results in misleading inventories. Chapter 3 showed that availability of data is often the main reason for exclusion, while using relevance as criteria an organization can be triggered to make this data available. When zooming in on the principle of relevance, several criteria to map relevant emissions can be listed, see Table 11.

**Table 11 Elements used to determine relevance. Source: WRI & WBCSD, 2011**

| Element | Description |
|---|---|
| **Size** | Significant contribution to total scope 3 emissions |
| **Influence** | Organization is expected to be able to influence the emissions |
| **Risk** | Organization can be exposed to risks leading from these emissions |
| **Stakeholders** | Organization's stakeholders deem emissions critical |
| **Outsourcing** | Previously done activities in-house, that are now outsourced |
| **Sector guidance** | Sector-wide guidance define emissions as significant |
| **Other** | Situation-specific criteria |

The information provided shows that more guidance is available compared to the Corporate Standard (WRI and WBCSD, 2011a). There is still however a great deal of freedom for reporting organizations to include or exclude certain sources, as long as these decisions are justified. This means that a great deal of so-called 'random reporting' can occur.

### 4.2.2 Data collection

The data collection process outlined by the Scope 3 Standard consists of four steps (WRI and WBCSD, 2011a):

1. Prioritize data collection efforts
2. Select data
3. Collect data and fill data gaps
4. Improve data quality over time

The first step is relevant for SMEs, since data collection requires resources. Therefore prioritizing collection efforts helps in efficiently creating inventories. To prioritize data collection efforts, the Scope 3 Standard outlines different possibilities. The magnitude of GHG emissions can be used when estimations are available. These estimations can be based on industry-average data, environmentally extended input output (EEIO) data, proxy data, or rough estimates. When estimations are known, scope 3 activities can be ranked by impact (WRI and WBCSD, 2011a).

Another approach is to prioritize emissions on the basis of spend. A spend analysis can be used to rank upstream types of purchased products. An important note using this approach is that financial data does not always correlate with emissions. Relatively expensive products may cause minimal emissions, while relatively cheap products may have significant GHG impact (WRI and WBCSD, 2011a).

Next to the magnitude of GHG emissions and information on spend, other criteria can be used to prioritize data collection efforts on certain activities. These may be activities that the company has influence over (e.g., a product that could be bought at other companies), contribute to the company's risk exposure, stakeholders (e.g., shareholders) deem critical, have been identified as significant by sector-specific guidance (in terms of quantity), and/or involve GHG- or energy-intensive materials (WRI and WBCSD, 2011a).

Two main methods exist to quantify emissions, being direct measurement and calculation. To calculate upstream scope 3 emissions, data is needed. The two types of data needed for calculation are activity data and emission factors. According to the Scope 3 Standard, "activity data is a quantitative measure of a level of activity that results in GHG emissions" (WRI and WBCSD, 2011a). Emission factors are used to convert activity data into GHG emissions data. When non-$CO_2$ emissions are involved, Global Warming Potential (GWP) values are needed to convert non-$CO_2$ emissions into $CO_2$-equivalents ($CO_2e$). Figure 14 shows an overview of the quantification methods, while Figure 15 provides examples of activity data and emission factors.

| *Quantification method* | *Description* | *Relevant data types* |
|---|---|---|
| **Direct measurement** | Quantification of GHG emissions using direct monitoring, mass balance or stoichiometry<br>**GHG = Emissions Data x GWP** | Direct emissions data |
| **Calculation** | Quantification of GHG emissions by multiplying activity data by an emission factor<br>**GHG = Activity Data x Emission Factor x GWP** | Activity data<br>Emission factors |

**Figure 14 Quantification methods for scope 3 emissions. Source: WRI & WBCSD, 2011a**

| *Examples of activity data* | *Examples of emission factors* |
|---|---|
| Liters of fuel consumed | kg $CO_2$ emitted per liter of fuel consumed |
| Kilowatt-hours of electricity consumed | kg $CO_2$ emitted per kWh of electricity consumed |
| Kilograms of material consumed | kg PFC emitted per kg of material consumed |
| Kilometers of distance traveled | t $CO_2$ emitted per kilometer traveled |
| Hours of time operated | kg $SF_6$ emitted per hour of time operated |
| Square meters of area occupied | g $N_2O$ emitted per square meter of area |
| Kilograms of waste generated | g $CH_4$ emitted per kg of waste generated |
| Kilograms of product sold | kg HFC emitted per kg of product sold |
| Quantity of money spent | kg $CO_2$ emitted per unit of currency spent |

**Figure 15 Examples of activity data and emission factors. Source: WRI & WBCSD, 2011a**

Data used for calculation can either be primary data or secondary data. Primary data includes data obtained from suppliers and is specific to the activities in the supply chain. Secondary data includes "industry-average data (..), financial data, proxy data, and other generic data" (WRI and WBCSD, 2011a). An organization has to obtain primary data for their scope 3 inventory from their suppliers. It makes sense to approach the most relevant suppliers first, and create a more comprehensive inventory over time. Not all suppliers will have GHG inventory data available. In this case, the reporting organization can encourage and help these suppliers to collect this information. Tier 1 suppliers may not always cause the most significant GHG emissions. Therefore going deep into the upstream supply chain increases the understanding of scope 3 emissions.

When primary data is not available (yet), secondary data may be used. Databases provided by national governments are an example of this type of data. When data gaps exist, proxy data may be used. This is data "from a similar activity that is used as a stand-in for the given activity. Proxy data can be extrapolated, scaled up, or customized to be more representative of the given activity" (WRI and WBCSD, 2011a).

When scope 3 activities are prioritized, an organization can select the data that will be used. This selection can be based on business goals, relative significance of scope 3 activities, availability of data, and/or quality of available data (WRI and WBCSD, 2011a).

Concerning the quality of available data, the Scope 3 Standard provides the following data quality indicators (WRI and WBCSD, 2011a):

1. technological representativeness – *how similar is the technology used to the technology where the data is retrieved from*
2. geographical representativeness – *represents data from the same area*
3. temporal representativeness – *represents data from the same timeframe*
4. completeness – *how many relevant sites are included over an adequate time period to even out normal fluctuations*
5. reliability- *is data verified or based on assumptions*

A specification of these indicators together with qualitative scores is included in 'Appendix E – Data Quality Indicators'. It is not realistic to expect a scope 3 inventory to be perfect in the beginning. Therefore the reporting organization can always improve the inventory through the data quality indicators (e.g., when five year-old emission factors are used, more actual data can be sought for the next reporting moment).

### 4.2.3 Data allocation

As presented in the previous section, primary data can be obtained from upstream suppliers. When a common process of the supplier has multiple valuable products as inputs or outputs and it is not possible to collect data at the individual input or output level, it is necessary to partition emissions among inputs and outputs. This process is called allocation, presented in Figure 16. The Scope 3 Standard states that allocation is not preferable. Before applying allocation, the reporting organization can try to (1) obtain product-level GHG data from suppliers, (2) separately sub-meter energy use and other activity data (see examples in Figure 15) or (3) use engineering models to separately estimate emissions related to each product (WRI and WBCSD, 2011a).

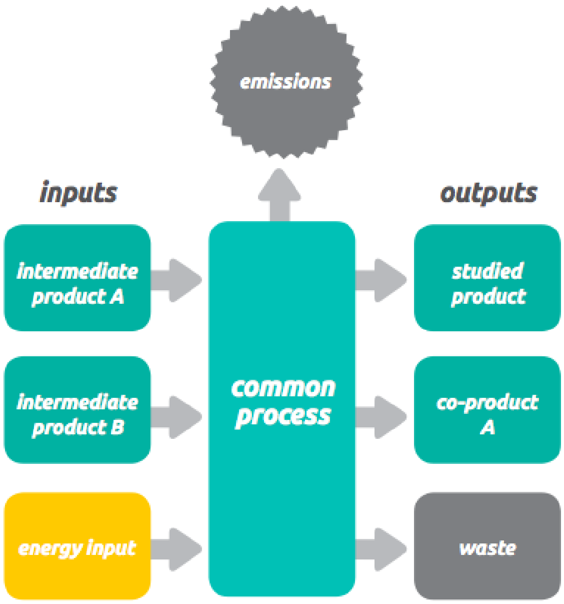



**Figure 16 Need for allocation. Source: WRI & WBCSD, 2011a**

When none of the three approaches is possible, the next option is to use physical factors to allocate emissions. When this is not suitable, economic factors may be used. The reporting organization can try to obtain already allocated emissions from their suppliers, or allocate the emissions themselves. The whole decision process of allocation is visualized in Figure 17.

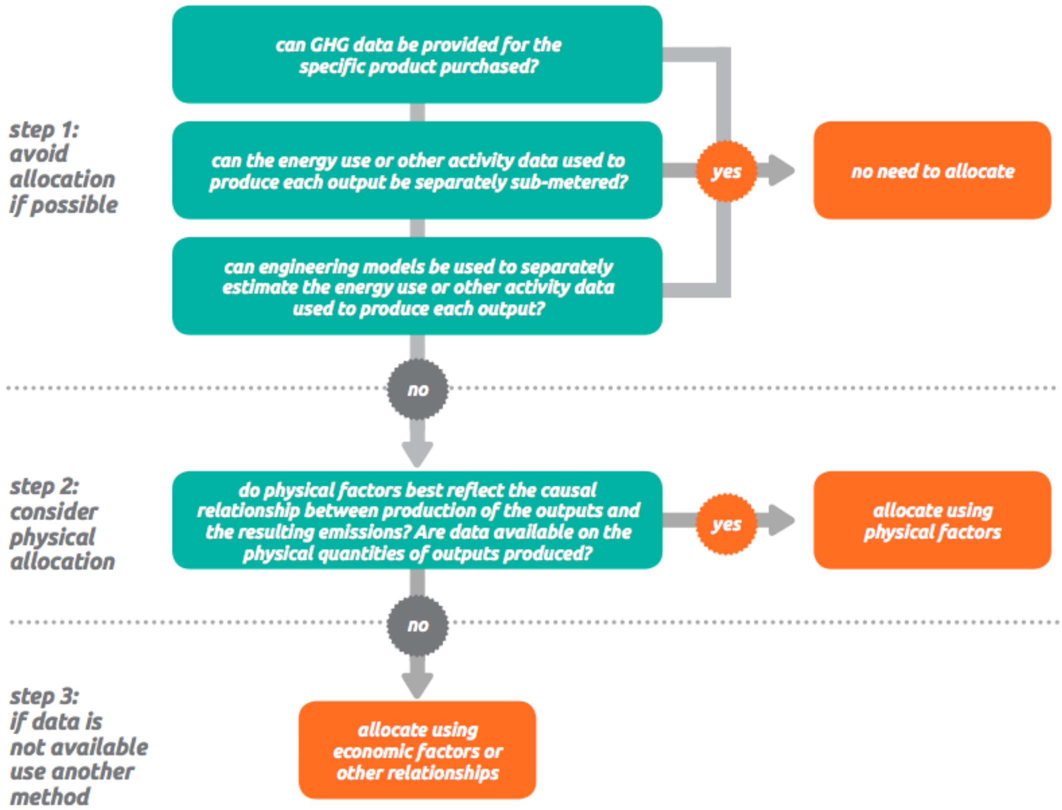



**Figure 17 Allocation decision tree. Source: WRI & WBCSD, 2011a**

### 4.2.4 Reporting and reduction targets

A scope 3 inventory is not a goal in itself. It creates the insight needed for the construction industry to play a pivotal role in emission reduction (Wong et al., 2012). When the reporting organization wants to change their scope 3 inventory, reduction targets can be set. A base year has to be determined, on which the reduction targets will be based. Then, the emissions can be tracked over time and an organization may choose to report these developments in a report. Either a first a third party can help the organization to assure the inventory, before actually publishing this report.

In the report scope 3 emissions should be reported by category (see paragraph 4.2.1.2) in $CO_2e$; exclusions have to be listed and justified. For each category the reporting organization has to include types and sources of data and a description of the data quality. Furthermore, a description of methodologies, allocation methods, and assumptions is needed. The cooperation with upstream suppliers to calculate emissions has to be mentioned by stating the percentage of emissions calculated through information obtained in this way (WRI and WBCSD, 2011a).

## 4.3 Product Standard

The GHG Protocol Initiative published a guidance document on Life Cycle Analysis, namely the *Product Life Cycle Accounting and Reporting Standard* (or: Product Standard). This standard is largely based on ISO standards and PAS 2050, which are briefly discussed in paragraph 3.4.2. The intention of the GHG Protocol is to provide guidance and additional specifications to help organizations report product life cycle inventories in a consistent manner. By doing so, performance can be tracked, suppliers can be involved and products can be differentiated (WRI and WBCSD, 2011b). The relation of the Product Standard to the Scope 3 Standard is visualised in Figure 12.

This paragraph will explain how the Product Standard works. The identification of a product inventory will be explained first, followed by data collection and quality. Thereafter data allocation will be described, and reporting and reduction targets.

### 4.3.1 Identify a Product Inventory

In the Product Standard the life cycle approach and the attributional approach are followed. A product GHG inventory, also known as a product carbon footprint, is not identical to an LCA; it is a subset of an LCA since it only focuses on the climate change impact category. The accounting methodologies and requirements in the Product Standard however follow the life cycle approach as established by ISO LCA standards 14040 and 14044 (WRI and WBCSD, 2011b).

In the attributional approach GHG emissions or removals are linked (or: attributed) to the studied product. Along its life cycle attributable processes are selected to compile the inventory. The upstream attributable processes need to be identified to create the upstream product GHG inventory. Another possible approach is the consequential approach; this approach is however not used by the Product Standard and therefore not further explained.

In this paragraph the scope of a product inventory will be discussed first, followed by boundary setting.

#### *4.3.1.1 Scope of a Product Inventory*

The Product Standard is in many aspects similar to the Scope 3 Standard. The same six GHGs are therefore included, organizations shall apply a 100 year Global Warming Potential (GWP) factor to GHG emissions data and organizations shall quantify and report the total inventory results in $CO_2e$ per unit of analysis. More specific to the Product Standard is that organizations quantify and report the percentage of total inventory results by life cycle stage (WRI and WBCSD, 2011b).

The reporting organization defines the studied product. This can be based on an already available organizational scope 3 inventory, on EEIO information, or on physical or economic factors (such as mass, volume, or spend). Then the unit of analysis is selected. This is defined as the performance characteristics and services delivered by the studied product. When a final product is considered (or: a product with only the end user as next step) this unit of analysis shall be defined as a functional unit. This unit (mostly) consists of three general parameters (WRI and WBCSD, 2011b):

1. the magnitude of the function or service
2. the duration or service life of the function or service
3. the expected level of quality

For intermediate products, the unit of analysis is a functional unit when the function of the final product is known. If not, the unit of analysis is the reference flow; it is the amount of product on which the results of the study are based (WRI and WBCSD, 2011b). This can be for example a box of 50 units of a certain product. An important aspect to consider is that the reference flow is of use to the user of the GHG inventory report.

#### 4.3.1.2 Boundary setting

A GHG inventory consists of service, material, and energy flows that are input for the product throughout its life cycle. These inputs are attributable processes. The Product Standard uses five general life cycle stages (WRI and WBCSD, 2011b), visible in Figure 18. This is a simplified life cycle, and organizations can add extra stages to reflect the life cycle of the product under investigation. Since this research focuses on the upstream emissions, only the parts of these steps that are in line with the eight categories mentioned in subparagraph 4.2.1.2 on page 36 and further will be included. This means that the stages 'use' and 'end-of-life' are not included, see Figure 18. Of the stages that are included, only the upstream emissions in these stages are considered.

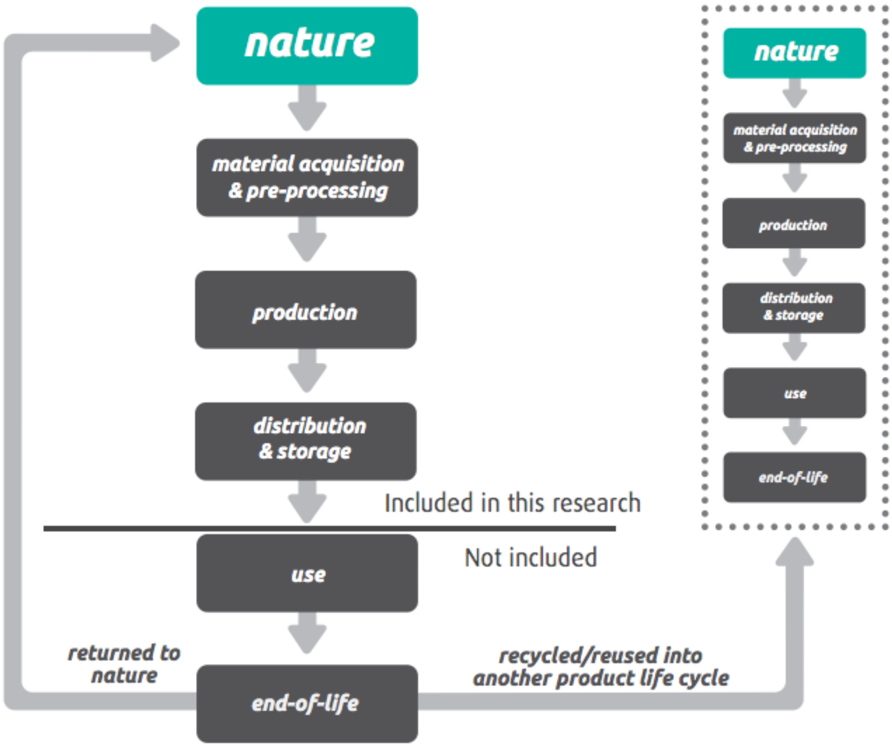



**Figure 18 Life cycle stages. Source: WRI & WBCSD, 2011b**

An organization can choose to exclude certain attributable processes (if justified), when (1) a data gap exists because primary or secondary data cannot be collected, (2) extrapolated and proxy data cannot be determined to fill the data gap, or (3) an estimation determines the data is insignificant (given that an insignificance threshold is included in the inventory report) (WRI and WBCSD, 2011b).

The Product Standard states that a process map should be included, in which inputs and the attributable processes are visualized. Non-attributable processes that are included in the boundary have to be reported by the reporting organization. It is not required however to include these processes. Non-attributable processes include energy, material, and energy flows due to capital goods, overhead operations (e.g., facility lighting) and corporate activities and services (WRI and WBCSD, 2011b). These elements are included in the Scope 3 Standard, and therefore form one of the main differences.

The boundary for the inventory will be the complete life cycle, from cradle-to-grave. A cradle-to-gate inventory is sufficient when the function of the final product is not known, however this has to be justified. In this inventory the time it takes to complete the entire life cycle has to be included (WRI and WBCSD, 2011b). In this research however, a cradle-to-gate inventory will be sufficient, since the gate-to-grave part refers mostly to downstream emissions.

### 4.3.2 Data collection

The Product Standard requires organizations to collect data for all processes included in the inventory boundary. Primary data is needed for processes that are under ownership or control by the reporting organization. Primary data "can be process activity data (physical measures of a process that results in GHG emissions or removals), direct emissions data (determined through direct monitoring, stoichiometry, mass balance, or similar methods) from a specific site, or data that is averaged across all sites that contain the specific process" (WRI and WBCSD, 2011b).

Secondary data "are defined as data that are not from specific processes in the studied product's life cycle" (WRI and WBCSD, 2011b). An example is the industry-average kilograms of material input into a process, or the amount spent on process inputs, either specific or a company/industry average.

Activity data can either be process activity data (e.g., energy: Joules of energy consumed), or financial activity data. For process activity data emission factors can be used as well to calculate GHG emissions. An EEIO emission factor can be combined with financial activity data to calculate GHG emissions. Financial activity data are always regarded secondary data. An overview of how direct emissions data, process activity data, and financial activity data relate to each other is visualised in Figure 19.

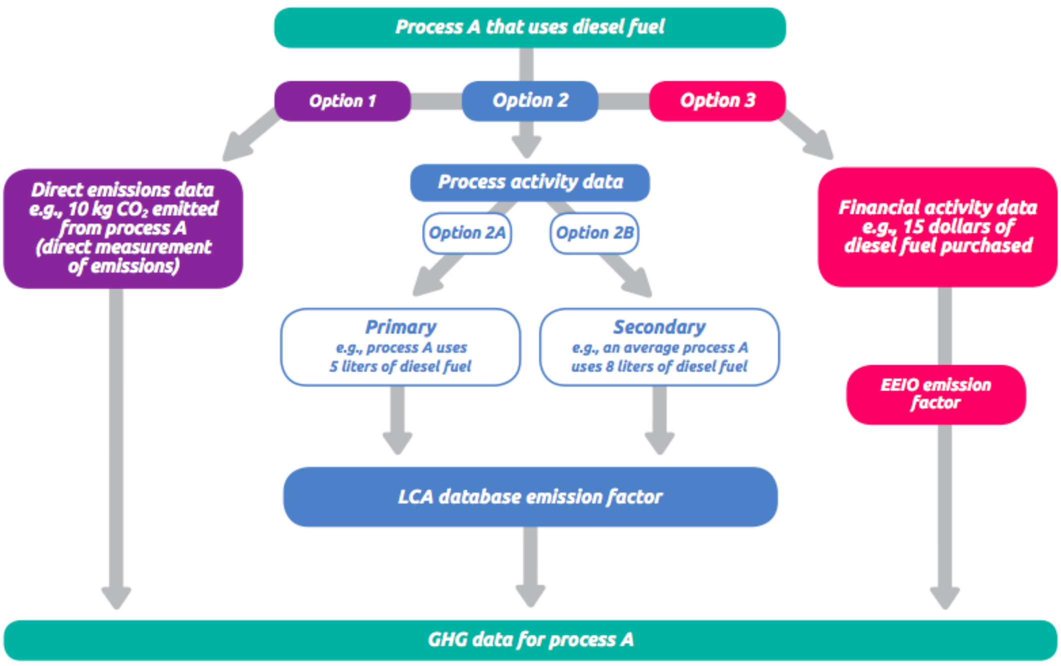



**Figure 19 Options to calcuate GHG data for a certain process. Source: WRI & WBCSD, 2011b**

To assure data quality the same five data quality indicators used by the Scope 3 Standard are used (see §4.2.2). When neither primary data nor secondary data is available, data gaps can be filled by either using proxy data or estimated data. Proxy data are data from similar processes, thereby being secondary data. This data can be either extrapolated, scaled up, or customized to represent the given process (WRI and WBCSD, 2011b). When proxy data are not available, a reporting organization can estimate data to determine significance and then either include or exclude the data (when justified). Figure 20 presents the decision tree for filling data gaps.

