Masters' Thesis

Sustainable Business and Innovation

Exploring measuring construct validity criteria for carbon management programs

Assessing Heineken's carbon management program 'Drop the C'

Menno Meijerhof 4229770

Menno.meijerhof@gmail.com

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Utrecht University

Dr. Jacco Farla

j.c.m.farla@uu.nl

Heineken N.V.

Lawrence Hambling

lawrence.hambling@heineken.com

Universiteit Utrecht

Faculty of Geosciences

I. Abstract

Over 20% of global greenhouse gas (GHG) emissions result from approximately the 2500 largest companies in the world. A global approach for reductions is needed since emissions resulting from the production of a product are caused by every step performed on the product along an often geographically widely spread supply chain. This research introduces an assessment scheme that can be used to assess the validity of company carbon management programs. Stakeholder perceptions were collected through semi-structured interviews and combined with a document analysis to establish the indicators as well as appropriate assessment criteria. The scheme consists of 21 indicators divided over five main themes (Complete goal and scope disclosure, In- and external verification, Representativeness, Data accuracy and reliability, and Materiality). Another finding is that a minimum validity level for a carbon management program is case dependent and is predominantly influenced by the size and maturity of the company and its suppliers. For the case study of Heineken's mature carbon management program called *'Drop the C'*, this means that a strict minimum validity level has been established. This minimum level is aligned with the European Commission's Product Environmental Category Rule and the Science Based Target initiative. The carbon footprint behind *'Drop the C'* was found to be a hybrid version of the product and company carbon footprint. This suggests that the current theory on carbon footprint levels should be revised to include a grey area between these two to accommodate this type of hybrid carbon footprints. The program *'Drop the C'* has been assessed and was found to have high validity overall. Yet, a decrease in validity from 2017 to 2018 is observed. It is important for Heineken to reverse this trend to keep showing continuous improvement.

Keywords: Aggregated product company carbon footprint, Carbon monitoring, Company carbon footprint, Low Carbon Supply Chain Management, Measuring construct validity, Product carbon footprint, Validity assessment

II. Executive Summary

There is a rise in societal and regulatory pressure exerted on companies. Consumers are becoming increasingly aware of the impact that the goods they consume have on the environment, which leads them to look for greener alternatives. Furthermore, the recent announcement of the European green deal acts as a strong driver for companies to increasingly focus on carbon management. With this focus on carbon management comes the need for companies to increase the validity of their carbon management programs. So far, a validity assessment scheme specifically for company carbon management programs was lacking. This research is a first attempt to establish such an assessment scheme.

An extensive document analysis in combination with the transcript analysis of 35 interviews resulted in the development of a validity assessment scheme for carbon management programs. 14 Validity categories emerged that were translated into 21 validity indicators. These indicators have been grouped in five main themes and collectively are believed to allow a validator to assess an entire carbon management program on all relevant validity aspects. The five main themes are: Complete goal and scope disclosure, In- and external verification, Representativeness, Data accuracy and reliability, and Materiality.

The importance of transparency and comparability in carbon management cannot be stressed enough. It is not always possible to be fully transparent or work in a completely comparable way from the first moment that a carbon footprint is set up. Some parts of the business might be sold off, or new ones acquired. For this reason, it is important to show continuous improvement over the years to show goodwill and the intention of reaching high transparency and comparability through the maturing of your carbon management program.

A single generic minimum validity level for each of the indicators cannot be established. Instead, the minimum level is context dependent. This means that factors like company size and maturity, supplier power relationships and disclosure methodologies influence the minimum level. Hence, this level needs to be established based on the context of the carbon management program under consideration. This has been done for Heinekens '*Drop the C*' carbon management program and based on this minimum level, the program was assessed. The assessment was carried out both company wide and on a supply chain section specific level. The overall validity of the program was found to be high. However, a decreasing trend in validity has been observed between the 2017 and 2018 methodological documents. It is very important for Heineken to reverse this trend and to keep showing continuous improvement over the years instead. The assessment led to a number of recommendations for Heineken that can allow them to increase the validity of their carbon management program. The recommendations are listed in Text Box 1 below.

Recommendations Overall

- Be more elaborate on which assumptions are made
- Be more explicit about the scope of the supply chain sections, mention which operating companies are in scope and what the emission/volume coverage is
- Be more precise about which sources are used and what the system boundaries are
- Communicate clear targets for the carbon footprint that are in line with the Science Based Target initiative
- Consistently state which methodological standards the Heineken methodology is aligned with throughout all methodological documents
- Focus on continuous improvement
- Rectify the statement mentioning to which carbon footprint the Science Based Target initiative commitment is made on the website and in the annual report
- Transparently describe how the acquired data is internally verified

Recommendations Agriculture

- Be more explicit about the scope '*Scope is cultivation of ingredients for beverage production*', add that 34 operating companies are included, representing 89% of emissions. And that the carbon footprint is extrapolated from 89% to 100%
- Correct chapter title of chapter 2 and make it more complete
- Describe how the unavailability of country of cultivation data from the spend analysis tool is dealt with
- Do not refer to 'EU approved data sets' but state which exact data sets are used and reference to those
- Increase accuracy for on farm data, move from secondary to primary data
- Reinclude hyperlinks to publicly available reporting documents and datasets
- Reinclude updated table listing all relevant emission sources and extend to include whether they are in scope and if primary or secondary data is used
- Stick to a single source of truth, upload supporting excel files to the HeiCF online environment
- Where distribution is mentioned, change to logistics to avoid confusion