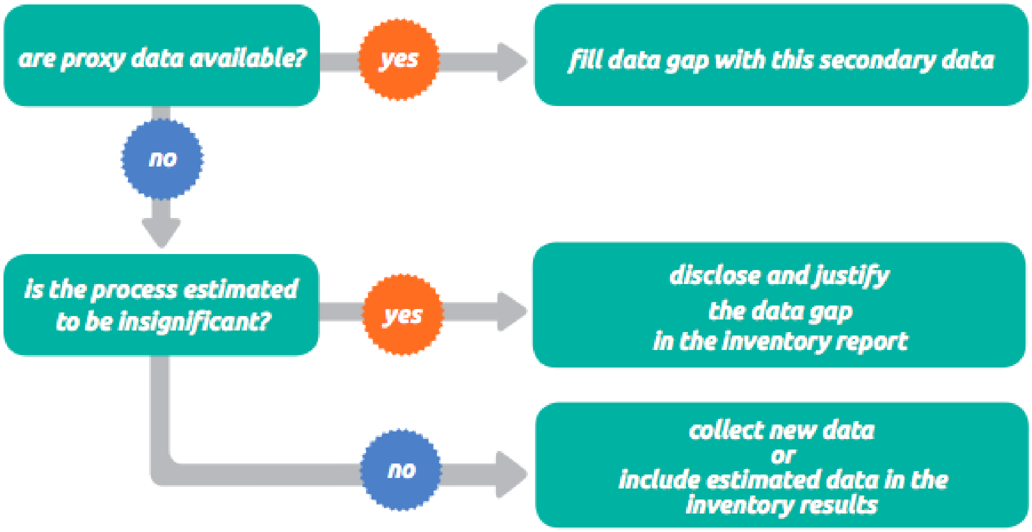



**Figure 20 Decision tree for data gaps. Source: WRI & WBCSD, 2011b**

### 4.3.3 Data allocation

When a common process has multiple valuable products as inputs or outputs and it is not possible to collect data at the individual input or output level, it is necessary to partition emissions among inputs and outputs. This process is called allocation, presented in Figure 16 (page 40). The Product Standard states that allocation is not preferable. Before applying allocation, the reporting organization can try to divide the process in small steps, redefine the functional unit, or use system expansion. When allocation is necessary, physical relationships can be used; when physical relationships are not usable, economic or other relationships can be used (WRI and WBCSD, 2011b).

### 4.3.4 Reporting and reduction targets

When reporting product inventories, uncertainties have to be included. During the whole process of creating a product's GHG inventory, uncertainties may arise. The Product Standard requires the reporting organization to communicate qualitative information on sources of inventory uncertainty and methodological choices. The choices include allocation methods, calculation models, and emission factors. The whole process of tracking and evaluating uncertainty is an iterative process, represented in Figure 21.

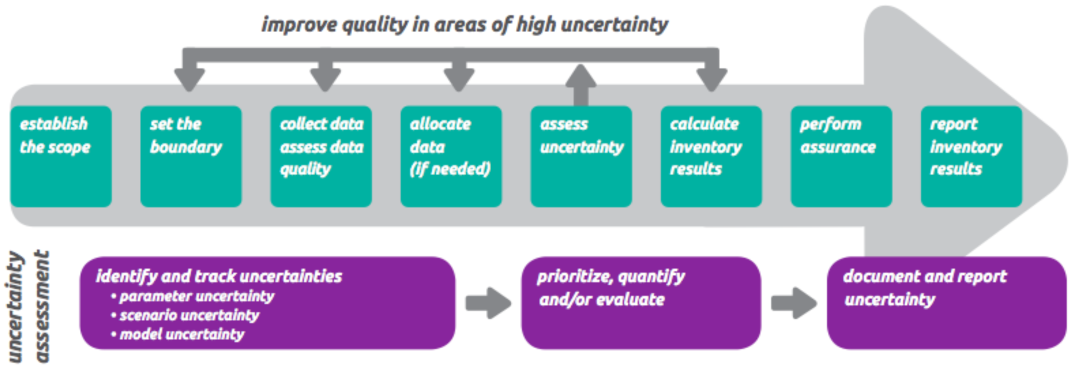



**Figure 21 Iterative process of tracking and evaluating uncertainty. Source: WRI & WBCSD, 2011b**

The calculation of inventories is done when all required data is collected. These inventories can then be reported. Reporting is however not a goal in itself, it merely paves the way for reduction of emissions (WRI and WBCSD, 2011b).

## 4.4 Reflection

The Greenhouse Gas Protocol came up with the term scope 3 emissions, around which the Scope 3 Standard is developed. A critical review of the actual Standard was not found during this research. This is mainly due to the fact that it only recently has been published. The findings presented in Chapter 3 will be reflected on the Scope 3 Standard, while for the Product Standard other sources will be used as well.

The organizational boundaries are a crucial element when composing scope 3 inventories (Pandey et al., 2011). The Scope 3 Standard does provide guidance on this topic, leading to a choice in consolidation approach. The consolidation approach is only a first step, communication about this approach and what activities are exactly included is essential. Categories are helpful in this respect (Huang et al., 2009a), which are accompanied with minimal boundaries in the Scope 3 Standard. A scope 3 inventory in which these minimal boundaries are followed can therefore be seen as a comprehensive inventory, whereby the point made by Downie and Stubbs (2011) is tackled. However, the Scope 3 Standard is very general in guidance on these boundaries, which leaves the choice on what will be included and excluded very much up to the person composing the inventory. Another downside is that the Scope 3 Standard does not provide specific information on how to deal with emissions occurring further upstream in the supply chain, where actually most emissions occur (Plambeck, 2012). It is stated that cradle-to-gate emissions are the minimum for category 1 emissions (purchased goods and services); the standard does however not zoom in on the difficulty of retrieving data from tier 2 suppliers or even further upstream.

Numerous tricks exist to interchange emissions amongst scopes (J. Mos, personal communication, March 25 2013), which leads to incomparable inventories. The calculation of a scope 3 inventory should therefore be combined with scope 1 and 2 inventories. This will not solve the entire problem, since exclusions are possible within the Scope 3 Standard and tricks will probably be found to alter inventories. One option is to communicate very clearly about every inventory, which is only partially facilitated by the Scope 3 Standard. A better option however is to provide an incentive for organizations to compose honest and complete inventories.

The Product Standard is based on the LCA approach. Every LCA consists of four main steps, being 1) Goal and scope definition, 2) Inventory analysis, 3) Impact assessment and 4) Interpretation (Bras-Klapwijk, Heijungs et al., 2003). These four steps can all be found in the Product Standard; they are however not as specifically mentioned as in other LCA literature. Therefore it is difficult to understand the core of LCA by reading the Product Standard. When analysing the first step, the main downside of the Product Standard is the generality. Essential in LCAs is how to deal with boundaries, since a LCA can become a never-ending activity. The Product Standard provides only general guidelines regarding boundaries, which may lead to difficulties among reporting organizations. More knowledge on LCAs and how boundaries can be established is essential to tackle this issue. The functional unit and the corresponding reference flow are essential in both the Product Standard as in LCA literature. The explanation on these elements found in LCA literature (Bras-Klapwijk et al., 2003) was however more clear than in the Product Standard itself. Again, more knowledge on LCAs is necessary to truly understand the topic.

The second step, inventory analysis, leads to a lifecycle inventory (Bras-Klapwijk et al., 2003). This aspect is only slightly mentioned in the Product Standard. Actually the choices normally made in step 2 and 3 together are predetermined in the Product Standard, since only GWP factors are used leading to an end score of $CO_2$e emitted. The Product Standard therefore automatically uses the mid-point method with global warming potential performance indicator, and climate change as selected impact category (Bras-Klapwijk et al., 2003). Ortiz, Castells et al. (2009) state that in the construction industry land use, acidification, eutrophication, stratospheric ozone depletion, abiotic resource depletion, and human toxicity are used next to global warming potential. The choice for global warming potential is not elaborated on in the Product Standard. Huang, Bird et al. (Huang, Bird et al., 2009d) do provide a very useful framework, on which the choice for global warming potential as focus impact category can be based. This is presented in Figure 22, which shows that priority is at the highest level and impact area is global for global warming. The choice of the GHG Protocol can therefore be justified.

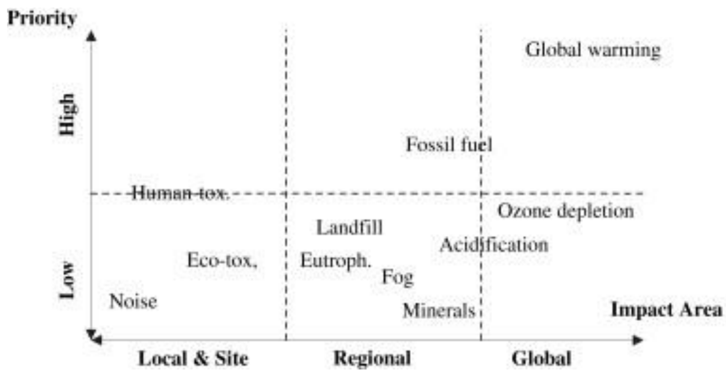


**Figure 22 Grouping and weighting of environmental impact categories. Source: Huang et al. (2009d)**

The usability of the Product Standard increases since less specific knowledge is necessary and less choices (such as impact category) have to be made. It is essential however that the user understands these steps and assumptions made by the GHG Protocol. Otherwise the value of the Product Standard is undermined, since good interpretation (step 4) of results is impossible.

The purpose of LCA is originally to compare different products or production methods (Bras-Klapwijk et al., 2003). In this research the purpose is however different, namely to compile an upstream scope 3 inventory. This will most probably cause alteration problems in the case studies. Furthermore, the generality of the Standard on one hand and the assumptions made on the other hand require a need for expertise to use the Product Standard in a sophisticated manner.

## 4.5 Preliminary conclusions

In this chapter the second research question is answered, being: *How are upstream scope 3 emissions assessed in available methods?* To answer this question two sub-questions have been included, one on the Scope 3 Standard and one on the Product Standard. The Scope 3 Standard provides extensive information on assessing upstream scope 3 emissions and tackles several issues mentioned by authors in literature. It assesses scope 3 emissions on a large scale, in which the eight upstream categories form an essential element. The Product Standard takes a fine-scale perspective by focusing on a single product, of which upstream scope 3 emissions are part. Overall, both standards are exhaustive documents and very general in their guidance. The generality is especially an obstacle in terms of usability; where should a user start and how should an inventory be improved over time? Also the required additional data needs to be retrieved from third party databases, which creates another obstacle. The Scope 3 Standard is efficient in quickly gaining insight in emissions with an effective result of category comparison. It can therefore be used as a starting approach. It should be noted however that organizations can omit certain categories when justified. Furthermore, to prevent organizations to move emissions from the third scope to scope 1 or 2, it is advisable to report all scopes together and not use the Scope 3 Standard as a stand-alone. The Product Standard requires more time and expertise, and is therefore less efficient. The visualizations and insights in the supply chain of products a reporting organization produces is however very effective. These insights may lead to specific suggestions for mitigating emissions.

The approach to use the Scope 3 Standard as a first 'quick scan' and the Product Standard to specify the lifecycle of different products in the inventory, seems most logic at this point in time. The next chapter will reveal if the same conclusions will follow when applying the standards in practice.

# 5 ASSESSMENT IN PRACTICE

The aim of this chapter is to experience both GHG Protocol standards in practice, which will answer question 3:

> *How can an SME in the construction industry use the Scope 3 Standard and the Product Standard effectively and efficiently to assess upstream scope 3 emissions?*

To achieve this two cases will be selected, on which both standards will be applied. The cases will be selected on similarity, which makes the two studies comparable. In the introduction the cases will be presented. Then the application of the Scope 3 Standard will be described, followed by the application of the Product Standard. Both applications will be compared in paragraph 5.4, followed by preliminary conclusions.

## 5.1 Introduction

Two different case studies have been executed in this research, for which two companies were sought. Criteria to select the companies follow logically from the research question (being an SME active in the construction sector) and have been complemented with three criteria to ensure the practicability of the case studies. The five criteria to select a company are:

1. Company is an SME
2. Company is active in the construction industry
3. Company has an interest in sustainability
4. Company sees an opportunity in creating insight in upstream scope 3 emissions
5. Company sells limited amount of different products or product configurations

Criteria number 3, 4 and 5 are essential to execute the case studies in the time available for the research. Cooperation of the companies is needed to retrieve required information, and when the company has no interest in the outcomes of the research this can delay the research (criteria 3 and 4). When a company produces a wide array of different products the Product Standard becomes very time consuming to execute (criteria 5). After several companies have been considered for the case studies, two companies are selected. Table 12 shows that both case studies can be used, since they meet the criteria. The case studies and why they meet the criteria will be discussed in more detail.

**Table 12 Case studies checked on criteria**

| Criteria # | Case study 1 – De Groene Paal | Case study 2 - Omnia |
|---|---|---|
| **1** | 5 employees | 75 employees |
| **2** | Supplier of foundation piles with integrated heat pump system | Producer of floor slabs |
| **3** | Product is directly linked to it | Sustainability is on agenda, due to parent company (Ballast Nedam) |
| **4** | Creates supply chain and marketing insights | For lifecycle insights that can be used for *CO2 Prestatieladder* |
| **5** | Only one product | One product (floor slab), with different configurations |

### 5.1.1 De Groene Paal

The first case study will be executed at *De Groene Paal* (DGP), which is a small company in the construction industry based in Amsterdam, the Netherlands (criteria 1 and 2). The organization developed a foundation pile that serves as the energy source for a heat pump at the same time. The name of this pile is also *De Groene Paal.* It is used in foundation renovation projects, where piles are used as foundational structure. DGP does not produce the product itself, they purchase foundation elements and heat pump technology and combine it in a smart way. Scope 3 emissions form a huge part of total emissions of DGP. The product has two functions, a constructive one and a heat exchange function. This heat exchange function can be used in winter to heat up the building, and in summer to cool down the building. The heat exchange takes place in the foundation pile, where liquid in pipes extracts either heat or cold from the wet earth layer in which the pile is situated (www.degroenepaal.nl).

The product decreases demand for natural gas, which is normally used for heating. This means a decrease in emissions as well. Communication about the positive side benefits of the product is interesting for DGP (www.degroenepaal.nl), and including insight in their upstream scope 3 emissions as well will improve insights. Both standards will be used to get (1) insight in their broad upstream scope 3 categories (Scope 3 Standard), and in how their product causes upstream scope 3 emissions in each production step (Product Standard).

### 5.1.2 Omnia Plaatvloer

*Omnia Plaatvloer* (shortly: *Omnia*) is a production company based in Coevorden, the Netherlands. They produce floor slabs (see Figure 23), including different variations in for example insulation or floor type. *Omnia* is a subsidiary of *Ballast Nedam*.

Their products are all prefabricated, therefore having a strong link with modular building projects and product platforms according to Veenstra, Halman and Voordijk (2006). The advantages of modular building include less waste and short construction periods, which are directly linked to sustainability. *Omnia* has an interest in sustainability, and uses it in their communication on their products. Furthermore, they are certified on the $CO_2$ performance ladder and state on their website that a 11% $CO_2$-reduction has been realised from 2008 (www.omniaplaatvloer.nl). Insight in their upstream scope 3 emissions will be relevant for *Omnia*, leading to insight on the organizational level (Scope 3 Standard) as well as on their product level (Product Standard). Comparing the outcomes can for example lead to insight in which method is most easy to use, in how much emissions are covered, and their accuracy.

**Figure 23 A floor slab**

## 5.2 Applying the Scope 3 Standard

When applying the Scope 3 Standard, the steps described in Chapter 4 are followed. Since two case studies are executed, both will be described separately followed by experience evolved from applying the Standard. In both cases the approach used is more input-output approach than hybrid, resulting in a wide area covered of total emissions, with a relative low accuracy. This approach is explicitly chosen to differ from the Product Standard.

### 5.2.1 Identify Scope 3 Emissions

The Scope 3 Standard is executed on DGP for the year 2013; the first project started at the end of 2012, therefore that year is not representative. For 2013 estimations are made. For Omnia the year 2012 is used. To identify upstream scope 3 emissions the organizational boundaries must be defined. The consolidation approach for the case studies is set at 'operational control'. This approach is the most logical one when the final goal is to mitigate emissions, as only the emissions over which the reporting organization has influence are included (B. Buckley, personal communication, March 1, 2013). DGP is a privately owned company, and DGP has no share in equity or operational control in other entities. For Omnia, which is owned by Ballast Nedam, 'operational control' is chosen as well. An overview of this information, accompanied by employee numbers, is included in Table 13.

**Table 13 Case information**

| | DGP | Omnia |
|---|---|---|
| **Reporting year** | 2013 | 2012 |
| **Consolidation approach** | Operational control | Operational control |
| **Number of employees** | 5 | 75 |

In the case studies all eight upstream categories are considered; however not all categories entail emissions. The minimal boundaries, described in 'Appendix D – Description & boundaries of upstream scope 3 emissions', are applied in the case studies. The optional elements of categories 4, 5, 6, 7 and 8 are not included. No emissions are excluded that are included in the minimal boundaries. This can lead to effort invested in a certain category, while this category is only responsible for a very small percentage of total upstream scope 3 emissions.

### 5.2.2 Data collection

The next step is to collect the data. The four steps outlined in paragraph 4.2.2 are not all necessary, since in the case studies an inventory is made at a certain point in time. Therefore the fourth step, improve data quality over time, is not executed. The first step, to prioritize data collection efforts, leads to the decision to include all sources where possible. For the Scope 3 Standard the input-output approach is used, wherefore it is possible to include all upstream scope 3 emissions. Furthermore, the aim of the research is to investigate the application of the standards, so including all sources is beneficial for a broader experience. Direct measurement will not be used, so the selection of data can be divided in two steps; first the activity data needs to be found, then the emissions factors and the GWP factors.

#### *5.2.2.1 Activity data*

Since the approach in the Scope 3 Standard in the case studies is mostly input-output, secondary data will be used. In category 1 all expenses are included. For Omnia financial information is retrieved to insert this information. Persistence was essential to retrieve this information; it is sensitive information when supplied on a high detail level, which may be used against Omnia as a subsidiary. Therefore rounded numbers are used. At DGP expected values are used, provided by Flip Verbeek, owner of DGP. This is not an ideal approach; for a start-up this is however the best suitable approach since using 2012 data provides very limited results. The reliability is tackled as much as possible by using the owner's expectations. For category 2, capital goods, investment information is used for Omnia, while at DGP an educated guess is made. To retrieve fuel- and energy-related emissions not included in scope 1 and scope 2 (category 3), Omnia retrieved the information from energy and gas providers, as well as purchasing information on diesel bought in 2012. DGP rents their office from a foundation, *De Groene Bocht*, and retrieved an educated guess on their use of electricity and gas. It is important to note that it is not possible to determine the exact amount, since there are no individual meters installed in the building where besides DGP, other organizations rent office space. DGP does not purchase any other fuel, such as diesel.

Category 4, upstream transportation and distribution, includes transportation from tier 1 suppliers to DGP or Omnia. Both companies purchase products of which transportation is already included in the price, wherefore this category is already included in category 1 (purchased goods and services). Distance and amount or weight of purchased products can be retrieved at both organizations, however double counting would occur if the price is already included in category 1 while at the same time category 4 is filled out with specifications.

Third-party disposal and treatment of waste (category 5) requires information on the type and amount of waste, and the way this waste is treated. For Omnia this is retrieved from their waste treatment company. For DGP an educated guess of the waste generated in a typical project, multiplied by the total amount of projects estimated in 2013. Transportation of waste is not included. Information on category 6, business travel, is not present at Omnia. It is perceived a very small amount if applicable at all, since the production and activities are for the majority based on the location in Coevorden. For DGP an estimation of taxi use and short haul flights (within Europe) is made.

**Table 14 Activity Data in case studies compared to Scope 3 Standard guideline**

| Category | Guideline S3S | DGP | Omnia |
|---|---|---|---|
| **1** | All purchased goods and services | Estimated values | Rounded numbers |
| **2** | All purchased capital goods | Estimated values | Investment data (rounded) |
| **3** | All purchased electricity and fuels | Estimated by 'landlord' | Retrieved from energy, gas and diesel providers |
| **4** | All transportation and distribution (from tier 1 and other transport) | Included in category 1 | Included in category 1 |
| **5** | Disposal and treatment of waste | Educated guess per project is multiplied | Retrieved from waste treatment company |
| **6** | Transportation of employees for business-related activities | Taxi use and flights are estimated | Not available; perceived as very small amount |
| **7** | Commuting | Estimated values | Estimated values |
| **8** | Operation of assets | No leased assets | No leased assets |

Employee commuting, category 7, is for DGP an easy estimation, since their limited number of employees. For Omnia an educated guess is made, based on the percentages of employees using a car, public transport, or bicycle/walking. The distance of each group is estimated as well. Category 8, upstream leased assets, is not of influence for both DGP as Omnia, since they do not lease assets. Table 14 presents the overview of all categories, compared to the Scope 3 Standard guidelines.

#### *5.2.2.2 Emission factors and GWP factors*

For the selection of emission factors and GWP factors the GHG Protocol provides no specific solution. The GHG Protocol does list several third party databases on their website where emission factors can be found (www.ghgprotocol.org/Third-Party-Databases). For category 1 and 2 an input-output table that entails emission factors is needed to calculate emissions. The databases that provide input-output data are scanned on publishing organization, after which three databases are selected for a review. The three databases are listed in Table 15.

**Table 15 Input-output databases selection**

| IO database | Carnegie Mellon University | Climate Earth Inc. | DECC/DEFRA |
|---|---|---|---|
| Full name | Carnegie Mellon EIO-LCA | CEDA Factors for the United States | 2010 Guidelines to DEFRA / DECC's GHG Conversion Factors for Company Reporting |
| Latest update | 2002 | 2010 (CEDA 4) | 2010 |
| Life Cycle Stages | Cradle-to-gate | Cradle-to-gate | Cradle-to-grave |
| Emission results | Total CO2-e | GWP | Total CO2-e, seperate GHGs, seperate scopes |
| Geography | USA, Germany, Spain, Canada, China | USA | UK, Global |
| Advantages | Huge amount of datasets | Life cycle stage information available | Also country specific data included |
| | | Information available at GWP level | Usable in Excel |
| | | Up-to-date data | Referred to in literature |
| | | | Up-to-date data |
| Disadvantages | Out-dated | USA specific and not free of charge ($250/month) | Part of data only UK specific |

The review leads to the selection of the DECC/DEFRA database (shortly: DEFRA). The Carnegie Mellon database is out-dated, the Climate Earth Inc. database is not free of charge. The DEFRA database is partly based on data from the United Kingdom, but it also has some country-specific data included. Therefore the DEFRA database is selected as the input-output source. For category 3 DEFRA also provides conversion factors for electricity, natural gas and fuel purchased by the reporting organization. These factors are used to calculate upstream scope 3 emissions. The electricity factors are country specific, for which the Dutch factors are used.

Category 4 concerns transport, however in both case studies the products purchased have transport included in the price. This means that inbound transport is already included under category 1. DGP does not have any other need for transport, Omnia on the other hand does transport floor slabs to production sites. Since it differs per order what the distance and corresponding weight is, the amount spent on outbound transport is included in category 1 instead.

To calculate category 5 emissions, DEFRA provides emission factors for waste as well. These emission factors will be used. For category 6 DEFRA provides an emission factor for taxi rides and business travel in cars not owned by the reporting organization, of which fuel is unknown. DEFRA also provides emission factors for air travel per passenger kilometre travelled. It is specified in either domestic, short-haul international or long-haul international. It is also possible to differentiate between classes. For category 7, DEFRA provides emission factors for different types of commuting. However, for this category information from the *Milieubarometer* is used. This is a source from *Stichting Stimular*, which is a foundation that stimulates SMEs to operate in a sustainable manner. Category 8 is for neither of the case studies relevant.

Within the emission factors of DEFRA and *Milieubarometer*, GWP factors are already used. This means that the calculation from other GHGs than CO2 (e.g. CH4) into $CO_2e$ quantities is already executed. The GWP factors used by DEFRA and *Milieubarometer* are the IPCC values published in the Fourth Assessment Report in 2007.

#### *5.2.2.3 Data quality*

The Scope 3 Standard mentions five data quality indicators, at which scores ranging from very good to poor can be achieved. In 'Appendix E – Data Quality Indicators' the description of the indicators with their the scores is included. This is a qualitative assessment (poor; fair; good; very good), which is for the purpose of this research turned into a quantitative scale (see Table 16).