Recommendations Raw materials and processing

- Always reference to specific source, also for average malting emission factor
- Be more explicit about the scope '*The scope of this GHG reporting guideline focuses on malting, and on the processing of 9 raw materials*', add that the focus is on top 25 malteries, representing over 99% of the emissions and 89% of volume sold
- Include justifications for all the assumptions made in the data gathering process
- Reinclude table that lists for each emission source if it is covered by primary or secondary data

Recommendations Beverage Production

- Add upstream emissions of fossil and renewable fuels to the list that states whether emissions are in scope or not, these emissions are in scope
- Be more explicit about the scope '*The scope of this GHG reporting guideline is beverage production (beer, cider, soft drinks and (packed) water)*', add that all operating companies with production sites for any type of drink are included, covering 100% of volume sold
- Reinclude description of changes compared to previous year
- Include refrigerant losses in flowchart
- In table 1: Imported CO_2 for soft drinks is listed as in scope, but also included in table 2 as justified for exclusion of attributable processes, clarify this discrepancy
- Justify use of Pjotr van Oeveren and Dough Witherspoon as credible source
- Update flowchart to make 'Water plant' green since this is included in the calculations and thus in scope

Recommendations Packaging materials

- Add to scope that top-22 operating companies are included, covering 87% of the volume sold
- Add to table '*emissions in scope or out of scope and specification of the data type*' the specification of data type
- Describe changes compared to previous year
- Justify deviations from the PEFCR methodology, knowledge on deviations gets lost with employee rotation otherwise
- Rectify statement made regarding which recycling rates for aluminum cans and glass bottles were used
- Reference adequately to the same dataset in one clear way
- Where '*European commission's EF compliant datasets*' is mentioned, be explicit about which dataset

Recommendations Logistics

- Add to scope that top 17 operating companies are in scope at and add that this covers 72% of the consolidated volumes
- Describe which inputs are excluded for the logistics CO_2 KPI but included for the total Heineken carbon footprint
- Reinclude an updated table with attributable processes that are excluded plus justification
- Reinclude an updated table with specific data sources and whether primary or secondary data was used
- Reinclude the missing 2017 assumptions or justify why they are left out in 2018

Recommendations Cooling

- Add to scope that 34 operating companies are included, covering 91% of the cooling carbon footprint, then extrapolated to 100%
- Do not refer to old excel files, update files and upload them to the HeiCF web application where the methodological documents can be found as well to keep a single source of truth
- For national grid emission factors, refer to the source
- In Figure 4, add the unit
- The total purchased fridges and total MWh/yr in table 5 are incorrect. 2018 values are added to the list but not to the total amount, this should be corrected

Text Box 1: Recommendations for Heineken to improve the validity of the 'Drop the C' program.

Disclaimer: The above-stated recommendations as well as any other recommendations for Heineken stated in this thesis are recommendations developed by Menno Meijerhof individually. Heineken is in no way obliged to follow these recommendations.

III. Abbreviation list

APCCF	Aggregated Product Company Carbon Footprint
BCS	Brewery Comparing System
CCF	Company Carbon Footprint
CDP	Carbon Disclosure Project
CF	Carbon Footprint
CM	Carbon Monitoring
CO_2eq	CO_2 equivalent
GHG	Greenhouse Gas
GHGP	Greenhouse Gas Protocol
GSCM	Green Supply Chain Management
GWP	Global Warming Potential
HeiCF	Heineken Carbon Footprint tool
IO	Input-Output
ISO	International Organization for Standardization
LCSCM	Low Carbon Supply Chain Management
MCF	Material Carbon Footprint
OpCo	Operating Company
PCF	Product Carbon Footprint
PEFCR	Product Environmental Footprint Category Rule
SBTi	Science Based Targets initiative
SCCF	Supply Chain Carbon Footprint
SSCM	Sustainable Supply Chain Management

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1. Introduction

With the recent announcement of the European Green Deal, pressure to reduce emissions caused by industries and large multinational companies in particular, will increase even further (Blanco et al., 2016; European Commission, 2019). There is thus greater incentive for companies, as well as increasing pressure on them from investors, governments and other stakeholders to invest more in setting, achieving and reporting on environmental goals in addition to financial ones (Kamp-Roelands et al., 2019; Stolker et al., 2020). Over 20% of global greenhouse gas (GHG) emissions result from approximately the 2500 largest companies in the world (Dubey et al., 2017). These companies predominantly disclose their emissions through the Carbon Disclosure Project (CDP). The CDP is a not-for-profit charity that runs the global carbon disclosure system. A global approach for reductions is needed since emissions resulting from the production of a product are caused by every step performed on the product along an often geographically widely spread supply chain (Nishitani et al., 2016). In 2019, the number of CDP supplier respondents reported that they are engaging with their suppliers on climate change increased to 35%, compared to just 23% in 2017 (Brackley et al., 2020). A supply chain is a network that consists of all parties (e.g. retailer, distributor, supplier, etc.), that are directly or indirectly involved in the production and delivery of products or services to final customers. This network includes both up- and downstream parties linked through physical distribution, flow of information and/or finances (Ben-Daya et al., 2019). With emitting parties so widely spread, it is important to find appropriate criteria to assess the validity of emission measurement for corporations to be able to avoid greenwashing practices.

Managing a supply chain is a very complex process (Tseng et al., 2019). It gets even more complex when conflicting objectives are included in the decision-making process. Emission reduction is such an objective that increases the complexity (Das & Jharkharia, 2018). To handle this complexity, knowledge about all emitting processes is key. It is impossible to set adequate reduction targets without knowledge about the emission intensity of processes. Emission intensity refers to the amount of emissions released by a certain process relative to a functional unit (e.g. kg CO_2eq emitted by brewing kettles per hl beer sold). This is where carbon reporting comes in.