**Table 16 From qualitative rating towards quantitative rating**

| Qualitative rating | Poor | Fair | Good | Very good |
|---|---|---|---|---|
| **Quantitative rating** | 1 | 2 | 3 | 4 |

These ratings are used to complete Table 17 and Table 18. To make a distinction in data used for the calculations, it is divided in activity data and emission factors. For these tables the completeness rating of the emission factors is not specified, since completeness is not scalable for emission factors.

**Table 17 Data Quality for Scope 3 Standard Omnia**

| | | Technology | Time | Geography | Completeness | Reliability |
|---|---|---|---|---|---|---|
| **Cat. 1** | AD | 3 | 4 | 4 | 3 | 2 |
| | EF | 2 | 3 | 2 | - | 3 |
| **Cat. 2** | AD | 3 | 4 | 4 | 3 | 2 |
| | EF | 2 | 3 | 2 | - | 3 |
| **Cat. 3** | AD | 4 | 4 | 4 | 3 | 4 |
| | EF | 3 | 3 | 3 | 3 | 3 |
| **Cat. 5** | AD | 3 | 4 | 4 | 3 | 3 |
| | EF | 2 | 3 | 2 | - | 3 |
| **Cat. 7** | AD | 3 | 4 | 3 | 3 | 2 |
| | EF | 3 | 4 | 3 | - | 3 |

The data quality indicators and the corresponding rating descriptions are very general. This undermines the value of Table 17 and Table 18 due to subjectivity. The indicator technology is sometimes difficult; when is technology different and when is it similar? For the indicator geography the term 'area' is vague; it is unclear whether a country, a province or another geographical area is meant. The difficulty of completeness lies in the huge difference between good (3) and very good (4): are *all* relevant processes included or more than 50 percent? This can be a huge difference. Furthermore, it is difficult to determine completeness when the complete inventory is unknown.

**Table 18 Data Quality for Scope 3 Standard DGP**

| | | Technology | Time * | Geography | Completeness | Reliability |
|---|---|---|---|---|---|---|
| **Cat. 1** | AD | 3 | 3 * | 4 | 3 | 2 |
| | EF | 2 | 3 | 2 | - | 3 |
| **Cat. 2** | AD | 3 | 3 * | 4 | 3 | 2 |
| | EF | 2 | 3 | 2 | - | 3 |
| **Cat. 3** | AD | 3 | 3 * | 4 | 3 | 2 |
| | EF | 3 | 3 | 2 | - | 3 |
| **Cat. 5** | AD | 3 | 3 * | 4 | 3 | 2 |
| | EF | 2 | 3 | 2 | - | 3 |
| **Cat. 6** | AD | 3 | 3 * | 3 | 3 | 2 |
| | EF | 3 | 3 | 2 | - | 3 |
| **Cat. 7** | AD | 3 | 3 * | 4 | 3 | 2 |
| | EF | 3 | 4 | 4 | - | 3 |

**) no indication given how to deal with estimated data in the future. Activity data is estimated to score 'good' (3).*

### 5.2.3 Data allocation

Activity data acquired for calculations is not obtained from upstream suppliers, except for category 3 from DGP. Rough estimates of the total electricity and gas quantities of the supplier of the office space are used to allocate emissions for this category.

### 5.2.4 Reporting and reduction targets

Omnia has a total of 16.500 tonnes CO2e upstream scope 3 emissions in 2012. For Omnia category 1 is by far the most important category. Almost 94% of total upstream scope 3 emissions are reported in this category. When specifying this category further, cement causes 31% and steel 52% of category 1. Category 2 represents 3.6%, category 3 1.7% and category 7 0.7%. Category 4, 6 and 8 are not relevant, while category 5 is such a small amount (3,3 tonnes CO2e) that it leads to a percentage of 0.0%. The precise emissions with their corresponding percentages are visible in Table 19 and Figure 24. The calculation is included in 'Appendix G – Background tables on Scope 3 Standard'.

**Table 19 Emissions at Omnia per upstream scope 3 category**

| Emissions per category | CO2e (tonnes) | Percentage |
|---|---|---|
| Category 1 | 15.498 | 93,9% |
| Category 2 | 596 | 3,6% |
| Category 3 | 281 | 1,7% |
| Category 5 | 3 | 0,0% |
| Category 7 | 122 | 0,7% |
| | | |
| TOTAL UPSTREAM SCOPE 3 EMISSIONS | **16.500** | 100% |

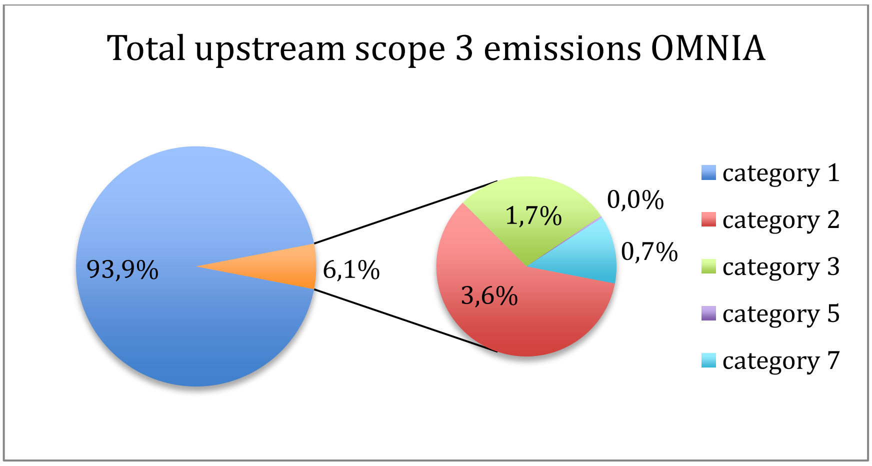



**Figure 24 Total upstream scope 3 emissions at Omnia**

For DGP total upstream scope 3 emissions in 2013 are estimated to be 277 tonnes CO2e. Also for DGP category 1 is by far the most important category (94.7%). Since DGP is a start-up, category 2 is a strange category. Depreciation of emissions is not used for investments wherefore this category is the second largest category (2.5%). However, these emissions will not occur with the same intensity the following years, since less capital goods will probably be acquired. Category 3 is of minor influence (0.2%), and so is category 5 (0.0%). Category 6 is quite significant (2.2%), due to several business related trips both in the Netherlands as well as to countries where suppliers are based. Commuting in category 7 accounts for only 0.4%, since most employees cycle to work. Category 4 (upstream transportation) is not included; all purchased products have transport to the desired location included in the price and downstream of DGP no transport takes place. Category 8 is not included either; when operational control is chosen the rented office is already included in scope 1 and/or 2 (WRI & WBCSD, 2011a). Exact emissions can be found in Table 20 and Figure 25. The tables used to calculate category emissions are included in 'Appendix G – Background tables on Scope 3 Standard'.

**Table 20 Emissions at DGP per upstream scope 3 category**

| **Emissions per category** | **CO2e (tonnes)** | **Percentage** |
|---|---|---|
| Category 1 – Purchased goods and materials | 262,3 | 94,7% |
| Category 2 – Purchased capital goods | 6,8 | 2,5% |
| Category 3 – Fuel and energy related | 0,6 | 0,2% |
| Category 5 – Waste generated in operations | 0,0 | 0,0% |
| Category 6 – Business travel | 6,1 | 2,2% |
| Category 7 – Employee commuting | 1,2 | 0,4% |
| | | |
| TOTAL UPSTREAM SCOPE 3 EMISSIONS | **277** | 100% |

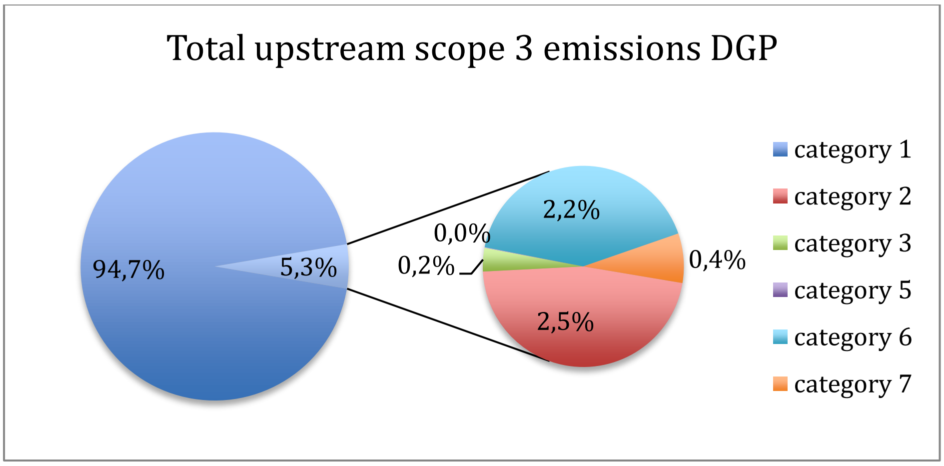



**Figure 25 Total upstream scope 3 emissions at DGP**

Now Omnia and DGP have insight in their upstream scope 3 emissions, it is possible to set reduction targets. These reduction targets can either lead to the decision to buy less of certain products or services, change the products or services they buy for other, more sustainable products, or stimulate other behaviour on aspects like commuting. Stimulate other commuting behaviour is clearly not the most influential one, looking at the percentages scored for category 7.

## 5.3 Applying the Product Standard

When applying the Product Standard, the steps described in Chapter 4 are followed. These different steps will be followed for both case studies.

### 5.3.1 Identify a Product Inventory

The Product Standard will result in a CO2e score per unit of analysis, wherefore selecting the unit of analysis is the first essential step. Omnia produces floor slabs in a wide variety. The variations include thickness, length and width, composition of the floor slab and amount of reinforcement. These variations in floor slabs leave the production site according to the order made by the client. Since every floor slab differs, it is not logical to take one specific floor slab as the unit of analysis. In this research a sample order is chosen that represents an average order. The unit of analysis for Omnia is therefore this sample order, consisting of roughly 15 tons of product (floor slabs), with 6,5 $m^3$ in volume. The details are provided in 'Appendix H – Background tables on Product Standard', due to confidentiality. This sample order is the reference flow, on which the outcomes of the product inventory will be based.

The service life of the reference flow is not known, which is not a problem due to the focus on upstream emissions. The service life would be of interest if downstream emissions were the topic of this research.

The life cycle stages included are (1) material acquisition and pre-processing, (2) transport to Omnia, (3) production and (4) transport to customer. Compared to the life cycle stages mentioned in Chapter 4, transport to Omnia is added. The reason for this additional stage is the fact that data is available for it, which creates more transparency and higher value for the final product inventory. The process map is visible in Figure 26, indicating what is included and what not. All attributable processes are included, while only electricity and gas usage of the production site is included as non-attributable process.

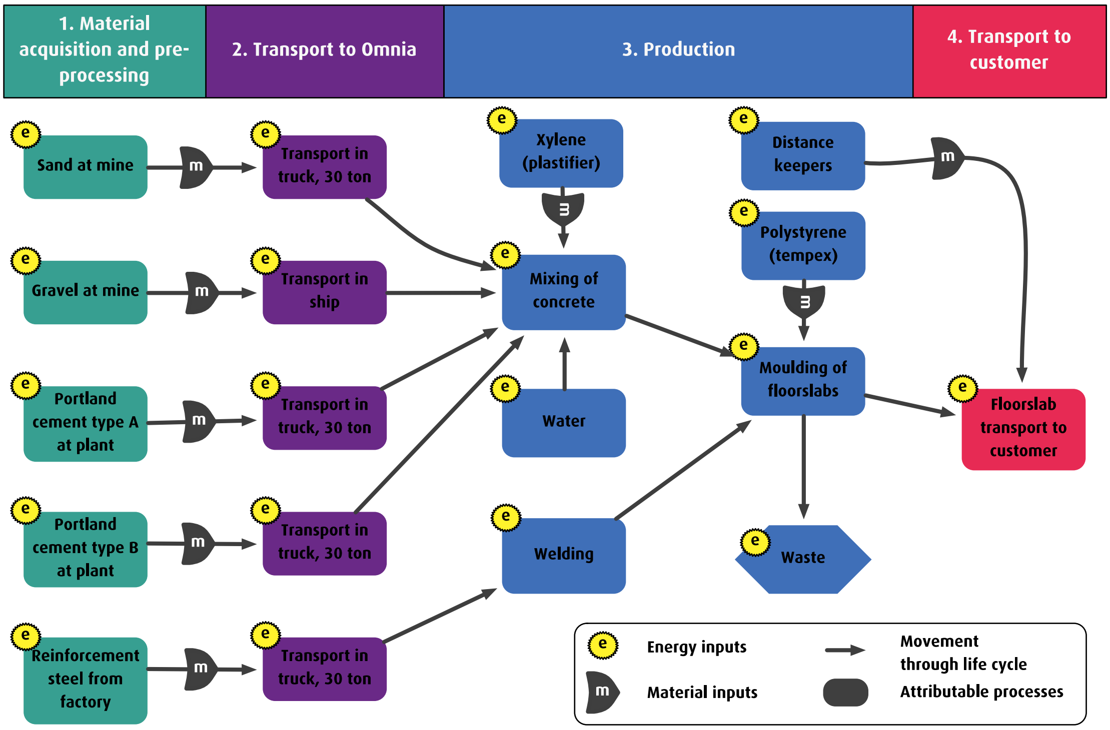



**Figure 26 Omnia Process Map**

For DGP a standard project is chosen as unit of analysis. This is a project in which a house is demolished and rebuilt with a lightweight frame. In this concept the heat pump technology is integrated in the foundation piles. All input elements used for the DGP are included in the unit of analysis and the corresponding reference flow, listed in Table 21.

**Table 21 Specification of reference flow at DGP. Source: Flip Verbeek, personal communication**

| Element | Quantity | Unit |
|---|---|---|
| Concrete poles | 5,29 | m3 |
| Concrete floor | 34,7 | m3 |
| Steel for pile | 0,416 | m3 |
| Reinforcement steel | 4164 | kg |
| Polybutylene pipes | 826 | m1 |
| Heat pump | 150 | kg |
| Glycol | 40 | L |
| Water | 78 | L |

Since only upstream emissions are considered, the service life is not specified. The life cycle stages (1) material acquisition & pre-processing, (2) transport to production site and (3) production are included. DGP does not have a distribution centre or production site; therefore only one transportation life cycle stage is considered (opposed to the two stages included for Omnia). All attributable processes are included (visible in Figure 27).

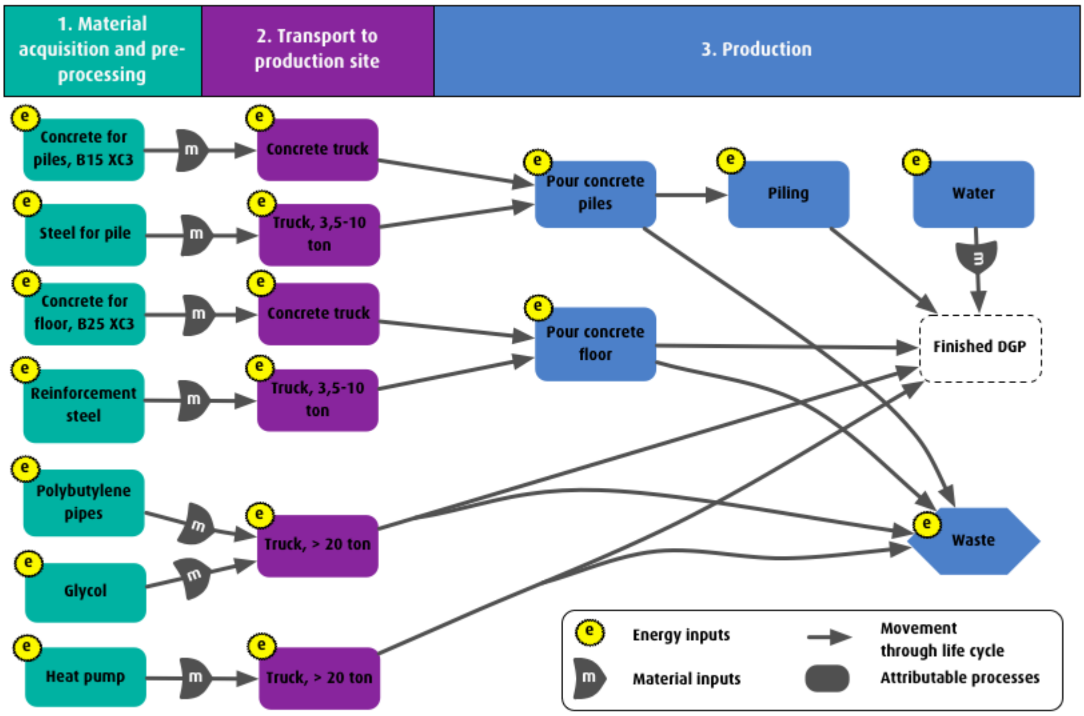



**Figure 27 DGP process map**

### 5.3.2 Data collection and allocation

The data collected to calculate GHG data differs per life cycle stage and per process. For none of the collected data direct, measured emissions values have been used; this type of data is simply not available at Omnia and DGP. The data that *is* used is process activity data, either primary data or secondary data. After this activity data is collected, emission factors will be sought to calculate GHG emissions.

#### *5.3.2.1 Activity data*

The sample order provided a good starting point for data collection for the material acquisition and pre-processing stage. Thereby the exact amount of reinforced steel could be determined (primary data). The other input elements of the sample order are calculated by dividing overall quantities; this secondary data is produced using allocation. Other input materials that do not end up in the final product are not considered relevant for this stage. In the beginning Omnia was not too eager to supply the required information. Detailed information of the sample order combined with overall quantities of materials and expenditures creates a vulnerable position, since the cost price can be estimated with this information. This illustrates the conservative reality of the construction industry, where supplying detailed information to a subsidiary hampers interests.

Transport to Omnia requires data on location of origin and location of Omnia, combined with mode of transport. The distance data is primary data, while the data used to calculate the corresponding emissions of the mode of transport are based on transport mode averages (secondary data). The weight data that is needed is the same data used in the material acquisition and pre-processing stage.

For the production stage inputs and outputs are visible in the process map, see Figure 26. For the reference flow no primary data is available at this level, therefore secondary data is used. This secondary data is retrieved using allocation. In the final stage, transport to customer, the sample order is transported. The average distance for an Omnia project is estimated at 75 kilometres (M. van der Holst, personal communication, March 5 2013). This is also secondary data.

The sample order was a good starting point for DGP. The material acquisition and pre-processing stage were already defined by this sample order, wherefore no additional calculations were needed. Only for the amount of polybutylene used it was calculated how much kilograms are actually in 826 meter of pipes, which is 52,5 kg.

For the transport to the production site, Flip Verbeek (personal communication, March 10 2013) provided the locations of different suppliers and the modes of transport. Distances were determined using Google Maps. In the final stage, production, the main input elements were determined. These are diesel for pouring the floor and the piles, and diesel for piling, and water to fill the heat pump system. Furthermore build and demolition waste is included in the calculations. Transport to the production site of workers is not included.

#### *5.3.2.2 Emission factors*

After the activity data is collected and allocated, emission factors need to be retrieved from a source. This is an essential, though difficult task. As with the Scope 3 Standard, the GHG Protocol provides a list of third party databases. This list however is not very useful for this part of the research, since the sources are very sector and/or country specific (e.g., Danish Food LCA), or not available free of charge (e.g., Ecoinvent). The approach used to collect, free of charge, the most relevant emission factors is therefore different. The approach used is displayed in Figure 28.

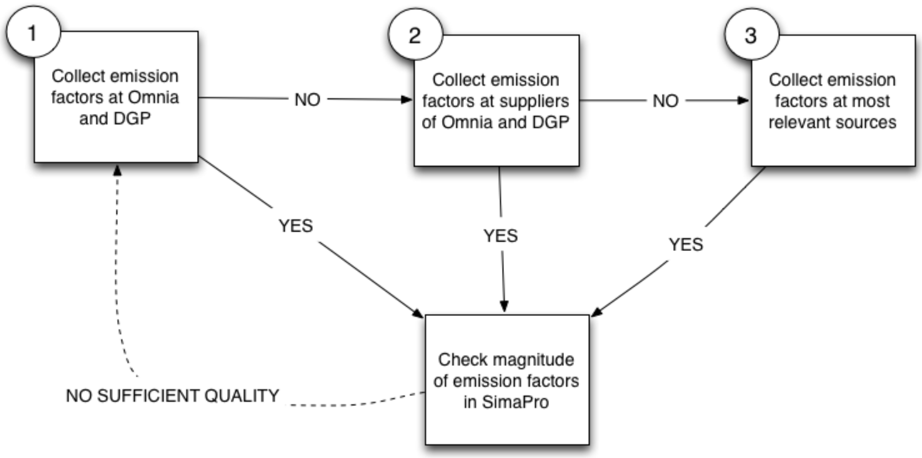



**Figure 28 Flowchart for selecting emission factor in Product Standard approach**

The correctness of emission factors is checked in SimaPro. This is special LCA software, in which the Ecoinvent database is used as input. This data can only be used as a check and is not included in this research, since it is used under an educational license. When it would be used as input for the cases to produce product inventories, the educational license would be violated (e.g., when Omnia publishes information on the product inventory). The ReCiPe mid-point method is used to calculate the climate change impact category score, with an amount of kg $CO_2e$ as a result.

The emission factors for the Omnia case are provided by Omnia (material acquisition and pre-processing, and production), retrieved from the *CO2 Prestatieladder* (transport to Omnia and transport to customer), and retrieved from DEFRA (production). A consultant calculated the emission factors retrieved from Omnia a few years ago. The check in SimaPro showed that these values are similar to the values found in SimaPro. All the material acquisition and pre-processing elements were almost the same, except for the emission factor for portland cement, strength class Z42.5. The emission factor used by Omnia was almost 50% lower. Due to low transparency of the calculation of the emission factor it is impossible to give the exact reason for this difference.

DGP did not have all the necessary information regarding emissions of the material acquisition and pre-processing phase available; contact with suppliers was necessary. This showed which information is available at suppliers and what difficulties arise in retrieving this information. One supplier was reluctant to give contact details of his supplier, since he was afraid that DGP would order their materials directly at that supplier. For concrete the producer provided the *Milieu Relevante Product Informatie* (Environment relevant product information: MRPI) document. At other suppliers no environmental impact information was available, wherefore other sources were needed to estimate emissions. For reinforcement steel the publicly available *Milieudatabase* (www.milieudatabase.nl) is used. For the transport phase *CO2 Prestatieladder* factors are used; for the production phase the *CO2 Prestatieladder* and DEFRA are used. Through the check in SimaPro it was clear that both steel and concrete were in the right range; the emission factor found for concrete in SimaPro was however a bit higher while the factor for reinforced steel was lower. This indicates the need for transparency and mentioning assumptions. An emission factor for polybutylene pipes was untraceable, wherefore it was checked with a similar material (HDPE). This resulted in the conclusion that the emission factor is in the right range. The emission factor for glycol was in the right range, while a comparable emission factor for the heat pump was not found.

#### *5.3.2.3 Data quality*

The Product Standard uses five indicators for data quality. In 'Appendix E – Data Quality Indicators' a description is given of these indicators. These data quality ratings are filled out for both case studies, leading to Table 22 and Table 23. These are comparable to Table 17 and Table 18; the difficulties for completing the tables are similar to those described in paragraph 5.2.2.3.