Carbon reporting is defined by the Greenhouse Gas Protocol (GHGP) as presenting carbon emission data to internal management and external users such as regulators, shareholders, the general public or specific stakeholder groups (GHGP, 2004). These carbon emissions are categorized into three scopes: scope 1 are direct emissions, scope 2 are indirect emissions from purchased energy, and scope 3 are all other indirect emissions (for more detail see section 4.1). Carbon reporting can be seen as a "market driven governance system" (Cashore, 2004) or a form of "voluntary organizational practice" (Herold & Lee, 2018). Its voluntary nature allows companies to choose between different measurement and reporting strategies to measure carbon emissions. This gives companies the possibility to create a reporting strategy that bests suits their business structure and provides them with the exact knowledge they need for reporting and decision-making (Hayward et al., 2013). However, this voluntary nature also results in differentiation of measurement methods among companies (Acquaye et al., 2017). When considering an entire supply chain, this differentiation causes inconsistencies, and consequently a decrease in validity (Jensen, 2012; Stolker et al., 2020). This in turn severely hampers the possibility of an end product manufacturer to legitimately report on, and set targets to reduce their supply chain carbon footprint (SCCF) (Nishitani et al., 2016).

Previous studies on carbon footprints (CF) have mainly focused on methods for both material carbon footprint (MCF) (Farmery et al., 2014; Ingrao et al., 2015; Kumar et al., 2014; Pandey et al., 2011) and product carbon footprint (PCF) estimation and measurement (Gaussin et al., 2013; Jassim et al., 2017; Mujica et al., 2016; Munasinghe et al., 2016), and cleaner supply chain practices (Lin et al., 2014; Srivastava, 2007; Subramanian & Gunasekaran, 2015). Research on SCCF has only focused on input-output (IO) analysis (Acquaye et al., 2017; Su et al., 2017; Zhu et al., 2018), where monetary transactions at different stages in the supply chain are multiplied by sector average emission per dollar factors to get an estimate of emission intensity (Heihsel et al., 2019). These studies show that a tradeoff exists between the effort intensity of a method and the accuracy it can reach, as well as limitations of the different measurement methods. Weidema & Wesnæs (1996) were the first and only researchers to establish data validity indicators for the measuring construct of academic carbon footprint studies but suggested that these need to be revised to be applicable in a corporate setting. Measuring construct is defined as the underlying structure of an operationalization used to measure a carbon footprint, including data measurement, assumptions made and partial calculations that collectively lead to a final outcome. No previous studies on the measuring construct of low carbon supply chain management (LCSCM) practices or criteria to assess its validity on a firm level were identified in literature, which is why the aforementioned scheme by Weidema & Wesnæs (1996) is still the one referred to in the most recent GHG protocol supply chain emissions reporting standard (GHGP, 2011b).

To ensure that their SCCF is valid, end product manufacturers need to use legitimate criteria to assess and adapt their LCSCM measuring construct, to allow it to both be used by all suppliers in the supply chain and at the same time provide them with adequate and valid data on their emissions. This is part of what LCSCM research concerns itself with. Unfortunately, compared to sustainable supply chain management, the theoretical foundation of LCSCM is still in the nascent stage. Therefore, qualitative empirical research into measuring construct validity of LCSCM practices is needed in this field (Das & Jharkharia, 2018). It is this knowledge gap that this research aims to fill.

A prime example of an end product manufacturer that faces the above-mentioned problem is the global beer producing company Heineken. With over 40.000 suppliers and distributors in a supply chain that covers 192 countries (*Heineken*, 2018), collection of homogeneous and valid data for their SCCF is paramount. Heineken already has a program in place called '*Drop the C*' which is aimed at measuring and lowering their SCCF. Heineken is currently in the process to '*increasingly use actual primary performance data, …, rather than estimates*' (*Heineken*, 2018). With the increasing use of primary performance data, the importance of legitimate criteria to assess the validity of this data increases too. To fulfill this need, a tool was developed called the Heineken carbon footprint tool (HeiCF). This is an online Microsoft Power BI based data collection and calculation tool that links into the various internal and external datasets which it then uses to automatically calculate Heinekens carbon footprint. This tool has been rolled out in spring 2020 and officially went live on the 15th of April. For Heineken now the task remains to determine what the validity of their *'Drop the C'* program is based on the HeiCF tool and the current methodology. Cook & Campbell, (1979) defined construct validity as 'the extent to which an operationalization measures the concept it is supposed to measure'.

The research question is in line with a question proposed by Das & Jharkharia (2018). Given the absence of a research body on the topic, this resulted in the following exploratory research question and sub-questions:

RQ. What are appropriate criteria to assess the validity of the measuring constructs of carbon management programs?

Sub-RQ 1. On the developed criteria scheme, what is a legitimate minimum validity level?

Sub-RQ 2. What is the validity of the measuring construct of Heinekens' *'Drop the C'* program?

The remainder of this thesis is divided into seven chapters. Section 2 provides the theoretical background to the topic of research, and relevant theoretical concepts will be explained. Section 3 introduces the proposed research design, provides details about the types of data that have been used and how this data has been collected. Section 4 contains background information on GHG accounting and reporting as well as on the global beer brewing sector in which Heineken operates. Section 5 presents the results, followed by the discussion and conclusion in sections 6 and 7 respectively. Finally, acknowledgements are made in section 8.