**Table 22 Data quality of Omnia Product Standard**

| | | Technology | Time | Geography | Completeness | Reliability |
|---|---|---|---|---|---|---|
| Material acq. & pre-proces | AD | 3 | 4 | 4 | 3 | 3 |
| | EF | 3 | 3 | 1 | - | 3 |
| Transport to Omnia | AD | 3 | 4 | 4 | 3 | 3 |
| | EF | 3 | 4 | 3 | - | 4 |
| Production | AD | 3 | 4 | 4 | 3 | 3 |
| | EF | 3 | 3 | 1 | - | 3 |
| Transport to customer | AD | 3 | 4 | 4 | 3 | 3 |
| | EF | 3 | 4 | 3 | - | 4 |

**Table 23 Data quality of DGP Product Standard**

| | | Technology | Time | Geography | Completeness | Reliability |
|---|---|---|---|---|---|---|
| Material acq. & pre-proces | AD | 3 | 4 | 4 | 3 | 3 |
| | EF | 3 | 3 | 2 | - | 3 |
| Transport to DGP | AD | 3 | 4 | 4 | 3 | 3 |
| | EF | 3 | 4 | 3 | - | 3 |
| Production | AD | 3 | 4 | 4 | 3 | 2 |
| | EF | 3 | 4 | 3 | - | 3 |

### 5.3.3 Reporting and reduction targets

The Product Standard describes that results of the product inventory should be communicated per life cycle stage, including the percentages of the total inventory. Figure 29 shows the visualized results for Omnia, making clear that the main impact is caused at the material acquisition and pre-processing stage. In 'Appendix H – Background tables on Product Standard' the underlying calculations can be found.

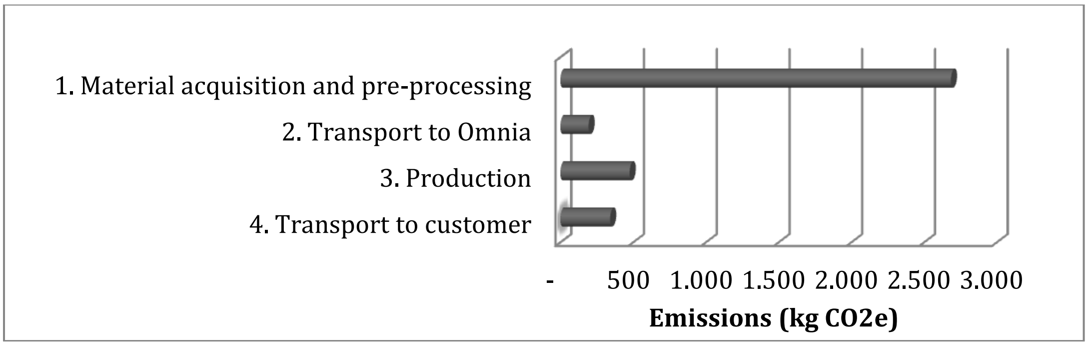



**Figure 29 Results Omnia from Product Standard; CO2e emissions per lifecycle stage**

Table 24 lists the total emissions per life cycle stage exactly combined with percentages. The total emissions caused by the functional unit are almost 3.700 kg CO2e; the material acquisition and pre-processing stage accounts for 73% of this total.

**Table 24 Results Omnia from Product Standard**

| Lifecycle stage | Emission (kg CO2e) | Percentage |
|---|---|---|
| 1. Material acquisition and pre-processing | 2.685 | 73% |
| 2. Transport to Omnia | 194 | 5% |
| 3. Production | 476 | 13% |
| 4. Transport to customer | 342 | 9% |
| | | |
| **TOTAL EMISSIONS** | **3.697** | **100%** |

The results for DGP are visualized in Figure 30 and Table 26. The calculations made for these results are included in 'Appendix H – Background tables on Product Standard. The share of the material acquisition and pre-processing stage is for DGP even larger than for Omnia. 96% of total upstream scope 3 emissions are caused in this stage. Compared to Omnia, the reasons for this difference are (1) that DGP has no transport to DGP stage, and (2) the production stage has a lower impact, since only fuel for production on site is included. At Omnia the product is actually produced in their facility, resulting in higher emissions in this stage and a lower share for the material acquisition and pre-processing stage.

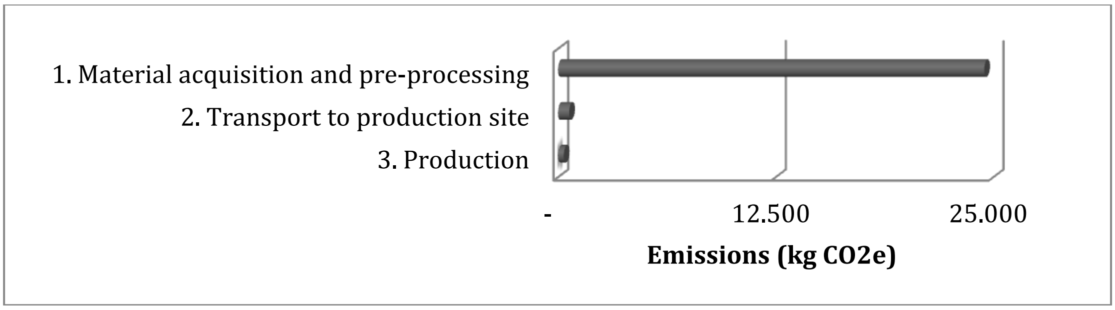



**Figure 30 Results DGP from Product Standard; $CO_2e$ emissions per life cycle stage**

The share of the material acquisition and pre-processing stage is for DGP even larger. 96% of total upstream scope 3 emissions are caused in this stage. Compared to Omnia, the reasons for this difference are (1) that Omnia has no transport to DGP stage, and (2) the production stage has a lower impact, since only fuel for production on site is used. At Omnia the product is actually produced in their facility, resulting in higher emissions in this stage and a lower share for the material acquisition and pre-processing stage.

**Table 25 Results DGP from Product Standard**

| Life cycle stage | Emission (kg $CO_2e$) | Percentage |
|---|---|---|
| 1. Material acquisition and pre-processing | 24.479 | 96% |
| 2. Transport to production site | 640 | 3% |
| 3. Production | 329 | 1% |
| | | |
| **TOTAL EMISSIONS** | **25.448** | **100%** |

## 5.4 Comparing the use of the Standards

The comparison between the Scope 3 Standard and the Product Standard is made on the aspects of effectiveness and efficiency. Effectiveness is regarded as *successfully producing an intended result*, while efficiency relates to *maximum productivity with minimum wasted effort* (see 'Appendix A – Problem definition terms' for a definition of these terms). The intended result is to assess upstream scope 3 emissions and present these emissions in an understandable way. This comparison is displayed in Table 26.

**Table 26 Comparing the Scope 3 Standard and the Product Standard**

| | | Scope 3 Standard | Product Standard |
|---|---|---|---|
| **Effectiveness** | + | Complete inventory is reached, besides some categories that are not relevant | Process map leads to easy understanding of emissions |
| | | Clear comparison between categories is possible, which shows irrelevance of certain categories | Separation into different process steps leads to more insights further upstream |
| | - | Final results give insight in numbers, less in process | Check in SimaPro of used emission factors gives reason to doubt accuracy of inventory results |
| | | Reliability of activity data is arguable (estimations), so is quality of emission factors (e.g., geography) | Non-attributable processes are not necessary to include; less overall insight in upstream scope 3 emissions than Scope 3 Standard |

| | | | |
|---|---|---|---|
| **Efficiency** | + | Quick approach when using the input-output approach and the eight categories for upstream emissions | Examples for process map are well explained in Standard |
| | | Financial data is already present, not much additional data is needed | DEFRA and other Dutch branch organizations provide emission factors for more general products when needed |
| | | Emission factors are available at DEFRA and *CO2 Prestatieladder*; no time wasted while searching for it | |
| | - | Scope 3 Standard is quite general | Product Standard is very general |
| | | Some categories are rather vague (e.g., category 8) when using the standard for the first time | Product Standard is not meant to assess only upstream emissions, wherefore more time is needed to decide exact boundaries |
| | | Predictions made for data not included in current data quality scoring methodology | Retrieving emission factors and activity data for specific materials is time-consuming |

When zooming in on the intended result of both Standards, it is interesting to compare the outcome of the inventory calculations. For Omnia, the input materials with the highest impact in category 1 in the Scope 3 Standard (the category where almost 94% of total upstream scope 3 emissions are located) are compared with their calculated emissions in the Product Standard. For this purpose the material acquisition & pre-processing phase is combined with the transport to Omnia phase, and multiplied with the quantities produced in the reporting year to get comparable values. The emissions occurring in the production phase are not included in this calculation. This decision is made because (1) allocating these emissions to individual input materials leads to high uncertainties and (2) only 13% of total upstream emissions occur in the production phase (according to the Product Standard). The results of this comparison are included in Table 27. Besides the huge difference for 'Cement type B' the results are within a 20% difference margin. The extra effort needed to apply the Product Standard is therefore not the best approach to get a first impression of upstream scope 3 emissions. The 89% difference for 'Cement type B' however does indicate the usefulness of diving deeper into the origin of emissions; it can be traced back to the emission factors retrieved from Omnia. The emission factor for 'Cement type B' is a factor two larger than 'Cement type A', while the DEFRA factor used in the Scope 3 Standard calculation stays the same.

**Table 27 Comparison of S3S and PS results for Omnia**

| Material | S3S calculated emission (ton CO2e) | PS calculated emission (ton CO2e) | Difference (S3S = 100%) |
|---|---|---|---|
| **Sand** | 229 | 191 | -16% |
| **Gravel** | 617 | 613 | -1% |
| **Cement type A** | 401 | 412 | 3% |
| **Cement type B** | 4306 | 8139 | 89% |
| **Reinforcement steel** | 8075 | 6575 | -19% |

For DGP the input materials concrete and reinforcement steel are compared. Together they represent 73% of category 1 emissions, which account for nearly 95% of total upstream scope 3 emissions. The PS calculated emission is a combination of the material acquisition & pre-processing phase and the transportation phase, and multiplied with the quantities in the reporting year to get comparable values.

**Table 28 Comparison of S3S and PS results for DGP**

| Material | S3S calculated emission (ton CO2e) | PS calculated emission (ton CO2e) | Difference (S3S = 100%) |
|---|---|---|---|
| **Concrete** | 29,6 | 24,8 | -16% |
| **Reinforcement steel** | 125,3 | 96,8 | -23% |

Differences for both cases between the Scope 3 Standard and the Product Standard are relatively small. Caution is however advisable since findings at other companies and/or in other industries can differ (B. Buckley, personal communication, April 16 2013).

## 5.5 Preliminary conclusions

In this chapter the third research question is answered, being*: How can an SME in the construction industry use the Scope 3 Standard and the Product Standard effectively and efficiently to assess upstream scope 3 emissions?* The insights in effectiveness and efficiency will be discussed first, leading to the answer how an SME can use both Standards together. *Omnia* and *De Groene Paal* were the case study companies. The case studies showed that the Scope 3 Standard and the Product Standard are extensive and very general documents. The vague guidelines for Data Quality Indicators are an example of the generality. The generality may be beneficial when using the Standards as a framework to design a more specific method; when using it for a specific industry and type of organization, like in the case studies, it hampers efficiency.

The Standards have distinct characteristics. The Scope 3 Standard is efficient by providing the eight upstream categories; these categories are clear for the user and focus efforts to find relevant information. Also the use of financial data and the availability of emission factors make it an efficient approach. The emission factors needed for the Product Standard are more difficult to retrieve; DEFRA and Dutch branch organizations provide some. A huge improvement would be if an open-source database with lifecycle emission factors is available. The commercial value combined with the difficulty of a reliable database hamper this development.

The insight in the eight upstream categories and the possibility to compare them makes the Scope 3 Standard effective. The quality of the results of the Scope 3 Standard is however significantly lower (e.g., scores on geography and reliability are low) than results of the Product Standard. The process map of the Product Standard provides effective insights.

An SME can use both Standards effectively and efficiently when combining them in a smart way while generality of the Standards is decreased. In this combination, (1) an SME is guided through both Standards, specified on an SME in the construction industry, (2) the type of activity data that needs to be retrieved is clear, and (3) the source of emission factors that are needed is clear. In the combination the Scope 3 Standard can be used as starting point. Case studies showed that results differ mostly in a range of +/-20% compared to the Product Standard, wherefore it is an acceptable first scan. An extra improvement will be if the generality of Data Quality Indicators is tackled as well. The insights in the upstream categories should be combined with lifecycle insights to create an effective visualization of assessed emissions. The smart combination will be the topic of the next chapter.

# 6 Method development

In this chapter the fourth and final research question will be answered, being:

> *Which method can be designed for an SME in the construction industry to assess upstream scope 3 emissions?*

At the end of this chapter it is clear how the method works, and why it suits the needs of an SME in the construction industry. In the introduction the theoretical input elements will be presented together with elements from previous chapters. The next paragraph will deal with Data Quality Indicators, after which the actual method is presented. In paragraph 6.4 the method will be reflected upon, followed by preliminary conclusions.

## 6.1 Introduction

The method that will be designed in this chapter assesses the impact of an SME on the environment; it is an environmental assessment method. Cole (1999) mentions three distinct roles for building environmental assessment methods, which are (1) providing a common and verifiable set of criteria and targets, (2) providing the basis for making informed design decisions (3) providing an objective assessment of a building's impact on the environment. Although the method in this chapter will assess scope 3 emissions of an SME instead of a building, the same roles are valid. Cole (1999) states that a distinction between the three roles and making the distinction explicit when structuring the assessment method is beneficial. These roles will be referred to later on in this chapter.

An environmental assessment method contains four key aspects according to Cole (1999). These four aspects are either implicit or explicit included in all existing building environmental assessment methods. These four aspects will therefore also be used when designing the method in this chapter, and will be referred to during the chapter. The aspects are:

1. **Input module**. Information is required to assess the object of study.
2. **Assessment module.** Performance scores are calculated.
3. **Output module**. Results of an assessment must be summarized and communicated.
4. **Explanation of Performance.** An output profile is most valuable when accompanied by an explanation (Cole, 1999).

In the input module for the method designed in this chapter primarily activity data will be used, combined with emission factors. The assessment module will basically be the calculation of emissions. In the design of the output module and the explanation of performance the results will be communicated.

The method that is developed in this chapter will not only be based on the aforementioned information. The insights gained in Chapter 3 and 4 and the experience of the case studies in Chapter 5 will be used as well. The main findings of these previous chapters are presented in Table 29, together with their implications for the method and sometimes already linked to the aspects of an assessment method identified by Cole (1999).

**Table 29 Findings on which method is based**

| Chapter | Conclusion from chapter | Input for method |
|---|---|---|
| **3** | GHG Protocol is widely used | GHG Protocol serves as basis for the method |
| | More sources reported lead to more chances on good mitigation | Focus on efficient inclusion of many sources; more reported emissions with lower reliability is therefore in initial steps acceptable |
| | Current inventories incomparable, often due to differing organizational boundaries | Transparent starting point of and communication on boundaries; relevant in *input module* and *explanation of performance* (Cole, 1999). |
| | Hybrid model can take best of both worlds | Combine input-output method with LCA; both models are used |
| **4** | 'Creative assessing' may transfer emissions between scope 1, 2 and 3 | Integrate scope 1 and 2; report clear results of all scopes together in *output module* |
| | Iterative process of improving an inventory is not clear | Include clear consecutive steps for improvement; a user has a clear starting point, and is guided through the method |
| | Input-output method is more suitable for quick-scan than LCA | Input-output method will be used as starting point; after retrieving general information, the first step in the method will be based on input-output method |
| **5** | Generality of Scope 3 Standard and Product Standard | Include sources that have to be used and create clear-cut path in method (e.g., method automatically couples input-output table emission factors to inserted activity data). |
| | Inventory differences between Scope 3 Standard and Product Standard are relatively small | Using Scope 3 Standard in combination with DEFRA factors is reliable starting point |
| | Difficult to retrieve primary data | Start with secondary data; primary data used in later steps. Estimations of financial information can be used in first step, later on more specific information |
| | Eight upstream emissions categories from Scope 3 Standard are effective | Include the eight upstream categories of Scope 3 Standard. Categories can be compared with eachother in this way |
| | Insight in lifecycles is effective visualization for more understanding of most impactful products | Use Product Standard for effective, deepening insights in upstream supply chain |
| | Data Quality Indicators (DQIs) are general and difficult to use | Alter DQIs and provide SME/construction industry examples |

The combination of Cole's key aspects and Table 29 result in:

- Scope 3 Standard is starting point, used as a first estimation and thereafter for deepening insights
- Product Standard used after S3S, as a first estimation and for deepening insights
- The *input module* is guided as much as possible (activity data & emission factors)
- The *assessment module* is not explicitly visible; it is executed in the background
- *Output module* and *Explanation of Performance* used for effective insights

Before moving to the method, the last implication (Data Quality Indicators) for the method mentioned in Table 29 requires an alteration step.

## 6.2 Data Quality Indicators

The Data Quality Indicators (DQIs) presented by the GHG Protocol are very general and therefore difficult to use, as became clear in Chapter 5. Therefore the DQIs are altered and complemented with construction sector specific examples. These examples help users to select the right score, and decrease subjectivity. For DQI 'time' the time periods are reduced, since in the case studies this indicator did not lead to insights. DQI 'geography' is changed into more specific descriptions that leave less room for misinterpretation. For DQI 'completeness' the time period is left out since it created more misunderstanding in the case studies than clarity, and this indicator is not requested for emission factors. The percentages are changed to raise the threshold for a (very) good score. The altered indicators and examples are presented in Table 30.

**Table 30 Method Data Quality Indicators with examples. Derived from WRI & WBCSD, 2011a**

| | **Representativeness to the activity in terms of** | | | | |
|---|---|---|---|---|---|
| **Score** | **Technology** | **Time** | **Geography** | **Completeness** | **Reliability** |
| **4 Very good** | Data captures precisely same technology | Data less than 2 years of diff., or not changed | Region or site specific data | Data captures over 90% of estimated total | Verified data based on measurement |
| *AD ex.* | *Kilometres travelled in diesel 1.6l engine car* | *Data from reporting year or previous year is used* | *Site specific concrete mixtures used* | *Category 1 is known to cover more than 90% of all expenses* | *Measured emissions at production location, primary data* |
| *EF ex.* | *EF for concrete with exactly same mix and production technique* | *EF of fuel staying the same over 5 years* | *EF for sand of specific mining location* | n/a | *Verified EF of car supplier, based on own measurement of specific car* |
| **3 Good** | Similar technology | Data with less than 4 years of difference | Country specific data | Data captures over 75% of estimated total | Verified data partly based on assumpt. or non-verif. data based on measurement |
| *AD ex.* | *Kilometres travelled in diesel car* | *Used commuting data is 3 years old* | *Dutch industry average of concrete mixture used* | *For transport phase more than 75% of transport is inlcuded* | *Measured electricity data allocated to process* |
| *EF ex.* | *EF for steel without specs of production* | *Used DEFRA factors date 3 years back* | *EF provided by CO2 Prestatieladder* | n/a | *Most EFs from DEFRA* |
| **2 Fair** | Different yet comparable technology | Data with less than 6 years of difference | Continent specific data | Data captures over 50% of estimated total | Non-verified data partly based on assumptions or a qualified estimate |
| *AD ex.* | *KMs travelled in 'petrol unknown' car* | *Business travel estimations are 4 years old* | *Other European concrete mixture used* | *Category 2 investment data covers over 50% of estimated total* | *Financial data estimated by expert* |
| *EF ex.* | *Comparable EFs from DEFRA* | *EFs for transport are 4 years old* | *EF provided by DEFRA and not Neth. specific* | n/a | *Non-verified factors based on assumpts.,* |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | *retrieved from supplier* |
| **1 Poor** | Technology totally different or unknown | Data with more than 6 years of difference, or unknown | Data from an area that is unknown | Data captures less than 50% of estimated total | Non-qualified estimate |
| *AD ex.* | *Kilometres travelled with unknown modality* | *Unknown date of origin for investment data* | *Unknown where concrete mixture is produced* | *Business travel only 20% reported of estimated total* | *Estimate for investments is done by non-expert* |
| *EF ex.* | *Non-comparable EFs from DEFRA used* | *Publication date of EF is unknown* | *EF found on the internet with unknown location* | n/a | *Source is unkown* |

In the method EFs will be determined automatically (based on preselected third party databases) or through a short questionnaire. For AD questionnaires are used. An improvement is that not for every DQI questions will be asked, since not every DQI is relevant for every type of EF or AD.

## 6.3 The Hybrid US3 Method

The new method's name is based on the combined use of the input-output model and LCA, and the focus on upstream scope 3 emissions (US3). It is created in Excel because (1) users don't need special software, (2) it is a widely used program and (3) the aim of the method can be realized. The method consists of four steps (two for each Standard). The Scope 3 Standard is the starting point (step 1 and 2), thereafter the Product Standard is used to gather lifecycle insights (step 3 and 4). This is in line with the first of the three options discussed in the introduction of Chapter 4 (page 34 and further). An important attribute of the method is that users are guided through the method; it is clear in which worksheet they need to start, and only the cells that *need* to be completed, *can* be completed. The general and unclear character of the iterative process in both Standards is tackled in this way. Table 31 presents the outline of the method.

**Table 31 Outline of method**

| Element | Content | Underlying method |
|---|---|---|
| **Get started** | General information | n/a |
| **Step 1** | Quick scan using input-output method | Scope 3 Standard |
| **Step 2** | Shift from second. data & estimates to hybrid approach | Scope 3 Standard |
| **Step 3** | Main product (functional unit) lifecycle insights, secondary data is sufficient | Product Standard |
| **Step 4** | Shift from secondary data and estimates to primary data (high score on DQI) | Product Standard |

This outline is transformed into a framework (see Figure 31). In this framework all four key aspects mentioned in the introduction are either implicit or explicit included. The rounded rectangles (regardless of the colour) are questionnaires or data entry sheets, thereby being *input modules*. On the background the data that is entered is being assessed, wherefore *assessment modules* are not explicitly visible in Figure 31. The hexagons (regardless of the colour) are *output modules* and include aim, emissions, Data Quality Indicator scores, slider (see 6.3.3), or functional unit. The outputs are displayed for every step in an end visualization. This visualization is partly an *output module,* partly an *explanation of performance.*

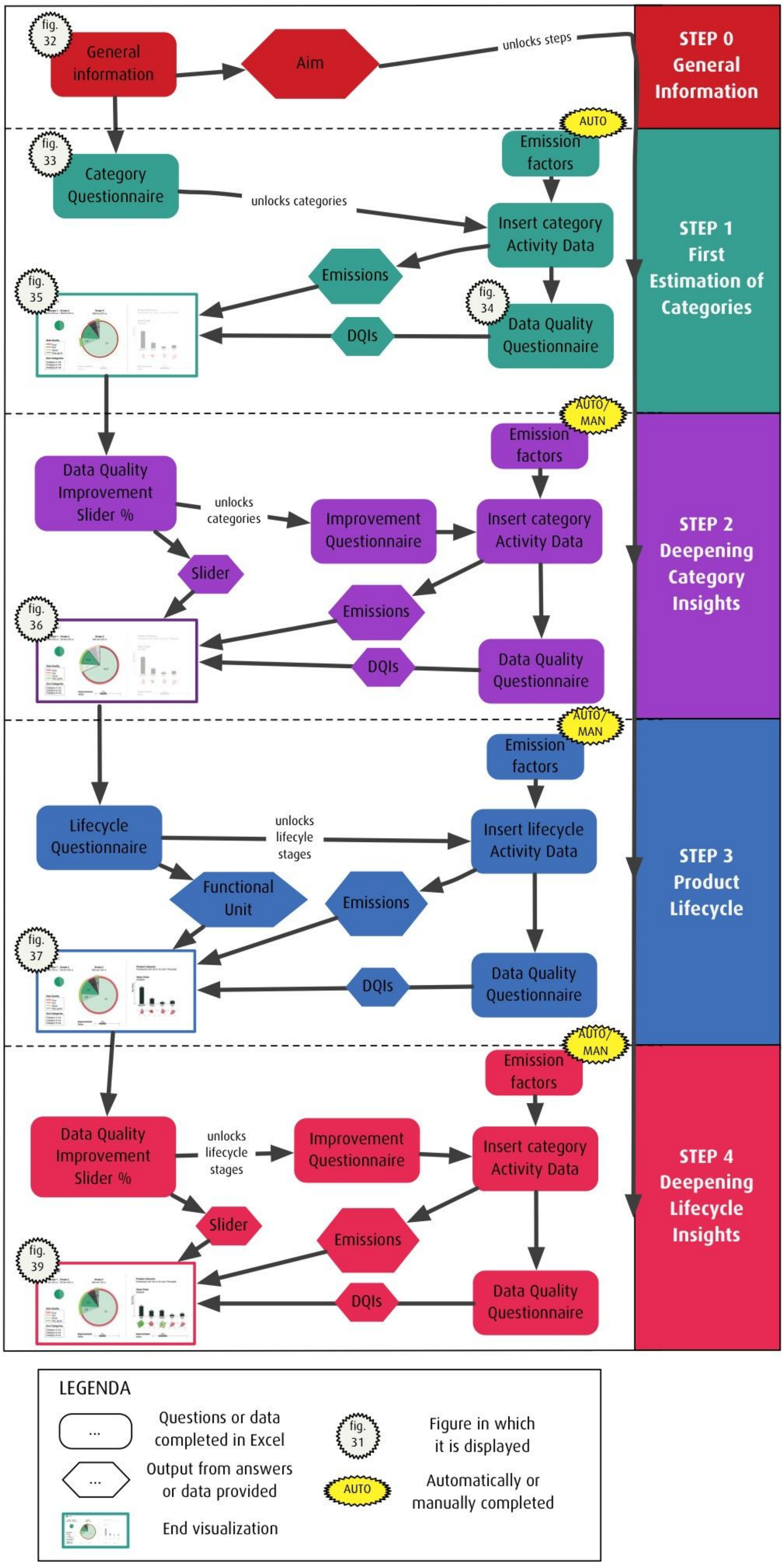



**Figure 31 The Hybrid US3 Method Framework**

### 6.3.1 Step 0 – General Information

This step is named 'Step 0' to show that this is a starting point, not the actual assessment. Before starting with the steps, an SME has to fill in the first worksheet. This worksheet is displayed in Figure 32. General information is requested and most important, the aim of the SME using the model is asked for. This is essential, since the steps that will become available depend on this answer. The selection of one of these four options, leads to the method consisting of one, two, three or four steps. Logically, the four-step model is the most exhaustive one. The consolidation approach, which determines the boundaries of what activities are included, is also asked for, together with other applicable boundaries. This is essential when publishing the results, since the inventory has to be transparent and comparable. This is mentioned by Cole (1999) as one of the distinct roles of an assessment method, namely to provide an objective assessment. This objectivity can be displayed in the *output module* and *explanation of performance.*

The first step is an *input module,* only the aim can be seen as output since it unlocks steps. This is visible in Figure 31.

GET STARTED

GENERAL INFORMATION

| | |
|---|---|
| Started with Method on | [specify] |
| Method completed on | [specify] |
| Person who completed it | [specify] |
| Function | [specify] |
| | |
| Company name | [specify] |
| Sector | [select] |
| Company type | [select] |
| Location of headquarters | [specify] |
| Number of other locations | [specify number of locations, not including HQ] |
| Reporting year | [select] |
| Employees in FTE | [specify] |

| | |
|---|---|
| Goal of model | Basic insight in upstream scope 3 emissions<br>Good insight in US3 emissions<br>Insight in US3 combined with product life cycle analysis<br>Insight in US3 combined with thorough insight in LCA |

| | |
|---|---|
| Consolidation approach | [select] |
| Activities/operations excluded | [specify] |
| Reasoning of exclusion | [specify] |
| Locations included in inventory | [specify] |

**Figure 32 Get started worksheet**

### 6.3.2 Step 1 – First estimation of categories

In the first step of the Hybrid US3 Method only the Scope 3 Standard is used, where all eight upstream categories are used. The starting point of the first step is a short questionnaire, where for every category one or more questions are included. This is an *input module.* Depending on the answers worksheets for categories become unlocked and must be completed; the other option is that they are excluded. This questionnaire is included in Figure 33.

| | QUESTIONNAIRE STEP 1 - COMPLETE BEFOREHAND | |
|---|---|---|
| 01. | QUESTIONS CATEGORY 1 - PURCHASED GOODS & SERVICES | ANSWER |
| 01.01 | Can spend information be estimated? | [yes/no] |
| 02. | QUESTIONS CATEGORY 2 - CAPITAL GOODS | ANSWER |
| 02.01 | Can investments made be estimated? | [yes/no] |
| 03. | QUESTIONS CATEGORY 3 - FUEL- AND ENERGY RELATED ACTIVITIES | ANSWER |
| 03.01 | Can quantities of purchased electricity be estimated? | [yes/no] |
| 03.02 | Can quantities of purchased gas be estimated? | [yes/no] |
| 03.03 | Can quantities of purchased fuel be estimated? | [yes/no] |
| 04. | QUESTIONS CATEGORY 4 - UPSTREAM TRANSPORTATION & DISTRIBUTION | ANSWER |
| 04.01 | Can transport from tier 1 suppliers be estimated? | [yes/no] |
| 04.02 | Can other inbound transport be estimated? | [yes/no] |
| 04.03 | Can outbound transport be estimated? | [yes/no] |
| 05. | QUESTIONS CATEGORY 5 - WASTE GENERATED IN OPERATIONS | ANSWER |
| 05.01 | Can quantity and type of waste be estimated? | [yes/no] |
| 06. | QUESTIONS CATEGORY 6 - BUSINESS TRAVEL | ANSWER |
| 06.01 | Can distance and transport mode of business travel be estimated? | [yes/no] |
| 07. | QUESTIONS CATEGORY 7 - EMPLOYEE COMMUTING | ANSWER |
| 07.01 | Can distance and transport mode of commuting be estimated? | [yes/no] |
| 08. | QUESTIONS CATEGORY 8 - UPSTREAM LEASED ASSETS | ANSWER |
| 08.01 | Can upstream leased assets be estimated? | [yes/no] |

**Figure 33 Questionnaire to start step 1**

Since users of the Hybrid US3 Method will not know beforehand which categories will be relevant for the total inventory, at this point all categories are included. The only exclusion rule possible is when the category is not applicable (e.g., no emissions from upstream leased assets). Furthermore, for category 4 it is possible that inbound transport is included in the price paid for products. These emissions will then be accounted for in category 1. For all categories financial estimations may be used; for category 3 (energy related emissions) and 7 (commuting) it is also possible to provide more specific information at this point. This information is retrieved through the questionnaire as well. The main goal of this step is to get an educated estimation of upstream scope 3 emissions. It is therefore not necessary to include *all* spend, or to specify the precise commuting distance of every employee. Quantities may be rounded and estimated. The person estimating the data should however be able to make the *educated* estimations.

When all unlocked categories are completed, emission factors are automatically determined and coupled to activity data. Excel then calculates emissions, being the *assessment module* (see Figure 31). A completion questionnaire (*input module*) has to be filled out before the first step is definitely finished. The answers on these questions (multiple choice) determine the Data Quality Indicator scores for activity data. The DQIs for emission factors are already known, since the method predetermined the use of DEFRA for most categories and *CO2 Prestatieladder* transport and commuting. The questions for category 1 are included in Figure 34; the questions for the other categories are similar and therefore not included. An important point of improvement is that not every DQI is asked for (see paragraph 6.2). For some categories a certain DQI is not relevant; in Figure 34 no question is asked about 'technology', since it is not relevant when using financial activity data (B. Buckley, personal communication, April 16 2013).

| QUESTIONNAIRE STEP 1 - COMPLETE AFTERWARDS | | | |
|---|---|---|---|
| 01. | QUESTIONS CATEGORY 1 | ANSWER | result |
| 01.01 | From which year is AD used, relative to reporting year? | [select] | 0 |
| 01.02 | From which geographical area is AD? | [select] | 0 |
| 01.03 | Which percentage of estimated spend is covered by AD? | [select] | 0 |
| 01.04 | How reliable is AD? | [select] | 0 |

**Figure 34 Questionnaire to finish step 1**

When this is completed the 'Reporting' worksheet will present results combined with a visualization as displayed in Figure 35. The figure presents (1) the proportion of scope 1 and 2 relative to scope 3 (size of circles), (2) the total inventory quantities of all scopes, (3) the size of the categories included, (3) the data quality of the different categories (displayed in the outer circles with differing colours; cumulative score achieved amongst all DQIs is compared to best possible score to determine end score), and (4) the categories that are excluded. Since this end visualization entails more information than just output data, it is regarded as a combination of an *output module* and *explanation of performance*. The aim is to provide an objective assessment, in line with Cole (1999)

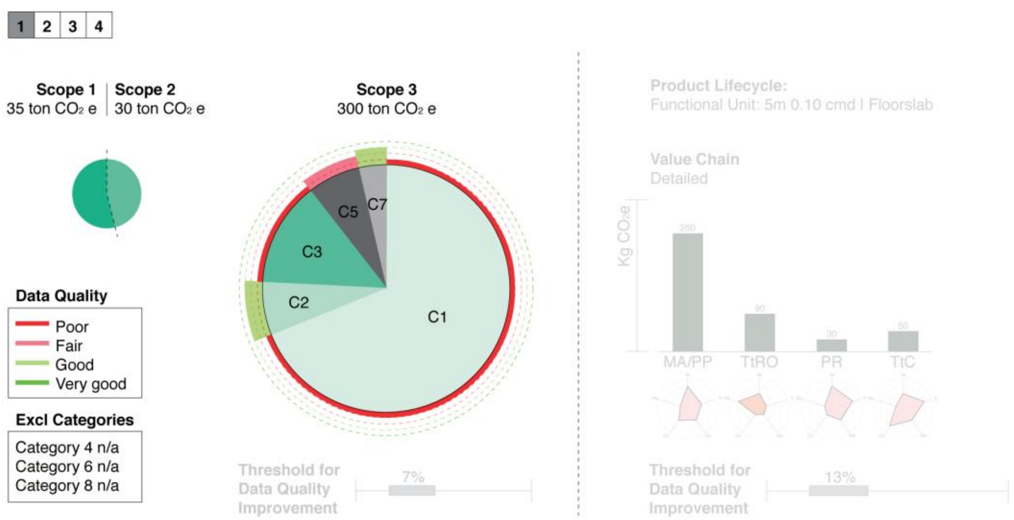



**Figure 35 Step 1 of Hybrid US3 Method**

### 6.3.3 Step 2 – Deepening category insights

In the second step the Hybrid US3 Method sticks to the Scope 3 Standard. This step is used to improve the inventory, where the focus is on the most impactful categories. The logic is that when a first estimate is made, it is more efficient to focus on improving the inventory than diving directly in the life cycle of certain product(s). To focus efforts on the most impactful categories, a Threshold for Data Quality Improvement is the starting point of step 2. With this slider the user determines above which percentage data quality of categories need to be improved. When, for example, category 7 represents 4,5% of the inventory and the slider is set at 4%, category 7 will have to be improved. When the slider is set at 5%, category 7 will remain unchanged. This slider creates the freedom to determine the tipping point that suits the needs of the reporting organization, and therefore helps in efficiently composing an inventory. This slider is displayed in the final report, which guarantees transparency. It is therefore regarded output in Figure 31.

Where in the first step financial data is mainly used, the categories selected for improvement do require more specific information. This can for example be quantity information (e.g., tons of steel) on purchased materials (category 1), amount of waste (weight) combined with waste treatment method (category 5), or distance and travel mode for business travel (category 6). A short multiple-choice questionnaire is used to determine how detailed the information is requested in the worksheets. The corresponding emission factors are selected through coupled databases from DEFRA and the *CO2 Prestatieladder*, or manually imported. When manually imported, it is (1) based on own available factors or factors found in industry databases such as www.milieudatabase.nl. After these *input modules*, assessment is done similar to step 1, leading to emission output. The second step is finished when final questions are answered that lead to DQI scores (output). This leads to a new visualization in the 'Reporting' worksheet, displayed in Figure 36. Category 1 and 3 (C1 and C3) are improved, as can be noticed from the '+' in the pies. Their data quality improved compared to the first step; category 1 moved from 'poor' to 'fair', while category 3 moved from 'fair' to 'good'. The improvement slider is displayed, indicating that the percentage is set at 7%.

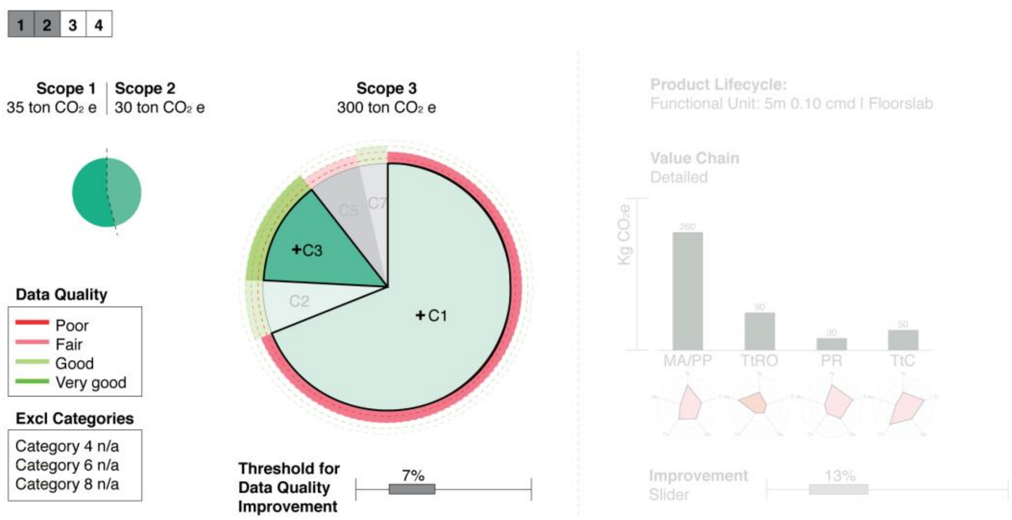



Figure 36 Step 2 of Hybrid US3 Method

### 6.3.4 Step 3 – Product Lifecycle

In the third step the Product Standard comes in. The case studies showed that category 1 is the most impactful category, in which input materials represent the majority of emissions. Through a multiple-choice questionnaire the most impactful purchased goods and services are coupled to a product the reporting organization produces or assembles. The answers on the questionnaire also determine the functional unit and which life cycle phases are included. The functional unit is regarded output, since it is displayed in the end visualization. Only attributable processes will be used at this point, and similar to the categories in step 1 exclusion is not advised. Relevant input fields are opened in which the relevant activity data can be specified. The questionnaire also forms the basis for the process map that the user needs to compose. This process map is however not displayed in the main visualization.

Contact with suppliers led to delay in the case studies, therefore in step 3 activity data and emission factors are retrieved from own information or online available databases, such as DEFRA or www.milieudatabase.nl. The approach displayed in Figure 28 (page

60) is therefore slightly altered. After all input elements are completed, assessment leads to emissions (output, see Figure 31). The third step is concluded with questions to determine DQI scores (output). The results of step 3 are visualized in Figure 37, where the functional unit is mentioned first. Then the life cycle stages are presented with the corresponding upstream emissions in each phase; MA/PP is material acquisition and pre-processing, TtRO is transport to reporting organization, PR is production and TtC is transport to customer. In this way, the Product Standard creates additional background on emissions already reported, thereby explaining the output that is gathered.

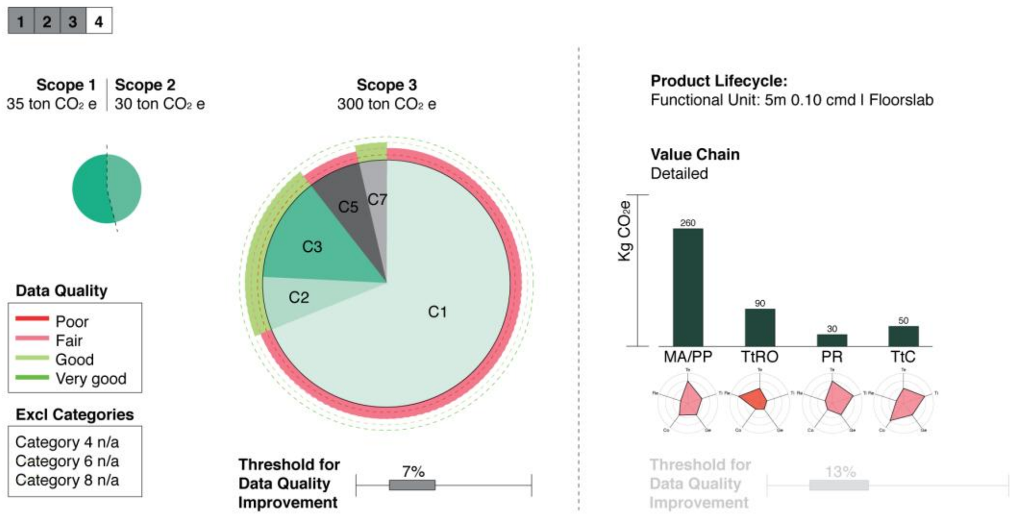



**Figure 37 Step 3 of Hybrid US3 Method**

The figure below each life cycle stage represents the data quality; these 'data quality spiders' visualize the data quality of each life cycle phase. The scores together lead to a final score which determines the colour of the spider. In Figure 38 the spiders of MA/PP and TtRO are represented in more detail.

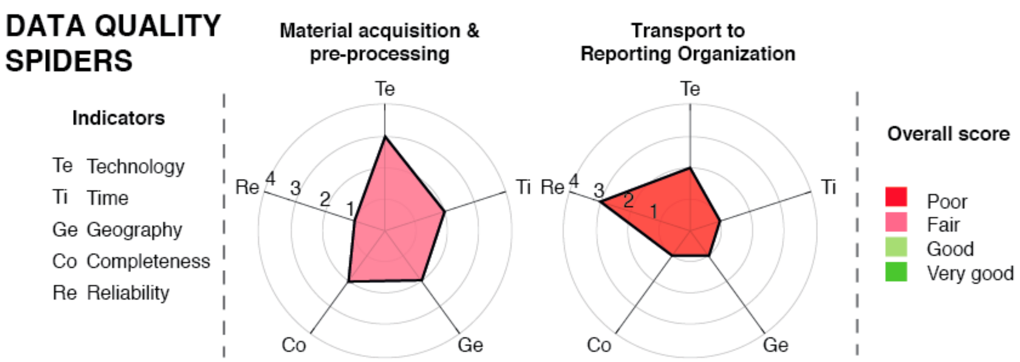



**Figure 38 Data Quality Spiders**

### 6.3.5 Step 4 – Deepening lifecycle insights

In the fourth and final step the life cycle phases are approached in a similar manner as the categories in step 2. A slider is included to determine the tipping point above which a phase requires more specification; the user can select the percentage on the slider which is regarded output in Figure 31. After determining the percentage a short questionnaire determines which cells need to be completed and if an extra life cycle phase will be added. Non-attributable processes are included as well at this point. To complete the cells, the most specific information that can be retrieved will be asked for. Contact with suppliers is an essential element, since supplier-specific information is the most precise. These data has to be checked with factors used in step 3, and their difference needs to be verified. This is included in the final questionnaire, on which DQIs are based as well. The visualization of step 4 is similar to step 3, as can be seen in Figure 39. The improvement slider is set at 13%, and it can be seen that an extra life cycle stage is added (MA/PP became two single phases). Similar to the second step, the improved phases (or categories in step 2) are recognizable by the '+'.

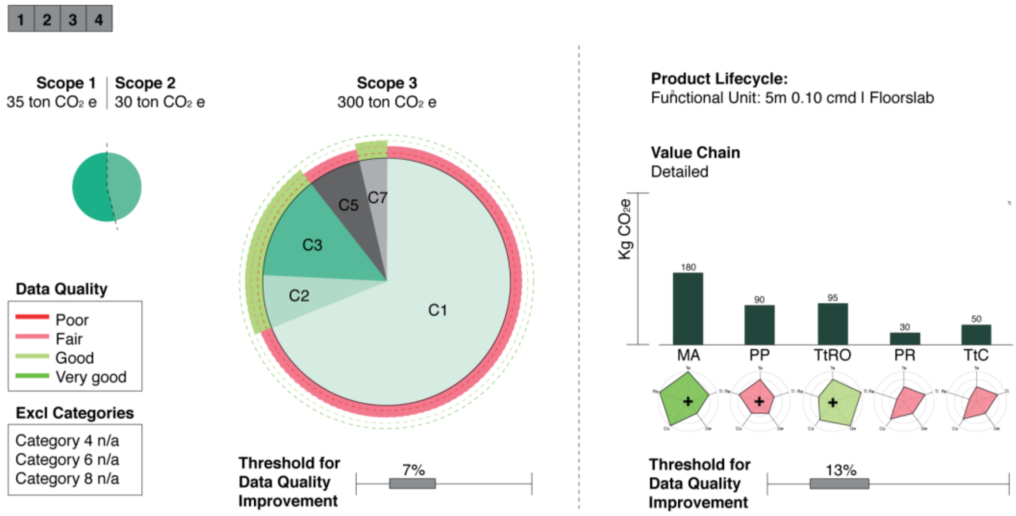



**Figure 39 Step 4 of Hybrid US3 Method**

## 6.4 Reflection on method

In this section the developed method will be reflected upon. This reflection will not lead to evidence that the method is either good or not good. Since the method is in its conceptual phase, this is also not the goal. An evaluation of the proposed method, with insights in perceived effectiveness and efficiency and possibilities for improvement is the goal.

One route to gain these insights is to compare the proposed method with the Scope 3 Standard and the Product Standard. Potential users of the method, SMEs in the construction industry cannot compare them, since potential users currently do not use the Scope 3 Standard and the Product Standard. This comparison is therefore done through an interview with Benedict Buckley, Research Analyst at the World Resources Institute (WRI), involved in the design of both Standards. In an interview with him the improvements made in the proposed method are discussed, how the method relates to the Product Standard and the Scope 3 Standard, and further improvements.

Another route is to reflect on the method as a method in itself; potential users are very logic for this approach. For the potential users a questionnaire with closed questions is not the best option, since validation is not the goal. The goal is to gain rich insights in the perceived effectiveness and efficiency of the method, resulting in possibilities for improvement. Semi-structured interviews will be used to retrieve insights. The questions will be based around three important themes; effectiveness, efficiency and improvements. The interview protocol is included in 'Appendix F – Interview introduction and questions'. To increase chances on valuable interviews the selection of interviewees is important. They must work for an SME, or be the owner, and the product or service they produce/sell, must relate to sustainability (e.g., *De Groene Paal*) or they must have the aspiration to operate in a more sustainable way (e.g., *Omnia*). To prevent biased answers, interviewees cannot already be involved in the case studies.

The criteria used to select interviewees are:

- Interviewee must be owner of, or working for an SME in the construction industry
- The SME must be (1) produce/sell a product or service related to sustainability, or (2) must have the aspiration to operate in a more sustainable way
- Interviewee must be potential user of the method for his organization
- Interviewee may not have been involved in the case studies carried out earlier in this research

Finally, the outline for the method presented in the introduction of this chapter will be reflected upon.