2. Theoretical background

An extensive body of literature exists on supply chains and all its related aspects. One of these aspects is sustainable supply chain management (SSCM). This body of literature encompasses both the social and environmental dimension of sustainability. Take out the social dimension and you end up with green supply chain management (GSCM), a field of study that focusses on how to integrate environmental thinking into regular supply chain management (Chin et al., 2015). Despite being solely focused on environmental supply chain issues, GSCM still has a broad scope since it includes pollution control, natural resource conservation and waste management (Das & Jharkharia, 2018; Shaharudin et al., 2019). Set aside these aspects and you arrive at LCSCM. The remainder of this section will cover concepts in the field of LCSCM, private governance, greenwashing and finally concepts related to construct validity in empirical academic research will be covered.

2.1 Low carbon supply chain management

There are two schools of thought about LCSCM. The first school defines LCSCM as an extension of GSCM that indirectly helps firms to reduce their CF (Das & Jharkharia, 2018; Kushwaha & Sharma, 2016). The second school defines LCSCM as different from GSCM due to LCSCM's specific goal of voluntarily reducing GHG emissions and the strong correlation to energy (Jassim et al., 2017; Mujica et al., 2016). For this research, the definition of the second school of thought will be adopted.

LCSCM is a relatively new discipline which focusses on GHG emission reductions on a firm level, including up- and downstream parts of the supply chain. LCSCM revolves around the perception that all actors across the supply chain have something to gain from reducing GHG emissions. Parties upstream in the supply chain have something to gain because reductions of GHG emissions also result in the reduction of environmental costs and risks stemming from the supply chain (Blanco et al., 2016; Borkovskaya et al., 2018). In addition, both the firm under consideration and parties downstream in the supply chain can capitalize on the growing market segment of environmentally conscious consumers by improving their reputation (Chen et al., 2017; Nishitani, 2011). The growing number of studies showing that firms can achieve greater economic benefits from collaboration with, and integration of suppliers in their supply chain (Arimura et al., 2011; Soosay & Hyland, 2015) resulted in LCSCM becoming a more important environmental strategy than individual environmental initiatives (Nishitani et al., 2016).

There are four forms of LCSCM that can be utilized by firms to manage supply chain actors in different places in the supply chain. These forms are: direct collaboration, indirect support, carbon monitoring, and official requirements (Nishitani et al., 2016). Carbon monitoring is the form of LCSCM that will play a central role in this research. The outcome of carbon monitoring is one of the factors that can lead to official requirements becoming stricter.

2.1.1 Carbon monitoring

The importance of supply chain actors' performance should not be underestimated. Mao et al. (2016) identified that as much as 90% of the total emissions of a firm can originate from indirect supply chain emissions. Carbon monitoring (CM) is an activity that firms can undertake to influence supply chain actors' emission performance. It refers to target setting of GHG emissions reduction in the supply chain, as well as routine measurement and evaluation of these targets by a firm (Rohani et al., 2017). Guided by this evaluation, the firm can use suppliers' GHG emission performance as a criterion for supplier selection by including it in their official requirements. Target setting can be done on different levels ranging from material level up to industry level (Figure 1). Measurement of the CF on each of these levels is done using different measuring and modelling techniques.

The material level is the lowest and least complex level on which a CF can be calculated. The predominantly used measuring technique for MCF calculations is the process-based Life Cycle Assessment (LCA). An LCA comes with high precision, yet sometimes they are time-consuming due to difficulties in obtaining the needed level of detail for the inventory data. For the precision to be reached, uniformity in parameter distributions and assumptions on inputs is important. Ziyadi & Al-Qadi (2019) show that ± 10% variation in parameter values resulted in 28% variation in global warming potential (GWP) output.

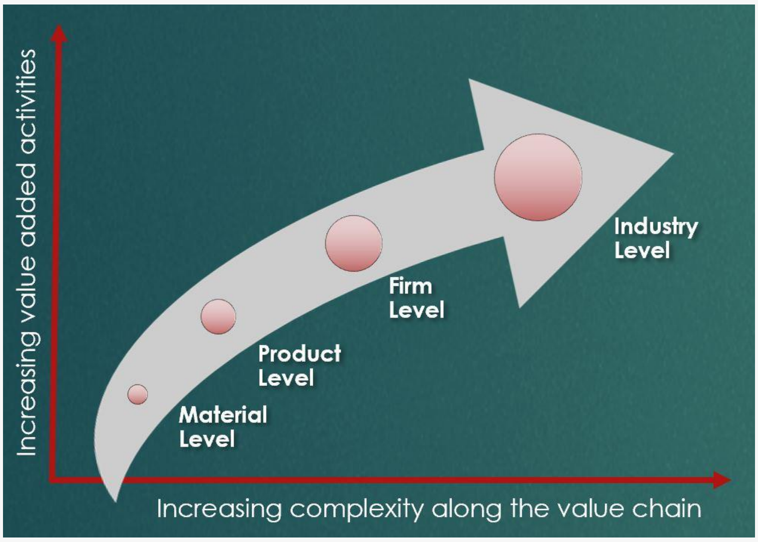


Figure 1: Different levels of carbon footprint plotted based on value chain complexity vs. number of value-added activities (Acquaye et al., 2018).

Moving towards higher complexity and added value brings us to the product level. On this level, hybrid IO-based LCAs are often used to calculate carbon footprints. The choice for this hybrid version is usually motivated by lacking data on certain materials or processes, for which IO analysis is used to fill in the gaps (Nakamura & Nansai, 2016).

Another step further in complexity and value-added activities is the firm level. Due to its high level of complexity and large number of different products being produced by most firms, IO analysis is still the most used method for SCCF calculations in academic studies to date (Blanco et al., 2016). IO models are efficient and eliminate cutoff error, yet at the same time they introduce significant aggregation errors and uncertainties (Heihsel et al., 2019). This type of modelling provides a consistent method to make a first estimation of a firm's supply chain emissions. However, once reduction measures are implemented in the supply chain, these are not captured by this type of modelling due to the use of sector average, instead of firm specific data. It is this shortcoming that makes it impossible for firms to establish and monitor reduction targets solely based on IO analysis results. Therefore, in order to be able to set targets, firms need to undertake more complex efforts.

Across industries the GHG protocol is the predominantly used standard for carbon monitoring on a firm level (GHGP, 2004; Green, 2010; Hertwich & Wood, 2018). The GHG protocol initiative is a multi-stakeholder partnership of businesses, governments, and non-governmental organizations. Their mission is to develop internationally accepted carbon monitoring and reporting standards for business, to allow them to undertake these more complex efforts as well as to promote their broad adoption (GHGP, 2004).

The standard distinguishes between three different categories of emissions referred to as 'scopes.' The main purpose of classifying emissions into different scopes is to improve transparency and avoid double counting of emissions. Scope 1 are direct emissions which result from sources that are owned or controlled by the company. Scope 2 and 3 are indirect emissions which are a consequence of the activities of the company but occur at sources owned or controlled by another company (GHGP, 2004). Scope 2 solely consists of the indirect emissions resulting from the generation of energy that is purchased and used by the reporting firm. All other indirect emissions fall under scope 3. Figure 2 provides an overview of the scopes with some examples of activities that fall under them. Currently scope 3 is still referred to as an optional reporting category. However, increased stakeholder pressure is motivating more and more firms to start reporting on this scope in detail.

The emissions are calculated using both primary and secondary data. Primary data refers to activity data directly measured at the emission source (e.g. fuel consumption of a car, energy consumption of a laptop). Secondary data refers to the emission factors that are needed to get from the primary data to the actual emissions (e.g. the amount of CO_2eq emitted when 1l of fuel is burned). CO_2eq stands for CO_2 equivalent and refers to the cumulative global warming potential of all six main greenhouse gasses emitted by a certain process, in which for instance CH_4 has a CO_2eq factor of four. Thus, one kg of CH_4 counts as four kgs of CO_2eq whereas one kg of CO_2 counts as one kg of CO_2eq.

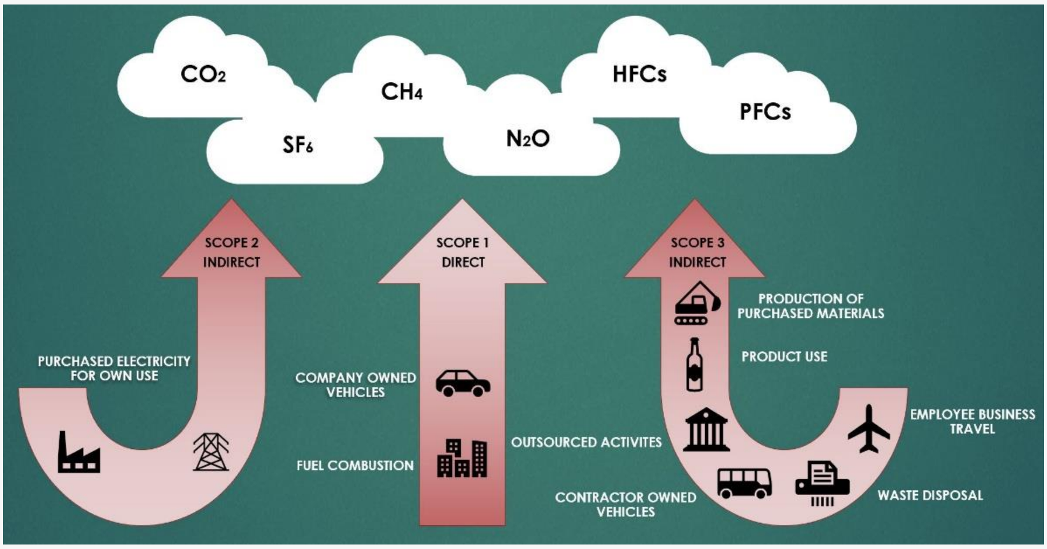


Figure 2: Overview of emission scopes (GHGP, 2004).

2.1.2 Official requirements and supplier selection

Production firms need their suppliers to meet certain quality standards in order to make the final product live up to their customer's expectations. These standards are depicted as formal requirements in the firm's conditions of trade (Darnall et al., 2008). Official requirements are important for two reasons. Firstly, if suppliers, even highly skilled ones, do not understand the precise needs of the firm, they will not be able to deliver precisely those raw materials and parts that the firm desires to purchase (Kuo et al., 2015). Secondly, supplier selection is one of the most important components of production and logistics management for many companies. This process can be considered as a multi-criteria decision-making problem which is influenced by price, quality, technical capability, delivery, and (environmental) performance (Zhan, 2019). In 2019, 43% of CDP Supply Chain program members confirmed that they currently deselect existing suppliers based on their environmental performance (Brackley et al., 2020). However, if the firm does not have well formulated requirements it will not be able to transparently base supplier selection on clear criteria. This can lead to a loss in reputation and willingness among suppliers to conduct business with the firm. This causal relationship works both ways. Arimura et al. (2011) shows how firms promoting environmental practices through communication using clear criteria based on the International Organization for Standardization (ISO) 14001 standard are 40% more likely to positively influence their suppliers environmental performance relative to firms that do not use clear criteria in their communication. The ISO 14001 standard specifies requirements for an effective environmental management system.