### 6.4.1 Expert interview

In the interview with Benedict Buckley it became clear that the choice to use the Scope 3 Standard first, and the Product Standard thereafter is logic. Although the Standards mention that the Product Standard can be used first as well, or simultaneously with the Scope 3 Standard, the most logic and efficient combination is this one according to Buckley (personal communication, April 16 2013). The burden of collecting (primary) data is tackled to focus on educated estimates and secondary data first, before moving to primary data. According to Buckley (personal communication, April 16 2013) this approach is in line with experiences in the field. It is beneficial to create a clear-cut path in both Standards. The alteration of DQIs and providing examples of them is beneficial as well; this is something that the GHG Protocol will not do due to their guiding role. The completeness score for EFs is left out in the designed method, a decision Buckley agrees with.

The visualizations of the different steps create valuable insights according to Buckley (personal communication, April 16 2013). To create a method that is more in line with the guidance of both Standards, Buckley suggested to include quantitative amounts of separate categories (similar to the format of the Scope 3 Standard to report results in).

### 6.4.2 Potential user interviews

Three persons will be interviewed, all meeting the criteria mentioned in paragraph 6.4:

1. Sam Kin (SK), owner of SolarSwing (www.solarswing.nl)
   *SolarSwing develops transparent sun shading. In the future sun shading solutions with integrated solar panels will be developed; a sustainable product whereby emissions become relevant.*
2. Jaap Nieuwenhuijse (JN), co-owner of Nieuwenhuijse Arends Bouw- en Risicomanagement (www.nabr.nl)
   *NABR manages building projects and wants to integrate sustainability more in their day-to-day activities and the projects they manage. Not only is NABR a SME in the construction sector, it also has intensive contacts with other SMEs in projects*
3. Sander Leegwater (SL), project manager at Schouten Techniek (www.schoutentechniek.nl)

*Schouten Techniek is a full service installation company. They have integrated sustainable products into their portfolio, of which heat pumps are an example.*

Before the actual interview is conducted, an introduction on the topic of the Hybrid US3 Method is given to the interviewees. The introduction, the interview questions and the answers provided by the interviewees are included in 'Appendix F – Interview introduction and questions'.

None of the interviewees assessed emissions prior to the interview, nor do the interviewees know other SMEs that currently assess their emissions. The first step is perceived as an easy step by the interviewees. The required data for almost all categories can be retrieved from bookkeeping (category 1, 2, 5, 6, and 7). Category 4 (transport) is a more complex category, since transport is often provided free of charge (SL). Category 3 (fuel- and energy related) depends on the rental situation. For JN and SL it is easy to retrieve the required data; SK is based in a shared office facility, wherefore these amounts are more difficult to assess. The resources needed for this first step are little. All interviewees agree that a person inside the organization should collect data, since some expertise of the own organization is needed. No specific expenses are needed and no or very limited contact with suppliers. The only investment is basically a time investment; SL estimates three days per month while JN estimates 1,5 day for the assessment of an entire year. The difference can be explained by the difference in size of both organizations.

The visualization of step 1 needs some additional information. The topic is quite complicated, wherefore it is not immediately clear what the categories are and how they relate to the three scopes (JN, SK). The comparison that can be made between the categories is very valuable (JN, SK, SL), as is the insight in the relative proportion of scope 3 to scope 1 and 2. Questionable is whether an SME will actually use this; this can either be more relevant in a more mature market of products where differences are less clear (SK), or when competitors start to use the assessment method as well (SL). As suggestion for improvement an explanation on how financial information relates to emissions is mentioned (SK), and the inclusion of what categories are through text or symbols (JN, SL).

When more specific information needs to be retrieved for step 2, SL states that this is possible for all categories and eventually turns out to be a time and effort investment. For category 1 the large quantities and bulk products are possible (SK, JN), while for products like an electromotor it becomes difficult (SK). Which materials are included in this product? Category 3 is simple (JN), or a landlord needs to provide specification (SK). An estimation is needed for waste, but this is possible (JN). For business travel and commuting, category 6 and 7, kilometres are relatively easy (JN, SK), while type of vehicle is not always possible (JN). SK states that business travel and commuting is now quite easy, but when SolarSwing will grow, this will become more complicated. Next to additional time, the interviewees state that contact with suppliers will sometimes be needed to retrieve data. The resources needed for this second step require additional time; JN estimates another three days for a year report. Contact with suppliers is at some aspects needed, for specific emission factors for example. SK states that it can depend upon the supplier if additional data is (1) available, and (2) can be shared. Some suppliers may for reasons of competitive advantage not want to supply very specific details on their products.

In step 2 data quality is improved by the user on certain categories; it is valuable to see what has been improved (JN, SL, SK). It is questionable however if the right categories have been chosen; can the largest categories also be improved (JN)? Furthermore, it is not clear if a threshold has been used below which quality has to be improved anyway (SL). Improvements would be to automatically determine the Threshold for Data Quality Improvement (SK), to include the potential for improvement and not only size of the category (JN), and explain what the aim (minimum level) of data quality is (SL).

For step 3 – Product lifecycle – the choice for a specific product is not immediately perceived as effective. This can be because no products are produced (JN), because a wide variety of products are produced (SL, SK). It is beneficial though when the company has focal products to create more insight (SK, SL). JN sees an opportunity for buildings projects he works on, since these insights can be very valuable to make decisions on issues related to sustainability. To retrieve the required information, contact with own suppliers is needed and perhaps even higher upstream (SK, SL). Confidentiality is likely to become an issue (SK). Step 3 is clearly another league than step 1 and 2, and therefore it is likely that more time is needed, and even expertise and guidance (SL, JN). The end visualization is effective, since it is intuitively clear what should be improved (JN). SK however states that intuitively the Data Quality Indicators seem to be worse when the spider grows; this is not the case. An important question evolving from the visualization is: can you actually influence the most impactful lifecycle phases? This is not displayed yet in the visualization (SK). Improvements would be to include downstream emissions, since a product like a heat pump initially has a high impact which will be paid back during the use phase (SL).

In step 4 – Deepening lifecycle insights – the separation of material acquisition and pre-processing is perceived as effective. The interviewees do not purchase raw materials, wherefore it is interesting to see where actually in the supply chain emissions originate (JN, SK). The higher quality of data, the aim of step 4, is however not entirely in own control; suppliers need to have or retrieve these more specific data (SL). This control issue also relates to the quality of the data; you have to trust your supplier whether supplied data is correct. This dependency grows when moving up in the supply chain. The relation you have with the supplier will determine how much effort is needed; a mutual dependency will most probably lead to a smooth process, a dependency on the side of the reporting organization will lead to a more difficult process (SL). This step requires time, expertise and persistence to collect all data needed, while quality of data can be doubtful (SL, SK, JN). An improvement for this step would probably be to set the percentage for the Threshold for Data Quality Improvement automatically (SK).

### 6.4.3 Reflection on introduction

In the introduction of this chapter key aspects of an environmental assessment method and findings of previous chapters were presented. The key aspects of Cole (1999) are all implicit or explicit incorporated in the method. They formed a valuable starting point to design the framework for the method. Most improvements can be made in the output module and the explanation of performance. For the potential user interviewees the visualizations were valuable, but not always totally clear. More explanation should be included either in the visualization or in the Excel questionnaires and worksheets. For the output module actual figures will be an improvement. When including potential for improvement in the method, the input and assessment module need to be altered.

The conclusions from previous chapters were translated into input elements for the method in Table 29. These input elements have been used throughout the design of the Hybrid US3 Method, and are reflected upon in Table 32.

**Table 32 Reflection on input for Hybrid US3 Method and their result**

| Chapter | Input for the Hybrid US3 Method | Result for the Hybrid US3 Method |
|---|---|---|
| 3 | GHG Protocol serves as basis | GHG Protocol is used as basis |
| | Focus on efficient inclusion of many sources | Step 1 and step 3 encourage inclusion of many sources in an efficient manner by making a predetermined choice for sources |
| | Transparent communication on boundaries | Visualizations list excluded categories. Precise boundaries (e.g., which tier is exactly included) are difficult in one visualization; excel sheet needs to be seen for this information. Consolidation approach is mentioned in excel sheet |
| | Combine input-output method with LCA | Step 1 and 2 are input-output, step 3 and 4 are LCA |
| 4 | Integrate scope 1 and 2; report clear results of all scopes together | Visualizations present all scopes together; insight in proportions. |
| | Include clear consecutive steps for improvement | The four steps are a consecutive approach |
| | Input-output method will be used as starting point | In step 1 the input-output approach is used |
| 5 | Include sources that have to be used, create clear-cut path | DEFRA and *CO2 Prestatieladder* are already included in the method; no choice has to be made. A point of attention remains the collection of reliable, accurate lifecycle data |
| | Using Scope 3 Standard in combination with DEFRA factors is reliable starting point | DEFRA is main source for step 1, where the Scope 3 Standard is used |
| | Start with secondary data; primary data used in later steps. | Completion of activity data is guided through questionnaires, where in step 1 and 3 focus is on secondary data; step 2 and 4 focus on primary data. |
| | Include the eight upstream categories of Scope 3 Standard | Eight categories are included in method |
| | Use Product Standard for effective, deepening insights in upstream supply chain | Step 3 introduces Product Standard. Focus is on supply chain insights; main challenge in quality of AD and EFs |
| | Alter DQIs and provide SME/construction industry examples | See Table 30. Indicators are altered and examples provided |

## 6.5 Preliminary conclusions

In this chapter the fourth research question is answered, being *Which method can be designed for an SME in the construction industry to assess upstream scope 3 emissions?* The method designed in this chapter is the Hybrid US3 Method, based on the key aspects of environmental assessment methods and the findings from previous chapters. The method consists of four steps, preceded by a general information step. In the general information section, the user provides its aim. The aim determines how extensive a reporting organization will report, thereby facilitating "a common and verifiable set of criteria and targets" (Cole, 1999). This assessment method gives room for users to demonstrate their efforts on environmental assessment.

The Hybrid US3 Method tackles the main downsides of the Scope 3 Standard and the Product Standard, namely their exhaustive and general character. It combines both Standards in a smart way, wherefore fewer resources are needed to use the method. The consecutive steps, consisting of questionnaires and coupled Excel worksheets, help the user through the method. Combined with predetermined sources for emission factors and guidance on which kind of activity data needs to be supplied it improves efficiency. Users don't have to waste time for example on finding emission factors. The Threshold for Data Quality Improvement is another element that improves efficiency; it is used in step 2 and 4 to focus data quality improvement efforts. Scope 1 and 2 are included in the final visualizations to improve clear and transparent reporting. The Data Quality Indicators are altered for the targeted users of this method and visualized in such a way that the overall quality of the inventory is immediately visible.

The expert interview underlined that the role of the GHG Protocol is focused on guidance, wherefore a specific method designed in this chapter is not their aim. The Hybrid US3 Method is however perceived as a smart combination of both Standards. The clear-cut path is beneficial as are the visualizations of the method. Including total emissions of the different categories and lifecycle stages would bring it more in line with reporting guidelines of the GHG Protocol.

The potential user interviews revealed that step 1 and 2 are very easy to use, while the visualizations are evaluated as effective as well. More explanation is however needed to fully understand the visualizations according to the interviewees. Step 3 and 4 probably need guidance from an expert (or extensive explanation). The visualizations are valuable due to insight in the upstream supply chain, where insight in difference between material acquisition and pre-processing is especially valuable. It reveals information and choices that can be made to influence own upstream scope 3 emissions. The coupling of information on size and data quality is relevant according to the interviewees; adding potential for improvement of data quality and/or mitigating these emissions will enlarge the potential of the method. Table 33 indicates the main outcomes of the potential user interviews the categories *criticism* (downsides of the method), *extra guidance* (where is it needed?) and *potential for improvements*.

**Table 33 Main outcomes potential user interviews**

| Criticism | Extra guidance | Potential for improvements |
|---|---|---|
| Questionable whether SME will use the method, either due to priorities or when competitors are not using it | Additional guidance needed to understand (visualization of) step 1 | Choice for improving categories (step 2) and/or lifecycle stages (step 4) can also be based on potential for improvement, instead of only amount of emissions |
| Suppliers will not always be willing to supply specific information on emissions and/or product details | Explain relation between financial information and emissions | Automatically determine percentage above which categories and/or lifecycle stages have to be improved |
| Choice for specific product is not for every company effective | Expert guidance needed in step 3 and 4 | Include downstream emissions as well |

The Hybrid US3 Method creates solid ground for SMEs with less available resources than larger companies to assess scope 3 emissions. SMEs have less resources than their competitors in the industry, so this method may help them to gain insight in upstream scope 3 emissions. It has to be noted that users of the method have to be in some way familiar with the subject of upstream scope 3 emissions, otherwise it will be hard to complete the sheets and interpret results.

# 7 DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

## 7.1 Discussions

This research shows a route for a specific group of users to assess their upstream scope 3 emissions. The interview with Benedict Buckley, research analyst at the GHG Protocol, is used as input for this discussion section.

The Hybrid US3 Method's aim is assessing emissions. Emissions are however not the entire environmental impact an organization can have on the planet. The method can therefore never show the entire impact.

It is not the aim of the GHG Protocol, the organization that publishes the Scope 3 Standard and the Product Standard, to provide such methods. They are focused on guidance. The starting point to choose a hybrid model in which the input-output model is a starting point, is a good basis. Many categories can be included in a time and resource-efficient way, which improves chances on mitigation strategies. The Product Standard is an ideal approach for deepening insights. It is however doubtful if users can use this part on their own, and if specific expertise and additional guidance is needed. In the past consultants have pushed the GHG Protocol for more explicit guidance on Data Quality Indicators; the quality of data is however a subjective element due to differing realities between industries and companies, wherefore the GHG Protocol has decided not to provide it. Including more guidance on this theme is therefore beneficial, although subjectivity is not entirely taken away. Separate descriptions for activity data and emission factors may improve this. The visualizations of the different steps create valuable insights. As main improvements Buckley (personal communication) suggests (1) to include quantitative amounts of separate categories and (2) to make explicit that both activity data (AD) and emission factors (EFs) are included in the data quality score.

Downsides of the Hybrid US3 Method are communication on boundaries and the collection of activity data and emission factors. The downside of collecting AD and EFs was experienced during the case studies. The burden of collecting (primary) data is tackled to focus on educated estimates and secondary data first, before moving to primary data. According to Buckley (personal communication) this approach is in line with experiences in the field. However, in step 2 and step 4 more detailed data is needed. Especially when data needs to be retrieved from suppliers, interests of the reporting organization and the supplier can conflict. Collecting reliable and accurate EFs for the input-output method in step 1 and 2 is not very challenging. For step 3 and 4 however, it is difficult and can impede a good end result. EFs on specific lifecycle steps of specific products and/or materials is data that is hard to calculate due to the wide variety and the differing methods that exist. The value on the other side is enormous when products and materials can transparently be compared on their environmental impact. The development of the Environmental Product Declaration is a sign that on a European level the value is known (Zackrisson et al., 2008). At this point in time however, the difficulty of retrieving this data resulted in commercial databases that are not available free of charge. LCA software often refers to these databases, and there is no interest in providing this data free of charge. Different initiatives exist that try to change this situation, of which the environmental database *Milieudatabase* is an initiative most directly linked to the construction industry. This is still under development and proved not to be sufficient to collect all required data for the case studies.

## 7.2 Conclusions

To answer the main research question four sub-questions have been answered in this research. The conclusions on these sub-questions will be presented first, followed by the conclusions on the main research question.

#### Q1 – What are the underlying theoretic models to assess upstream scope 3 emissions?

The first sub-question showed that a wide variety of sources is included when upstream scope 3 emissions are assessed. The inclusion or exclusion rules applied differ and sometimes seem to be arbitrary. Depicting and communicating the underlying (organizational) boundaries is a challenge, which is an essential first step when assessing scope 3 emissions. Improvements of these aspects will improve comparability of inventories.

Three theoretic models exist to assess upstream scope 3 emissions; the *input-output model* is a large-scale approach, the *LCA model* is a fine-scale approach, and the *hybrid model* combines best of both worlds. These models are used by various parties as input for methods, guidelines and standards aimed at assessing emissions. The literature study showed that the Greenhouse Gas Protocol is the leading organization in this respect; they published the *Scope 3 Standard* and the *Product Standard* which both can be used to assess scope 3 emissions. The basis of the former is the *input-output model*, and the *LCA model* of the latter.

#### Q2 – How are upstream scope 3 emissions assessed in available methods?

In the second sub-question the Product Standard and the Scope 3 Standard are investigated. Both standards are exhaustive documents and very general in their guidance. The generality is especially an obstacle in terms of usability; where should a user start and how should an inventory be improved over time? Also the required additional data needs to be retrieved from third party databases, which creates another obstacle. Overall, the Scope 3 Standard is efficient in quickly gaining insight in emissions with an effective result of category comparison. The Product Standard requires more time and expertise, and is therefore less efficient. The visualizations and insights of the supply chain of products a reporting organization produces is however very effective.

#### Q3 – How can an SME in the construction industry use the Scope 3 Standard and the Product Standard effectively and efficiently to assess upstream scope 3 emissions?

*Omnia* and *De Groene Paal* were the case study companies. In both cases purchased goods and materials caused the majority of upstream scope 3 emissions. To locate the exact source in the upstream supply chain of these emissions, the Product Standard was very useful. Furthermore, the case studies showed that the Data Quality Indicators are difficult to use. Also, the enormous challenge to retrieve good activity data (primary) and emission factors became evident. Especially the emission factors needed for lifecycle phases formed a problem, since these factors are often not available free of charge. The case studies showed that emissions calculated with the Scope 3 Standard where mostly within a +/- 20% range compared to the Product Standard. It is therefore suggested that when using both Standards together, the Scope 3 Standard can be used as a first scan. Caution is however necessary, since this is based on only two cases.

**Q4 – Which method can be designed for an SME in the construction industry to assess upstream scope 3 emissions?**
The method developed combines both Standards, in which the general and exhaustive character of the Standards is tackled. After providing basic information, setting the goal and depicting organizational boundaries, four steps become available in the Hybrid US3 Method. The steps form a clear-cut path for the user, in which less time and expertise is needed compared to the Standards themselves. The selection of third party databases is already determined, as are the consecutive steps to move from an inventory based on assumptions to an inventory based on life cycle steps and information retrieved from suppliers. Each step is preceded by a questionnaire to create a tailor-made step for the user; only information that is applicable to the reporting organization is asked for. After each step a short questionnaire is completed to provide information on Data Quality Indicators; when possible quality scores are predetermined or left out when not applicable. The difficulties experienced in the case studies are tackled with this approach. In step 2 and 4 a Threshold for Data Quality Improvement creates the opportunity for the user to have influence over required improvement; based on available time/expertise and desired result a percentage can be specified above which categories and/or life cycle phases have to be improved.

The result of each step is displayed in a dashboard style. The visualizations show (1) which step of the method is completed, (2) total quantity of all scopes, including their proportion to each other, (3) categories excluded with reasoning provided, (4) the percentage set for the Threshold for Data Quality Improvement, (5) overall data quality score of individual categories, (6) functional unit of focus product, (7) where in the supply chain emissions occur and (8) precise data quality scores for life cycle phases on each indicator and the related overall score.

**MAIN RESEARCH QUESTION – What is an effective and efficient method for an SME in the construction industry to assess upstream scope 3 emissions, by combining the Scope 3 Standard and the Product Standard?**
The Hybrid US3 Method is the outcome of this research. It is a combination of an *input-output model* and *lifecycle analysis,* whereby it becomes efficient and effective for an SME to assess upstream scope 3 emissions. The general and exhaustive character of the Standards used as input for the method, the Scope 3 Standard (*input-output*) and the Product Standard (LCA), is tackled. The efficient aspects are the predetermined emission databases and factors, the clear-cut path through the method based on a framework, and the divide of both Standards into a more estimation-based step (step 1 and 3) and a deepening insights step (step 2 and 4). Since the *input-output model* requires less expertise to use it, and less effort to complete it, the Scope 3 Standard is used as starting point. The effective aspects are mostly in the visualizations of the steps: all eight upstream categories can be compared, the size of scope 3 emissions can be compared to the size of scope 1 and 2, and the visualization of the lifecycle leads to upstream supply chain insights. Setting the aim in the initial step (step 0) and determining the percentage of the Threshold for Data Quality Improvement are efficient and effective. A user determines the aim and the percentage of the slider, thereby the chance to be successful in achieving the desired result will increase effectiveness. Also chance on wasted effort or expense will decrease, since the user can choose to be less ambitious when difficulties in retrieving all the required data are foreseen.

The first scientific contribution of this research is an overview of academic knowledge on the assessment of upstream scope 3 emissions. This knowledge mainly concludes that it is a difficult activity, where often a hybrid approach is chosen to carry it out. This hybrid approach has until now not been captured in a framework. This research shows a direction to capture the two Standards published by the leading organization on this topic, the Greenhouse Gas Protocol, in one method. This new Hybrid US3 Method and its framework are the second scientific contribution of this research, because it tackles the main issues identified by scientific literature in existing methods. The new method increases the likelihood of including more upstream scope 3 categories for SMEs with limited resources, and the chance on more comparable inventories.

The general contribution of this research is that it shows that assessing emissions is not only possible for large companies with nearly unlimited resources. Assessing emissions is possible for small companies with fewer resources like time and money than large ones, when smart design decisions are made. This research therefore may help to make assessing emissions a mainstream activity. This will raise awareness on sustainability.

## 7.3 Recommendations

The research paves the way for future research, for which recommendations are presented. Thereafter recommendations for each organization directly involved in this research are presented.

### 7.3.1 Further research

This research was focused on the development of a method to assess upstream scope 3 emissions. During the research several gaps in existing knowledge have been identified that were out of the scope of this research. The recommendations for future research to fill up these gaps are:

- Critical review of outcomes retrieved by companies using the Scope 3 Standard and Product Standard

At the moment of research these reviews were not found; both standards have been published only recently. A critical review of outcomes will be beneficial, since current knowledge in literature shows the difficulties of this topic. These insights can serve as input for the GHG Protocol to improve their standards, and be used as input for the method developed in this research.

- Investigate how an open source network of lifecycle data can be established; which parties need which incentives and how can this be profitable?

Open source databases emerge in several industries. When combined with new business models open source can result in profitable business. The lifecycle data currently gathered and stored by businesses is not open source. An interesting research would be to investigate *how* lifecycle data can be provided free of charge, while a new business model creates revenues. If an open source database would have been available during this research, inventories could have been composed more quickly and more reliable.

- Expand the number of case studies investigate the similarity in outcomes of Scope 3 Standard and Product Standard

The case studies showed that the total emission outcomes of the Scope 3 Standard and the Product Standard are in the same range (+/- 20%). It is interesting to investigate the difference in more detail, since it can improve the reliability of solely using the first (and second) step of the method. Further research may show how the first two steps can be improved, and how the interaction between the first two steps and step 3 and 4 can be improved.

### 7.3.2 WZK

WZK works for organizations in the quest to create insight in their emissions. Projects show that attention is shifting from scope 1 and 2, towards a more integral inventory analysis including scope 3. Therefore, the recommendations for WZK are:

- Alter the Hybrid US3 Method for other projects

The Hybrid US3 Method is aimed at the construction industry. However, the number of projects WZK does in this industry is limited. Also, the method only assesses upstream scope 3 emissions. Altering the method to make it applicable to other projects can create business opportunities. The aspects that at least have to be altered are (1) the source for emission factors (this is now specified on construction industry relevant sources), and (2) the addition of downstream emissions to the method. In most industries, including the construction industry, downstream emissions are relevant as well. When WZK want to assess a full spectrum of scope 3 emissions, downstream emissions have to be included. This needs to be done for the Scope 3 Standard, and for the Product Standard.

- Find strategic partners to further develop the Hybrid US3 method

An essential step in developing the Hybrid US3 Method further is to create a fully functional software environment. WZK is not a software company. A strategic partnership with a software developer can minimize time and money investments for WZK. Another strategic partner will be a partner that can push the acceptance of the method. Branch organizations are a logical step in this perspective, since they can distribute this method under their members to raise awareness on sustainability.

### 7.3.3 Omnia

The main recommendations for Omnia (subsidiary) and Ballast Nedam are:

- Investigate the difference in emission factor between cement type A and cement type B

The emission factor Omnia uses for both cement types differs by factor two. Omnia can contact their cement supplier to provide a specification of the emission factor (when available). When the difference is indeed this big, this insight can lead to communication of this difference to customers, and/or looking for alternatives to lower the amount of cement used.

- Investigate the use of tempex, which accounts for the majority of production emissions

Tempex is used in the production process when moulding the floor slabs. The amount of tempex needed differs per order. The impact tempex has on the production phase of Omnia is significant, while it does not end up in the final product. It is therefore accounting for emissions due to waste treatment as well. Omnia can investigate the use of it more precisely, try to decrease it or even try to find an alternative.

- Stimulate industry wide initiatives aimed at environmental material data collection, such as the *Milieudatabase*

Omnia is a relative small company to have influence on the industry. Ballast Nedam however is large and well known. If Ballast Nedam is dedicated to make environmental material data more widely available, they can stimulate industry wide initiatives aimed at this goal, such as the *Milieudatabase.* The interesting fact is that if all large construction companies would help initiatives like these, their own efforts needed to conduct assessments will decrease. Ballast Nedam can make more precise scope 3 assessments, improving their insight and chances on mitigating emissions.

#### 7.3.4 De Groene Paal

The main recommendations for *De Groene Paal* are:

- Expand the Product Standard towards the downstream side; benefits of the product are downstream, especially when compared to other solutions (e.g,, energy use)

For the product DGP sells, the main benefits arise when using the product. A full lifecycle analysis including downstream emissions is therefore essential. In this way a traditional solution can be compared with their product, indicating the benefit over the entire lifetime. This can be used by DGP for communication and insights in their own product. The downstream emissions for the Scope 3 Standard are in this respect less relevance than the Product Standard, since main benefits will arise with insight in the product.

- Connect with suppliers to retrieve reliable activity data and emission factors, and create dialogue for lowering emissions

Suppliers did not have all relevant environmental information (such as emission factors) available for their products. If DGP wants to improve their data quality, contact with suppliers is needed to motivate them to find and/or calculate this information. When this first step is executed, depending on the relation with the supplier a conversation on mitigation strategies can be started.

# BIBLIOGRAPHY

## Literature


Boiral, O., J.-F. Henri, et al. (2011). "Modeling the impacts of corporate commitment on climate change." Business Strategy and the Environment.

Bras-Klapwijk, R. M., R. Heijungs, et al. (2003). Levenscyclusanalyse voor onderzoekers, ontwerpers en beleidsmakers.

Brown, L. H., P. G. Buettner, et al. (2012). "Estimating the life cycle greenhouse gas emissions of Australian ambulance services." Journal of Cleaner Production **37**: 135-141.

Cole, R. J. (1999). "Building environmental assessment methods: clarifying intentions." Building Research & Information **27:4-5**: 230-246.

Downie, J. and W. Stubbs (2011). "Evaluation of Australian companies' scope 3 greenhouse gas emiessions assessments." Journal of Cleaner Production.

Elkington, J. (1998). Cannibals with forks : the triple bottom line of 21st century business. Gabriola Island, BC ; Stony Creek, CT, New Society Publishers.

Fallaha, S., G. Martineau, et al. (2009). "Broadening GHG accounting with LCA: application to a waste management business unit." Waste Management & Research **27**: 885-893.

Finkbeiner, M. (2009). "Carbon footprinting—opportunities and threats." International Journal of Life Cycle Assessment **14**: 91-94.

Gerring, J. (2004). "What Is a Case Study and What Is It Good for?" The American Political Science Review **98**(2): 341-354.

Gerring, J. and R. McDermott (2007). "An Experimental Template for Case Study Research." American Journal of Political Science **51**(3): 688-701.

GRI (2005). "GRI Boundary Protocol."

Huang, Y., R. Bird, et al. (2009d). "Development of a life cycle assessment tool for construction and maintenance of asphalt pavements. ." Journal of Cleaner Production **17**(283-296).

Huang, Y. A., M. Lenzen, et al. (2009c). "The role of Input-Output Analysis for the screening of corporate carbon footprints " Economic Systems Research **21**(3): 217-242.

Huang, Y. A., C. L. Weber, et al. (2009a). "Categorization of scope 3 emissions for streamlined enterprise carbon footprinting." Environmental Science & Technology **43**(22): 8509-8515.

Huang, Y. A., C. L. Weber, et al. (2009b). Carbon Footprinting Upstream Supply Chain for Electronics Manufacturing and Computer Services. New York, Ieee.

Humphreys, P. K., Y. K. Wong, et al. (2003). "Integrating environmental criteria into the supplier selection process." Journal of Materials Processing Technology **138**: 349-356.

IPCC (2007). "Climate Change 2007: Impacts, Adaptation and Vulnerability. Summary for Policymakers. IPCC: Paris.".

ISO (2006). ISO 14061-1; Greenhouse gases, part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals.

Larsen, H. N. and E. G. Hertwich (2009). "The case for consumption-based accounting of greenhouse gas emissions to promote local climate action." Environmental Science & Policy **12**: 791-798.

Larsen, H. N., J. Pettersen, et al. (2011). "Investigating the Carbon Footprint of a University - The case of NTNU." Journal of Cleaner Production.
Larsen, H. N., C. Solli, et al. (2012). "Supply chain management - how can we reduce our energy/climate footprint?" Energy Procedia.
Matthews, H. S., C. T. Hendrickson, et al. (2008). "The Importance of Carbon Footprint Estimation Boundaries." Environmental Science & Technology **42**: 5839-5842.
Moody, D. (2009). "Information systems research method." Sheets from mastercourse taught at the University of Twente, Enschede.
Ortiz, O., F. Castells, et al. (2009). "Sustainability in the construction industry: A review of recent developments based on LCA." Construction and Building Materials **23**: 28-39.
Ozawa-Meida, L., P. Brockway, et al. (2011). "Measuring carbon performance in a UK University through a consumption-based carbon footprint: De Montfort University case study." Journal of Cleaner Production.
Pandey, D., M. Agrawal, et al. (2011). "Carbon footprint: current methods of estimation." Environ Monit Assess **178**: 135-160.
Peters, G. P. (2010). "Carbon footprints and embodied carbon at multiple scales." Current Opinion in Environmental Sustainability.
Plambeck, E. L. (2012). "Reducing Greenhouse Gas Emissions Through Operations and Supply Chain Management." Energy Economics.
Rietbergen, M. G. and K. Blok (2012). "Assessing the Potential Impact of the CO2 Performance Ladder on CO2 Emission Reduction."
Ryu, K., I. Moon, et al. (2012). "A fractal echelon approach for inventory management in supply chain networks." International Journal of Production Economics.
Schneider, L. and C. M. Wallenburg (2012). "Implementing sustainable sourcing - Does purchasing need to change?" Journal of Purchasing & Supply Management.
Seawright, J. and J. Gerring (2008). "Case Selection Techniques in Case Study Research. A Menu of Qualitative and Quantitative Options." Political Research Quarterly **61**(2): 294-308.
Seuring, S. and M. Müller (2008). "From literature review to a conceptual framework for sustainable supply chain management." Journal of Cleaner Production **16**(15): 1699-1710.
Sinden, G. (2009). "The contribution of PAS 2050 to the evolution of international greenhouse gas emission standards." International Journal of Life Cycle Assessment **14**: 195-203.
SKAO (2012). Handboek CO2-Prestatieladder 2.1. Utrecht.
Stechemesser, K. and E. Guenther (2012). "Carbon accounting: a systematic literature review." Journal of Cleaner Production **36**(0): 17-38.
Stein, M. and A. Khare (2009). "Calculating the carbon footprint of a chemical plant: a case study of AkzoNobel." Journal of Environmental Assessment Policy and Management **11**(3): 291-310.
UNFCC. (1998). "Kyoto Protocol." Retrieved 18 October, 2012, from http://unfccc.int/resource/docs/convkp/kpeng.html.
Veenstra, V. S., J. I. M. Halman, et al. (2006). "A methodology for developing product platforms in the specific setting of the housebuilding industry." Research Engineering Design **17**: 157-173.
Verschuren, P. and H. Doorewaard (2005). Het ontwerpen van een onderzoek, Uitgeverij Lemma BV.
Wiedmann, T. (2009a). "Editorial: Carbon footprint and Input-Output Analysis - an introduction." Economic Systems Research **21**(3): 175-186.
Wiedmann, T. and J. Barrett (2011). "A greenhouse gas footprint analysis of UK Central Government, 1990–2008." Environmental Science & Policy.

Wiedmann, T., M. Lenzen, et al. (2009b). "Companies on the Scale - Comparing and Benchmarking the Sustainability Performance of Businesses." Journal of Industrial Ecology.
Wong, J. K. W., H. Li, et al. (2012). "Toward low-carbon construction processes: the visualisation of predicted emission via virtual prototyping technology." Automation in Construction.
World Wide Fund for Nature, W. (2012). Living Planet Report 2012.
WRI and WBCSD (2004). A Corporate Accounting and Reporting Standard (revised edition).
WRI and WBCSD (2011a). Corporate Value Chain (Scope 3) Accounting and Reporting Standard.
WRI and WBCSD (2011b). "Product Life Cycle Accounting and Reporting Standard."
Zackrisson, M., C. Rocha, et al. (2008). "Stepwise environmental product declarations: ten SME case studies." Journal of Cleaner Production **16**: 1872-1886.

## Personal communication

Buckley, Benedict, Research Analyst, *World Recources Institute*. 16-4-2013, personal communication.

Holst, Marcel van der, Consultant, *ABLE2*. Various moments, personal communication.

Kin, Sam, Owner, *SolarSwing*. 16-5-2013, personal communication.

Leegwater, Sander, Project Manager, *Schouten Techniek*. 17-5-2013, personal communication.

Mos, Jochem, Owner, *EcoChain Technologies*. 25-3-2013, personal communication.

Nieuwenhuijse, Jaap, Co-owner, *Nieuwenhuijse Arends Bouw- en Risicomanagement.* 21-5-2013, personal communication.

Termeer, Gijs, Project Leader *CO2 Prestatieladder*, *SKAO*. 8-1-2013, personal communication.

Verbeek, Flip, Owner, *De Groene Paal*. Various moments, personal communication.

## Websites

www.cdproject.net
www.degroenepaal.nl
www.ghgprotocol.org/Third-Party-Databases
www.globalreporting.org
www.milieudatabase.nl
www.nabr.nl
www.omniaplaatvloer.nl
www.oxforddictionaries.com
www.schoutentechniek.nl
www.solarswing.nl
www.wzk.me

# APPENDICES

## Appendix A – Problem definition terms

The problem definition is:

> *SMEs in the construction industry do not know how to combine and use the Scope 3 Standard and the Product Standard to assess upstream scope 3 emissions in an effective and efficient way*

Each underlined section will be commented on briefly.

*SMEs*
Different definitions exist on small and medium enterprises. It can for example be based on number of employees and/or turnover.

*Construction industry*
The problem relates to the construction industry since this is a main contributor of total GHGE. There is not yet a sector-wide practice of assessing upstream scope 3 emissions.

*Scope 3 Standard and Product Standard*
The GHG Protocol developed these standards. It helps organizations to identify and assess upstream scope 3 emissions. Chapter 4 provides extensive insights on these standards.

*Upstream scope 3 emissions*
Emissions that are indirect and occur due to supply chain activities. The emissions occur either downstream or upstream. Upstream scope 3 emissions mostly relate to purchased goods and services. An organization can go as far as they want to compose a complete picture of upstream scope 3 emissions. For example, which emissions would you include from a supplier from your own supplier? Boundaries on what to include and what to exclude (and why) are necessary.

*Assessed*
According to Oxford Dictionaries (www.oxforddictionaries.com), the meaning of the verb 'to assess' in this context is:

> *"evaluate or estimate the nature (..), value or quality of something (..)"*

The value of something relates to the amount of upstream scope 3 emissions.

*Effective*
Oxford Dicitionaries describes this adjective as:

> *"successful in producing a desired or intended result"*

In the context of this research, the desired or intended result has to do with assessing scope 3 emissions. Extra criteria can be added to specify how much, which, or when emissions are assessed. Effective therefore does not say anything about *how* an organization assesses emissions, but about the fact *that* it assesses these emissions.

*Efficient*
According to Oxford Dictionaries the meaning of the adjective ‘efficient’ is:

> *“achieving maximum productivity with minimum wasted effort or expense”*

As can be seen, efficient does not include the goal of an organization. It merely states that an organization acts with a high productivity. In the context of this research, it relates to the productivity when assessing upstream scope 3 emissions.

## Appendix B – List of articles found in literature research

All articles found in literature research:

| Author | Title | Source | Year |
|---|---|---|---|
| Brown | Estimating the life cycle greenhouse gas emissions of Australian ambulance services | Science Direct | 2012 |
| Larsen | Supply chain management - how can we reduce our energy/climate footprint? | Science Direct | 2012 |
| Plambeck | Reducing Greenhouse Gas Emissions Through Operations and Supply Chain Management | Science Direct | 2012 |
| Randers | Greenhouse gas emissions per unit of value added ("GEVA") — A corporate guide to voluntary climate action | Science Direct | 2012 |
| Scipioni | Monitoring the carbon footprint of products: a methodological proposal | Science Direct | 2012 |
| Downie | Evaluation of Australian companies' scope 3 greenhouse gas emissions assessments | Science Direct | 2011 |
| Ozawa-Meida | Measuring carbon performance in a UK University through a consumption-based carbon footprint: De Montfort University case study | Science Direct | 2011 |
| Wiedmann | A greenhouse gas footprint analysis of UK Central Government, 1990–2008 | Science Direct | 2011 |
| Larsen | Investigating the Carbon Footprint of a University - The case of NTNU | Science Direct | 2011 |
| Lee | Integrating carbon footprint into supply chain management: the case of Hyundai Motor Company (HMC) in the automobile industry | Science Direct | 2011 |
| Peters | Carbon footprints and embodied carbon at multiple scales | Science Direct | 2010 |
| Scipioni | Voluntary GHG management using a life cycle approach. A case study | Science Direct | 2010 |
| Wiedmann | Companies on the scale - comparing and Benchmarking the Sustainability Performance of Businesses | Science Direct | 2009 |
| Larsen | The case for consumption-based accounting of greenhouse gas emissions to promote local climate action | Science Direct | 2009 |
| Burritt | Carbon Management Accounting: Explaining Practice in Leading German Companies | Lit. review | 2011 |
| Stein & Khare | Calculating the Carbon Footprint of a Chemical Plant: a Case Study of AkzoNobel | Lit. review | 2009 |
| Fallaha | Broadening GHG accounting with LCA: application to a waste management business unit | Lit. review | 2009 |
| Huang et al | Carbon Footprinting Upstream Supply Chain for Electronics Manufacturing and Computer Services | Lit. review | 2009 |
| Downie | Corporate Carbon Strategies and Greenhouse Gas Emission Assessments: The Implications of Scope 3 Emission Factor Selection | Forw. citation | 2012 |
| Pandey | Carbon footprint: current methods of estimation | Forw. citation | 2010 |

| | | | |
|---|---|---|---|
| Huang | The role of Input-Output Analysis for the screening of corporate carbon footprints | Google Scholar | 2012 |
| Wiedmann | Editorial: Carbon footprint and Input-Output Analysis - an introduction | Google Scholar | 2010 |
| Sinden | The contribution of PAS 2050 to the evolution of international greenhouse gas emission standards | Google Scholar | 2009 |
| Finkbeiner | Carbon footprinting—opportunities and threats | Google Scholar | 2009 |
| Huang | Categorization of Scope 3 Emissions for Streamlined Enterprise Carbon Footprinting | Google Scholar | 2009 |
| Matthews | The Importance of Carbon Footprint Estimation Boundaries | Google Scholar | 2008 |

Articles used in paragraph 3.2 – research synthesis:

| First author | Year | General insights | Sector specific | Case specific |
|---|---|---|---|---|
| Brown | 2012 | | x | |
| Downie | 2011 | x | x | |
| Fallaha | 2009 | | | x |
| Huang | 2009b | | x | |
| Huang | 2009c | x | x | |
| Huang | 2009a | x | | |
| Larsen | 2011 | | | x |
| Matthews | 2008 | x | | |
| Ozawa-Meida | 2011 | | | x |
| Pandey | 2010 | x | x | |
| Plambeck | 2012 | | | x |
| Stein | 2009 | | | x |
| Wiedmann | 2011 | | | x |

## Appendix C – Upstream scope 3 emission categories

### Category 1: Purchased goods and services

This category includes all cradle-to-gate emissions from products (both goods and services) acquired in the reporting year. It includes the products that are not otherwise included in category 2 through 8 (WRI and WBCSD, 2011a).

Cradle-to-gate means that all emissions occurring in the life-cycle of a product, up to the point of receipt by the reporting organization, are included. Emissions may include (WRI and WBCSD, 2011a):

- extraction of raw materials
- agricultural activities
- manufacturing, production, and processing
- generation of electricity consumed by upstream activities
- transportation of materials and products between suppliers
- any other activities prior to acquisition by the reporting company

It can be useful to differentiate between production-related and non-production-related products, or/and between intermediates and final products.

### Category 2: Capital goods

All cradle-to-gate emissions from capital goods purchased or acquired in the reporting year fall in this category. Capital goods are final products that have a long life and are used by the organization to manufacture a product, provide a service, or sell, store, and deliver merchandise. Machinery, buildings, facilities, and vehicles are examples of this category (WRI and WBCSD, 2011a).

### Category 3: Fuel- and energy-related emissions not included in scope 1 and 2

All emissions related to the production of fuels and energy, not included in scope 1 and 2, purchased and consumed in the reporting year fall in this category. Combustion of fuels and energy is not included, since these emissions should be accounted for in scope 1 and 2 (WRI and WBCSD, 2011a). Table 34 provides an overview of the three activities of this category that are relevant for this research.

**Table 34 Category 3 activities. Source: WRI & WBCSD, 2011**

| Activity | Description | Applicability |
|---|---|---|
| **Upstream emissions of purchased fuels** | Extraction, production, and transportation of fuels consumed by the reporting company (mining of coal, refining of gasoline, transmission and distribution of natural gas, production of biofuels, etc.) | Applicable to end users of fuels |
| **Upstream emissions of purchased electricity** | Extraction, production, and transportation of fuels consumed in the generation of electricity, steam, heating, and cooling that is consumed by the reporting company (mining of coal, refining of fuels, extraction of natural gas, etc.) | Applicable to end users of electricity, steam, heating and cooling |
| **Transmission &** | Generation of electricity, steam, heating, | Applicable to end users |

| | | |
|---|---|---|
| **Distribution (T&D) losses** | and cooling that is consumed (i.e., lost) in a T&D system | of electricity, steam, heating and cooling |

**Category 4: Upstream transportation and distribution**

"This category includes emissions from the transportation and distribution of products (excluding fuel and energy products) purchased or acquired by the reporting company in the reporting year in vehicles and facilities not owned or operated by the reporting company, as well as other transportation and distribution services purchased by the reporting company in the reporting year (including both inbound and outbound logistics)" (WRI and WBCSD, 2011a). Specifically, emissions that arise from transportation and distribution between the reporting organization and tier 1 suppliers are included. Third party activities that should be accounted for are inbound logistics, outbound logistics (e.g., of sold products), and transportation between an organization's own facilities. Outbound logistics are within the boundaries of upstream scope 3 emissions, since they are a purchased service. Different kind of transportation and distribution activities that can be included are air, rail, road and marine transport, and storage of purchased products in warehouses, distribution centers and retail facilities (WRI and WBCSD, 2011a).

**Category 5: Waste generated in operations**

Waste generated in the reporting organization causes emissions due to third-party disposal and treatment, which is accounted for in this category. Also wastewater treatment is included in this category. Only treatment by third parties is included in this category, since own waste treatment is accounted for in scope 1 (WRI and WBCSD, 2011a). Although waste treatment happens downstream in the supply chain, all emissions caused by waste of the reporting organization in the reporting year are accounted for in this category. This is because the service is purchased by the reporting organization. Examples include (WRI and WBCSD, 2011a):

- disposal in a landfill
- recovery for recycling
- incineration
- composting
- wastewater treatment

Transportation of waste is optional according to WRI and WBCSD (2011a).

**Category 6: Business travel**

All emissions caused by business-related transportation in vehicles owned or operated by third parties fall in this category. All modes of transport, such as air, road and rail, are included. Emissions caused by transportation in vehicles owned or operated by the reporting organization fall in scope 1 (fuel) or scope 2 (electricity). Emissions caused by leased vehicles are accounted for in category 8, upstream leased assets (WRI and WBCSD, 2011a).

**Category 7: Employee commuting**

This category contains emissions caused by employees traveling between their homes and working locations. This may arise from automobile, rail, bus, air or other another type of travel (WRI and WBCSD, 2011a).

#### Category 8: Upstream leased assets

In this category emissions caused by operation of assets that are leased by the reporting organization in the reporting year and not already included in scope 1 or 2. This category is about lessees, instead of lessors (which is a downstream category). The consolidation approach (see paragraph 4.2.1.1) can have impact on whether emissions caused by leased assets are reported under scope 1, 2 or 3 (WRI and WBCSD, 2011a).