2.2 Private Governance

Stakeholder groups are increasingly trying to influence corporations directly to change their practices in response to the stakeholder group's demand (Dana & Nadler, 2019). NGOs and consumers are exerting increasing pressure on corporations with weak environmental performance (Asmussen & Fosfuri, 2019; Lambin & Thorlakson, 2018). As a consequence, corporations adopt voluntary private rules (Fransen, 2018). Setting private rules gives corporations the ability to adapt their own policy and mitigate risks stemming from the increasing stakeholder pressure (Vatn, 2018). At the same time, these private governance schemes are used by corporations to set goals aimed at improving their supply chain sustainability performance in a valid way (Tröster & Hiete, 2018). This shows the importance of the research question; '*What are appropriate criteria to assess the validity of the measuring constructs of carbon management programs* '? Figure 3 shows how the organization is pressured by stakeholders to report on their footprint in a valid way. This results in the organization seeking a validity criteria scheme to assess the validity of their CM program, in order to avoid being accused for committing acts of greenwashing by the aforementioned stakeholders. In turn this influences the supply chain to improve their CM validity. The criteria that this research has developed are an example of private rules as part of a private governance scheme. Furthermore, it enables organizations to set targets for SCCF reductions, which similarly puts pressure on the supply chain to reduce their emissions.

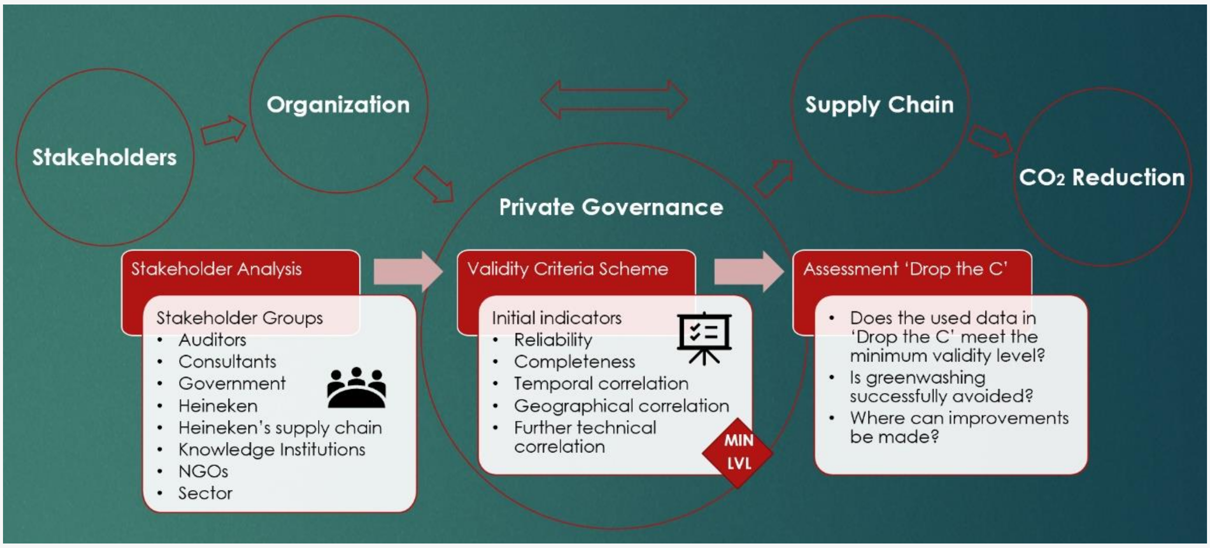


Figure 3: Validity criteria scheme as example of private governance.

2.3 Greenwashing

Greenwashing is defined as the inconsistency between substantive and symbolic actions (Siano et al., 2017). Substantive actions refer to the implemented initiatives that are in line with the sustainability approach. Symbolic actions are those that tend to deflect attention away from the real sustainability issues towards lesser issues, or those that create a form of 'green talk', aimed at satisfying stakeholders without taking concrete action. A valid CM program can act as proof for stakeholders that substantive initiatives are implemented by the company. These two examples fall under the seven sins of greenwashing described by Dahl (2010) as: fibbing, hidden trade-off, irrelevance, no proof, vagueness, worshiping false labels, and the lesser of two evils. The aim of the first sub-question '*On the developed criteria scheme, what is a legitimate minimum validity level*' is to establish a validity level that can guarantee that the company avoids committing greenwashing sins. Three sins have been identified as likely to occur in CM: fibbing, no proof and vagueness. Fibbing refers to the use of false claims or claims made based on false, inaccurate, or invalid information. No proof relates to the lack of third-party auditing to assure the reliability and singularity of claims made. Finally, vagueness refers to the use of ambiguous claims which can for instance be caused by inconsistent use of units in measurements (Dahl, 2010).

2.4 Construct validation in empirical research

Construct validation is the process of integrating evidence to support the meaning of a number which is assumed to represent a construct. Flake et al. (2017) describe three phases in construct validation: substantive, structural, and external. The substantive phase entails using previous literature to define the construct and to set the scope. The structural phase is where the factor structure and internal consistency are examined, and the external phase is where relationships of the construct to other constructs are examined.

These three phases correspond with the three step approach by O'Leary-Kelly & Vokurka (1998) to validate a measuring construct in empirical research (Figure 4). These authors claim that studies that utilize empirical measures but fail to adequately assess the construct validity of the measures are open to criticism. In line with this statement, this thesis argues that the

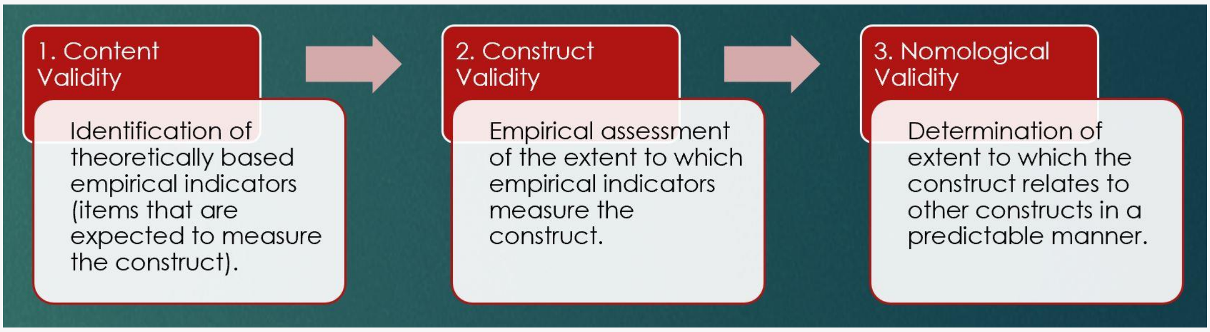


Figure 4: Construct validation process O'Leary-Kelly & Vokurka (1998).

same is true for carbon footprint measurements by firms. Increasing the validity of the measuring construct can therefore prevent greenwashing claims from stakeholders and increase the firm's legitimacy.

The theoretically based empirical indicators, as mentioned in step one, are identified in papers by Weidema and Wesnæs (1996) and Ciroth et al. (2020) and are the following: Accuracy, Completeness, Consistency, Materiality, Reliability, Representativeness, Transparency, and Verification (Table 1 and 2). These were identified by these authors as necessary and sufficient to describe those aspects of construct validity which influence the reliability of the result of an academic LCA study. However, they also mention how different data validity goals in a corporate setting may lead to quite different measuring construct validity requirements (Weidema & Wesnæs, 1996), meaning that the requirements for these indicators should be revised for a corporate setting. Ciroth et al. (2020) divided indicators to assess the validity of life cycle inventory data in life cycle inventory databases in five categories. The 'value' column shows how each indicator can be scored, which is through a yes/no, scientific/expert or text answer for the first category. The remaining four categories can be scored by a value of one up till five. Only 'Precision of the provided information' and 'Data access' are scored differently, namely one up till four and one, three or five, respectively.

2.5 Methodological standards

There is a big variety in documents of different natures to be found that describe measuring construct validity in one way or another. All documents listed in Table 3 were freely accessible and easy to find except for four documents of the ISO. These were also identified by interviewees as containing relevant information regarding measuring construct validity assessment. However, to get access, a license is needed. This has not been obtained for this research. Hence, these documents could not be included in the document analysis. Only the ISO 14044 standard was indirectly included based on the EPA's Guidance on Data Quality Assessment for LCI data document (EPA, 2016).

Figure 5 shows in how many documents the validity categories were mentioned (for description of validity categories, see chapter 3.1 Research design). The 15 documents that were included in the literature review show a high degree of overlap. Table 3 shows in which documents the identified validity categories are mentioned. The extent to which the indicators are covered differs from a single reference to extensive descriptions of how to assess the validity level. The remainder of this chapter contains three examples of how the level of detail different among the different documents to illustrate the type of information that was collected from them.

Table 1: Lifecycle inventory data review criteria, with indication of their values and scope (Ciroth et al., 2020).

Goal and scope completeness	Values	Scope		
		data set	flows / exchanges	any other data set field
Reference time	yes/no	x		
Reference geography	yes/no	x		
Reference technology	yes/no	x		
Reference model completeness	yes/no	x		
Reference sample completeness	yes/no	x		
Sample approach (scientific, or expert-based)	scientic / expert	x		
Supported LCIA methods with version number	text	x		
Conformance				
Time related conformance	1..5		x	x
Geographical conformance	1..5		x	x
Technological conformance	1..5		x	x
Model completeness conformance, flows and documentation	1..5	x		
Sample conformance, correctness and reliablity				
Sample conformance	1..5	x		
Accuracy of the provided information	1..5	x		
Precision of the provided information	1..4		x	
Reliability of the provided information	1..5		x	x
Consistency of the provided information	1..5		x	x
Materiality				
Mass- and energy balance in line with goal and scope	1..5	x		
LCIA results in line with goal and scope	1..5	x		
Order of 5 main drivers for main LCIA results in line with goal and scope	1..5	x		
Procedural and meta-information				
# of reviewers and their relation to data provider	1..5	x		
Data access	1, 3, 5	x		

As an example regarding technological representativeness; the Global Logistics Emission Council (GLEC) Framework mentions that low emission freight technologies are increasingly available and have strong potential for reducing carbon emissions, and that therefore a logistics provider investing in these technologies would want them to be represented in his CF (Greene & Lewis, 2019). However, the framework does not further mention how this can be assured, or which level of technological representativeness is needed to achieve this.