## Appendix D – Description & boundaries of upstream scope 3 emissions

Source: WRI and WBCSD, 2011a

| Category | Category description | Minimum boundary |
|---|---|---|
| **1. Purchased goods and services** | Extraction, production, and transportation of goods and services purchased or acquired by the reporting company in the reporting year, not otherwise included in categories 2-8 | All upstream (cradle-to-gate) emissions of purchased goods and services |
| **2. Capital goods** | Extraction, production, and transportation of capital goods purchased or acquired by the reporting company in the reporting year | All upstream (cradle-to-gate) emissions of purchased capital goods |
| **3. Fuel- and energy- related activities (not included in scope 1 or scope 2)** | Extraction, production, and transportation of fuels and energy purchased or acquired by the reporting company in the reporting year, not already accounted for in scope 1 or scope 2, including:<br>a) Upstream emissions of purchased fuels (extraction, production, and transportation of fuels consumed by the reporting company)<br>b) Upstream emissions of purchased electricity (extraction, production, and transportation of fuels consumed in the generation of electricity, steam, heating, and cooling consumed by the reporting company)<br>c) Transmission and distribution (T&D) losses (generation of electricity, steam, heating and cooling that is consumed (i.e., lost) in a T&D system) – reported by end user<br>d) Generation of purchased electricity that is sold to end users (generation of electricity, steam, heating, and cooling that is purchased by the reporting company and sold to end users) – reported by utility company or energy retailer only | a) For upstream emissions of purchased fuels: All upstream (cradle-to-gate) emissions of purchased fuels (from raw material extraction up to the point of, but excluding combustion)<br>b) For upstream emissions of purchased electricity: All upstream (cradle-to-gate) emissions of purchased fuels (from raw material extraction up to the point of, but excluding, combustion by a power generator)<br>c) For T&D losses: All upstream (cradle-to-gate) emissions of energy consumed in a T&D system, including emissions from combustion<br>d) For generation of purchased electricity that is sold to end users: Emissions from the generation of purchased energy |
| **4. Upstream transportation and distribution** | - Transportation and distribution of products purchased by the reporting company in the reporting year between a company's tier 1 suppliers and its own operations (in vehicles and facilities not owned or controlled by the reporting company)<br><br>- Transportation and distribution services purchased by the reporting company in the reporting year, including inbound logistics, outbound | - The scope 1 and scope 2 emissions of transportation and distribution providers that occur during use of vehicles and facilities (e.g., from energy use)<br><br>- *Optional*: The life cycle emissions associated with manufacturing vehicles, facilities, or infrastructure |

| | | |
|---|---|---|
| | logistics (e.g., of sold products), and transportation and distribution between a company's own facilities (in vehicles and facilities not owned or controlled by the reporting company) | |
| **5. Waste generated in operations** | Disposal and treatment of waste generated in the reporting company's operations in the reporting year (in facilities not owned or controlled by the reporting company) | - The scope 1 and scope 2 emissions of waste management suppliers that occur during disposal or treatment<br><br>- *Optional*: Emissions from transportation of waste |
| **6. Business travel** | Transportation of employees for business-related activities during the reporting year (in vehicles not owned or operated by the reporting company) | - The scope 1 and scope 2 emissions of transportation carriers that occur during use of vehicles (e.g., from energy use)<br><br>- *Optional*: The life cycle emissions associated with manufacturing vehicles or infrastructure |
| **7. Employee commuting** | Transportation of employees between their homes and their worksites during the reporting year (in vehicles not owned or operated by the reporting company) | - The scope 1 and scope 3 emissions of employees and transportation providers that occur during use of vehicles (e.g., from energy use)<br><br>- *Optional*: Emissions from employee teleworking |
| **8. Upstream leased assets** | Operation of assets leased by the reporting company (lessee) in the reporting year and not included in scope 1 and scope 2 – reported by lessee | - The scope 1 and scope 2 emissions of lessors that occur during the reporting company's operation of leased assets (e.g., from energy use)<br><br>- *Optional*: The life cycle emissions associated with manufacturing or constructing leased assets |

## Appendix E – Data Quality Indicators

Source: WRI & WBCSD, 2011a

| Score | Representativeness to the activity in terms of: | | | | |
|---|---|---|---|---|---|
| | Technology | Time | Geography | Completeness | Reliability |
| **Very good** | Data generated using the same technology | Data with less than 3 years of difference | Data from the same area | Data from all relevant sites over an adequate time period to even out normal fluctuations | Verified[3] data based on measurements[4] |
| **Good** | Data generated using a similar but different technology | Data with less than 6 years of difference | Data from a similar area | Data from more than 50 percent of sites for an adequate time period to even out normal fluctuations | Verified data partly based on assumptions or non-verified data based on measurements |
| **Fair** | Data generated using a different technology | Data with less than 10 years of difference | Data from a different area | Data from less than 50 percent of sites for an adequate time period to even out normal fluctuations or more than 50 percent of sites but for a shorter time period | Non-verified data partly based on assumptions, or a qualified estimate (e.g. by a sector expert) |
| **Poor** | Data where technology is unknown | Data with more than 10 years of difference or the age of the data are unknown | Data from an area that is unknown | Data from less than 50 percent of sites for shorter time period or representativeness is unknown | Non-qualified estimate |

## Appendix F – Interview introduction and questions

### *Introduction to topic (as explained to interviewee)*

Corporate Social Responsibility, or *Maatschappelijk Verantwoord Ondernemen* (MVO), increased in popularity and in relevance over the last years. Information on environmental impact of an organization is part of this broad field. Since Global Warming has high priority and global impact, this is the most used impact category. Greenhouse Gas Emissions, expressed as CO2-equivalent emissions, are used to quantify this. More and more large organizations report their emissions as a total score per year (e.g., 300 ton CO2e emissions in 2012).

Emissions can be categorized in 3 scopes; scope 1 relates to emissions emitted directly in company facilities or vehicles, scope 2 relates to electricity. Scope 3 emissions relate to emissions in the supply chain, either upstream or downstream. This scope mostly represents more than 75% of emissions of the combined scopes. This interview and the corresponding method is focused on the upstream part, of which the applicable categories are visualized in the figure below.

<show Figure 2>

The GHG Protocol designed two standards that can be used to assess scope 3 emissions. These Standards are very exhaustive and general in character, which decreases chances on usage by smaller organizations. However, insight in emissions caused by an organization is beneficial for mitigation strategies. An example is: what are the emissions caused by commuting of employees, and what is their relative size compared to purchased materials? The proposed method helps you with such insights.

The method developed by the researcher and presented in this interview is a combination of both, in which the exhaustive and general character is decreased.
It is no problem that the Standards developed by the GHG Protocol are unknown. Important is that you, the interviewee, are interested in the topic of sustainability and considering assessment of emissions of your organizations as an option. With the method you gain insight in your upstream scope 3 emissions. The method consists of several steps. How each step relates to the others, and what information is needed, is presented here:

<show Figure 31>

Each step ends with a visualization representing the emissions of the organization, which includes data quality scores as well.

<show Figure 35, Figure 36, Figure 37, Figure 38 and Figure 39>

*Interview questions*

After an introduction on the topic (see below) the following questions are asked.

| | |
|---|---|
| Name interviewee | |
| Date | |
| Start time | |
| End time | |
| Function of interviewee | |
| Name of organization | |
| Type of organization | |
| Other | |

The list of questions is presented below. At moments that the interviewee had difficulties answering the questions, the questions in italic are used.

1. Which emissions are currently assessed?
    - *Are scope 3 emissions currently assessed?*
2. How are the emissions currently assessed?
    - *Which method is used?*

3. To what extent can information on categories for 'step 1 – first estimation of categories' be provided? (efficiency)
    - *Can spend information be estimated?*
    - *Can spend information on capital goods be estimated?*
    - *Are amounts of electricity, gas, and fuel purchased easily available?*
    - *Can spend on transport be estimated?*
    - *Can spend on, and type of waste be estimated?*
    - *Can spend on, and transport mode of business travel be estimated?*
    - *Can distance and transport mode of commuting be estimated?*
    - *Can upstream leased assets be estimated?*
4. How much resources are needed to retrieve this information? (efficiency)
    - *How much specific expenses are needed?*
    - *Which specific expertise needed?*
    - *To what extent is contact with suppliers needed?*
    - *How much time investment is needed?*
5. In which way is the visualization of step 1 valuable? (effectiveness)
    - *Is insight in the eight categories valuable?*
    - *Is insight in their relative proportion valuable?*
    - *Is insight in Data Quality of the categories valuable?*
    - *Is size of scope 1 and 2, relative to 3 valuable?*
6. What suggestions for improvement do you suggest for step 1?

7. To what extent can estimations be exchanged for actual figures, to complete 'step 2 – deepening category insights'? (efficiency)
8. How much resources are needed to retrieve this information? (efficiency)
    - *How much specific expenses are needed?*
    - *Which specific expertise needed?*
    - *To what extent is contact with suppliers needed?*
    - *How much time investment is needed?*
9. In which way is the visualization of step 2 valuable? (effectiveness)
    - *How is the Threshold for Data Quality Improvement valuable?*
    - *How are data quality scores valuable?*
10. What suggestions for improvement do you suggest for step 2?

11. To what extent is in 'step 3 – Product lifecycle' the choice for a specific product to gain insight in its lifecycle valuable? (effectiveness)

12. How much resources are needed to retrieve this information? (efficiency)
    - *How much specific expenses are needed?*
    - *Which specific expertise needed?*
    - *To what extent is contact with suppliers needed?*
    - *How much time investment is needed?*
13. In which way is the visualization of step 3 valuable? (effectiveness)
    - *How is insight in lifecycle stage emissions valuable?*
    - *How is insight in data quality scores interesting?*
14. What suggestions for improvement do you suggest for step 3?

15. In which way is in 'step 4 – Deepening lifecycle stage insights' the choice for deepening insights on certain lifecycle stages valuable? (effectiveness)
16. How much resources are needed to retrieve this information? (efficiency)
    - *How much specific expenses are needed?*
    - *Which specific expertise needed?*
    - *To what extent is contact with suppliers needed?*
    - *How much time investment is needed?*
17. In which way is the visualization of step 4 valuable? (effectiveness)
    - *Is insight in Threshold for Data Quality Improvement valuable?*
    - *Is insight in improving data quality scores valuable?*
18. What suggestions for improvement do you suggest for step 4?

Other comments

…….

……

*Interview questions – S. Kin, SolarSwing*

| | |
|---|---|
| Name interviewee | Sam Kin |
| Date | 16-05-2013 |
| Start time | 10.34 |
| End time | 11.28 |
| Function of interviewee | Founder |
| Name of organization | SolarSwing |
| Type of organization | Supplier for construction industry |

1. Which emissions are currently assessed?

*None.*

2. How are the emissions currently assessed?

*Not applicable*

3. To what extent can information on categories for 'step 1 – first estimation of categories' be provided? (efficiency)

*An accurate financial system makes it easy to retrieve spend information, both for purchased goods/services as for capital goods. Amounts for electricity are harder to retrieve, an estimation can be made, but has never been made.*
*Spend on transportation can be estimated. Insight in waste is easy to retrieve. For business travel declarations can be used from any transport mode, and kilometer registration for lease cars. Commuting can be estimated as well, quite easy to to small size of company. Leased assets are not applicable.*

4. How much resources are needed to retrieve this information? (efficiency)

*Amount of resources is very small in this first estimation. No expenses needed, only some time to fill it out. The only difficulty at this point is the amounts of electricity and gas. Time and perhaps some expertise are needed to estimate these amounts.*

5. In which way is the visualization of step 1 valuable? (effectiveness)

*The visualization is not understandable without complementary explanation. The categories are not clear either. Categories seem to be products.*
*Insight in relative proportion is very valuable. It is clear where most impact is possible. However, it is not clear which emissions are most easy to reduce. The influence is not visualized.*
*The insight in DQIs is valuable. More effort leads to better data gets a visual result. The question remains if this extra effort leads to different practices. For SolarSwing this is not a priority. A different, high quality product is at this moment relevant. There is no differentiation in terms of amount of emissions.*
*Size of scopes shows that impact is higher when focusing on category 1 than on installing new insulation in your own office. However, 'een beter milieu begint bij jezelf', or: a better environment starts with yourself.*

6. What suggestions for improvement do you suggest for step 1?

*Step 1 is understandable. The intuitive link from financial information to emissions (€ -> CO2) is however not very simple. More explanation would be beneficial.*

7. To what extent can estimations be exchanged for actual figures, to complete 'step 2 – deepening category insights'? (efficiency)

*Euro's changing into more specific data is for some products possible, which are mostly bulk products. For specific products like an electro motor, this is not so easy. How many kilograms of electro motor do you buy? And which components are in it? It soon becomes complicated for assembled products.*
*For electricity and gas contact with the landlord can lead to more specific data.*
*Data for transportation can be detailed more as well. Distances are known, mode of transport can be asked for. Also the route the product travels should be asked for, since it is not always the shortest route from supplier to SolarSwing. Business travel and commuting is possible, but will become more difficult when SolarSwing will have more employees.*

8. How much resources are needed to retrieve this information? (efficiency)

*Some essential aspects are: does the supplier now the required data? If they know it, do they want to share it? It depends on the position and the added value of the supplier if they want to cooperate. The supplier of electro motors for SolarSwing is for example foreseen not to give specific data. At this point the financial interest of suppliers may hamper collecting required data.*
*No expenses are foreseen, mainly time to get into contact with suppliers and retrieve other information. Specific expertise is not necessary, as long as the required information is clear. The background of the method is however helpful to know what the data does.*

9. In which way is the visualization of step 2 valuable? (effectiveness)

*Aware of focus area, and quality of data. How relevant is it to let the user choose its own data quality improvement percentage? Why does the method does not do this automatically? Visible that data quality improves is valuable; reward for effort.*

10. What suggestions for improvement do you suggest for step 2?

*Make Threshold for Data Quality Improvement automatic. More guidance in what is actually seen in visualization.*

11. To what extent is in 'step 3 – Product lifecycle' the choice for a specific product to gain insight in its lifecycle valuable? (effectiveness)

*Ambiguous. Is it possible to make a distinction in products when same components are used? It is for communication with clients/customers beneficial. How do you allocate business travel, commuting, etcetera (categories from Scope 3 Standard) to this Product Standard?*

12. How much resources are needed to retrieve this information? (efficiency)

*Up until own suppliers this is feasible, however difficult (see also Q8). Interests may be different. Deeper into supply chain no insight yet. Confidentiality is a problem. Time is needed if you really want to go deeper into the supply chain, and persistence. Expertise not too much, expenses neither.*

13. In which way is the visualization of step 3 valuable? (effectiveness)

*The insight in where you want to have impact is valuable. It narrows down the insights from step 1 and 2. However, question remains if where you want to have impact is also the place where you can have impact.*
*Intuitively thought that more to the outside is worse, this is not the case. It offers the insight that when you want to make decisions, you know at least on what data quality decisions are based.*

14. What suggestions for improvement do you suggest for step 3?

*Consider changing the DQI scores from inside-out to outside-in.*

15. In which way is in 'step 4 – Deepening lifecycle stage insights' the choice for deepening insights on certain lifecycle stages valuable? (effectiveness)

*In the example material acquisition and pre-processing is further specified. It is interesting to see whether impact can be realized at your suppliers (pre-processing) or at steps before your supplier.*

16. How much resources are needed to retrieve this information? (efficiency)

*Similar to Q12. No additional thoughts.*

17. In which way is the visualization of step 4 valuable? (effectiveness)

*Slider could be done automatically, as stated in Q9. Improving data links to reward for effort.*

18. What suggestions for improvement do you suggest for step 4?

*DQI slider not clear.*

Other comments

*Divide in several steps is really beneficial. When someone gets stuck during a method, there is no product. In this method, at the end of step 1 there is already a result.*

*Interview questions – S. Leegwater, Schouten Techniek*

| | |
|---|---|
| Name interviewee | Sander Leegwater |
| Date | 17-05-2013 |
| Start time | 13:54 |
| End time | 14:50 |
| Function of interviewee | Project Manager |
| Name of organization | Schouten Techniek |
| Type of organization | Installation company |

1. Which emissions are currently assessed?

*Office building energy and gas usage is measured and can be used for emission calculations.*

2. How are the emissions currently assessed?

*Not applicable, no assessment done.*

3. To what extent can information on categories for 'step 1 – first estimation of categories' be provided? (efficiency)

*Financial department can supply spend on purchased goods, services and capital goods. Purchased gas and electricity is already available, and purchased fuel can be retrieved through fuel cards.*
*Transport is a difficult one. Arrangements with suppliers often lead to free transport (there is at least no specification of transport on bills). Transportation services that are purchased can be retrieved through financial department.*
*The amount spend on waste can be retrieved through financial department. Interesting point is that old metals is paid for when collected by another party. During projects it is arranged that waste is always taken care of by the contractor.*
*Business travel can be retrieved through declarations (financial department), and through the registration of kilometers.*
*Schouten Techniek pays for commuting costs in a standard way. Depending on the commuting distance employees either get nothing, a fixed amount X per month, or a fixed amount Y per month. This can be used for a first indication of commuting.*
*Leased assets are not applicable.*

4. How much resources are needed to retrieve this information? (efficiency)

*Majority of categories is easy to estimate at financial department, and combined with some other departments all information can be retrieved. When someone is responsible for retrieving all information, estimation of three days per month is given needed to keep track of the information flow. That person needs knowledge of administrative processes within Schouten Techniek to retrieve all the information and to know where information can be found.*

5. In which way is the visualization of step 1 valuable? (effectiveness)

*Schouten Techniek has the profile of a company that is involved in sustainable products and projects. It is however more important to know what products (such as heat pump installations) do than the organization as a whole. It becomes more valuable when all competitors report this as well (regulation).*
*The comparison of categories is helpful: where to focus on is known. The data quality is helpful as well, it is an extra dimensions than merely stating a number.*

6. What suggestions for improvement do you suggest for step 1?

*Insert an explanation what C1, C2 etcetera is. This is unclear now.*

7. To what extent can estimations be exchanged for actual figures, to complete 'step 2 – deepening category insights'? (efficiency)

*Basically this turns out to be a time/effort decision. All information can be specified in more detail. Large companies probably have someone fulltime for such tasks, at Schouten Techniek this is not the case. Especially in the current economic situation, this will not be the case either in the near future.*

8. How much resources are needed to retrieve this information? (efficiency)

*As said, time is mainly needed. This is coupled to expenses and expertise (see Q4). Contact with suppliers is needed for specified emission factors; however, no experience with suppliers that communicate environmental impact indicators of their products.*

9. In which way is the visualization of step 2 valuable? (effectiveness)

*Valuable to see improvement. Not clear how is dealt with categories that have already a score 'good'? Do you also improve these categories? What is the threshold?*

10. What suggestions for improvement do you suggest for step 2?

*See Q6. Indicate what the aim is of the quality level. Do you improve only based on size, or also on current quality?*

11. To what extent is in 'step 3 – Product lifecycle' the choice for a specific product to gain insight in its lifecycle valuable? (effectiveness)

*Schouten Techniek does not produce one product. Every project, every building is different. We are moving towards a more modular product (so called WKO-SKID), and this could be the focal product. This could be valuable for this product.*

12. How much resources are needed to retrieve this information? (efficiency)

*This step requires a lot of work that needs to be done once. Different league than step 1 and 2. In the modular product, numerous products are involved. It requires a lot of time, thereby money, and also expertise of the modular product to retrieve all the required data. Most of the impact is caused at suppliers, therefore cooperation of suppliers is essential.*

13. In which way is the visualization of step 3 valuable? (effectiveness)

*It is a clear visualization. It does however not tell the whole story of the product. A heat pump can be 10 times as bad compared to another solution, in the use stage this is 'paid back'. What about just indicating a label? A green product?*

14. What suggestions for improvement do you suggest for step 3?

*Including downstream cycle is beneficial.*

15. In which way is in 'step 4 – Deepening lifecycle stage insights' the choice for deepening insights on certain lifecycle stages valuable? (effectiveness)

*Higher quality is valuable, however it is a difficult step. This higher quality is however limitedly in own control. Most information depends on suppliers.*

16. How much resources are needed to retrieve this information? (efficiency)

*These insights are not in own control. When suppliers give information (if they have it) Schouten Techniek has to decide whether it is correct or not. They have to trust the supplier, although there is no guarantee it is good. If you want to go further upstream it is even more difficult.*
*Relation with supplier is leading in what information can be retrieved, or what information be established by supplier (or supplier of supplier). Some suppliers are more dependent and/or more willing than others.*
*If every client of suppliers ask for information on emissions than it will be different. The market will determine what will happen; than suppliers will find out the required information.*

17. In which way is the visualization of step 4 valuable? (effectiveness)

*Extra step of pre-production is valuable, since Schouten Techniek almost never purchases raw materials.*

18. What suggestions for improvement do you suggest for step 4?

-

Other comments

-

*Interview questions – J. Nieuwenhuijse, Nieuwenhuijse Arends Bouw en Risicomanagement*

| | |
|---|---|
| Name interviewee | Jaap Nieuwenhuijse |
| Date | 21-05-2013 |
| Start time | 14:34 |
| End time | 15:30 |
| Function of interviewee | Co-owner |
| Name of organization | Nieuwenhuijse Arends Bouw- en Risicomanagement |
| Type of organization | Installation company |

1. Which emissions are currently assessed?

*None.*

2. How are the emissions currently assessed?

*Not applicable, no assessment done.*

3. To what extent can information on categories for 'step 1 – first estimation of categories' be provided? (efficiency)

*Category 1 and 2 are easy, use bookkeeping for it. Category 3 is easy as well, the supplier sends a year specification. Category 4 is not applicable, since most transportation used is a car for office supplies, and these emissions are accounted for in category 6. Category 5 is possible as well, a monthly amount is paid to the waste management supplier. Category 6 is easy, since everyone registers their business kilometers. Category 7 is known, since employees are paid an allowance on their commuting. Category 8 is not applicable.*

4. How much resources are needed to retrieve this information? (efficiency)

*The information needs to be retrieved at specific places (bookkeeping for example), so someone at the company needs to do this. It does not require very specific expertise. Estimated time investment of 1,5 day to collect all the information for one reporting year.*

5. In which way is the visualization of step 1 valuable? (effectiveness)

*C1 t/m C7 needs some additional explanation. Relative proportion is valuable; where to focus on? Thickness of the rings (data quality) is interesting. An trade-off comes to mind: do you focus on largest portions or on lowest data quality? And, what is the relation between those two?*

6. What suggestions for improvement do you suggest for step 1?

*Insert the visualizations used in the figure by the GHG Protocol (Figure 2). Explanation about Scope 1 and 2, and their relations to Scope 3 misses to make that part understandable for a non-expert.*

7. To what extent can estimations be exchanged for actual figures, to complete 'step 2 – deepening category insights'? (efficiency)

*For category 1 this is only possible for products with large quantities, of which coffee is an example. Small office stuff is not possible. Category 3 is simple (euro's known, but actual quantities as well). Category 4 is not applicable (see Q3). Category 5 requires an estimation; information is not supplied by supplier. An average container can be weighted, which can be multiplied to get the yearly amount. Category 6 is possible for kilometers; specific type of vehicle is not always known. For category 7 kilometers are known, type of transport needs to be retrieved.*

8. How much resources are needed to retrieve this information? (efficiency)

*Expertise same as Q4. Contact with suppliers is not needed. Another 3 days are needed to retrieve these specific data for a one-year report.*

9. In which way is the visualization of step 2 valuable? (effectiveness)

*Gut feeling results in 20% for the Threshold for Data Quality Improvement. It is valuable to see which categories are improved. Question is: how do you know that data can actually be improved? Are smaller categories perhaps not way easier to specify than larger categories? How is the connection between size and potential for more specific data made?*

10. What suggestions for improvement do you suggest for step 2?

*See Q9. Integrate potential for improvement.*

11. To what extent is in 'step 3 – Product lifecycle' the choice for a specific product to gain insight in its lifecycle valuable? (effectiveness)

*NABR does not produce products, therefore this would not be possible. However, an interesting direction would be to focus it on a building project. Lifecycle insight in a building is valuable. It can be used to create focus and awareness to improve the sustainability score of a building project. Where in the supply chain is most impact possible? How good is data there?*

12. How much resources are needed to retrieve this information? (efficiency)

*For this step expertise and guidance is needed. Too complicated on first impression for own use.*

13. In which way is the visualization of step 3 valuable? (effectiveness)

*Seems quite technical, which I favor. Where can I improve is visible. However, expertise needed (see Q12).*

14. What suggestions for improvement do you suggest for step 3?

-

15. In which way is in 'step 4 – Deepening lifecycle stage insights' the choice for deepening insights on certain lifecycle stages valuable? (effectiveness)

*Presenting material acquisition and pre-processing separately is interesting. More insight. It shows the size of products or elements that are further up in the supply chain, and this relates to the choice you have as a project manager. Which materials are used? Where is their impact high? Can I choose for a different approach to create less impact?*

16. How much resources are needed to retrieve this information? (efficiency)

*See Q12.*

17. In which way is the visualization of step 4 valuable? (effectiveness)

*My interpretation is that when DQI-spider is small, and emissions high, these are focus areas. Improvement is possible, while impact is high. This is intuitive, but is right when I understand it correctly.*

18. What suggestions for improvement do you suggest for step 4?

-

Other comments

*BREEAM is in my opinion too academic. This tool has potential since it is practical, though difficult to understand sometimes. Interesting is the visual layer to communicate the size of your impact, and the corresponding data quality. The user can determine if and where it wants to have influence.*