On the other side of the spectrum there are documents like the Global Guidance Principles, this document describes principles to be followed to assure good practice when building life cycle assessment databases (UNEP et al., 2011). It for instance argues that temporal, geographical and technological information is important for consequential modelling within an LCI or LCA study (UNEP et al., 2011). It then goes on and dedicates three full pages to describe and list the considerations a practitioner can make to determine which information related to those three indicators is important to include in the metadata of a dataset. The document handles all the categories it mentions in the same elaborate way (UNEP et al., 2011).

Regardless of whether a document is elaborate or every concise about the categories, everything that is mentioned by the documents will be considered during the analysis and criteria scheme development in this thesis.

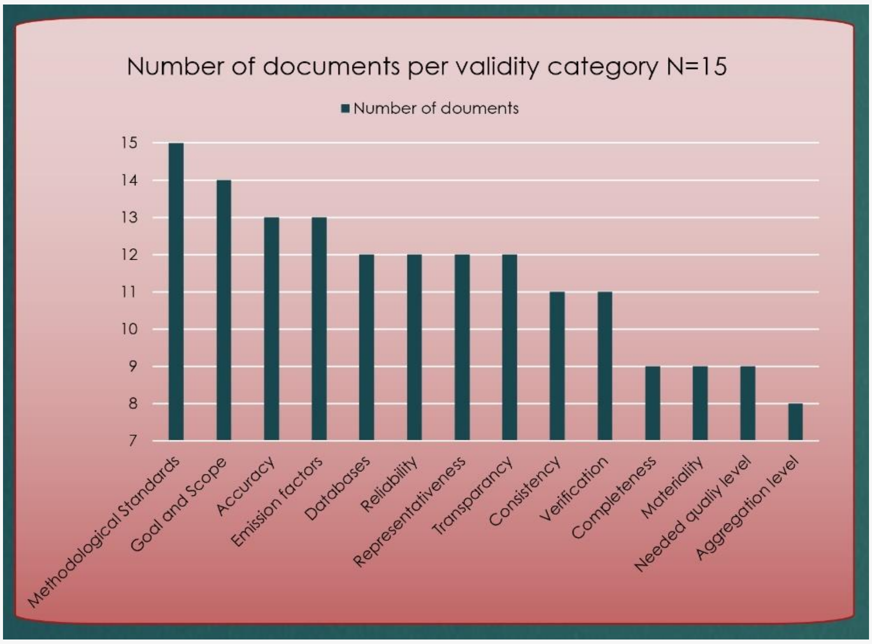


Figure 5: Graph showing the number of documents each ***validity category*** *is mentioned in.*

From the three documents of the GHGP that are included, the Corporate reporting standard (Scope 1 and 2) mentions all but two of the indicators (GHGP, 2004). It does however not further specify how high validity levels can be assured for the indicators except for verification and materiality. There is an entire chapter on the verification of GHG emissions which includes a description of materiality and how this term is usually applied by auditors (GHGP, 2004). The product and Corporate value chain (Scope 3) standards are more elaborate on all the indicators besides verification and describe them in an almost identical manner (GHGP, 2011b, 2011a). Both the product and value chain standards refer to the study by Weidema & Wesnæs (1996) for key validity indicator assessment criteria (Table 2).

Table 2: Pedigree matrix with 5 data validity indicators (Weidema and Wesnæs, 1996).

Indicator score	1	2	3	4	5
Reliability	Verified data based on measurements	Verified data partly based on assumptions or non-verified data based on measurements	Non-verified data partly based on assumptions	Qualified estimate (e.g. by industrial expert)	Non-qualified estimate
Completeness	Representative data from a sufficient sample of sites over an adequate period to even out normal fluctuations	Representative data from an adequate number of sites but from shorter periods	Representative data from an adequate number of sites but from shorter periods	Representative data but from a smaller number of sites and shorter periods or incomplete data from an adequate number of sites and periods	Representatieness unknown or incomplete data from a smaller number of sites and/or from shorter periods
Temporal correlation	Less than three years of difference to year of study	Less than six years difference	Less than 10 years difference	Less than 15 years difference	Age of data unknown or more than 15 years difference
Geographical correlation	Data from area under study	Average data from larger area in which the area under study is included	Data from area with similar production conditions	Data from area with slightly similar production conditions	Data from unknown area or area with very different production conditions
Further technological correlation	data from enterprises, processes and materials under study	Data from processes and materials under study but from different enterprises	Data from processes and materials under study but from different technology	Data on related processes or materials but same technology	Data on related processes or materials but different technology

Table 3: Document analysis on validity categories.

#	Title	Scope	Author	Accuracy	Aggregation level	Completeness	Consistency	Databases	Emission Factors	Goal and Scope	Materiality	Methodological standards	Needed level of data validity	Reliability	Representativeness	Transparancy	Verification
1	2011 - Global Guidance Principles	Product	Sonneman et al., 2011	x	x	x	x	x	x	x	x	x	x	x	x	x	x
2	General Product Environemental Footprint Category rules (PEFCR) 6.3	Product	EU Commission, 2018	x	x	x	x	x	x	x	x	x		x	x	x	x
3	WRI - COOL FOOD PLEDGE	Product	Waite et al., 2019	x		x	x		x	x		x	x	x	x	x	x
4	(PEF) Product Environmental Footprint Guide	Product	Manfredi et al., 2012	x		x	x	x	x	x		x	x	x	x	x	x
5	Corporate Value Chain (Scope 3) Accounting and Reporting Standard	Scope 3	GHGP, 2011	x	x	x	x	x	x	x	x	x		x	x	x	x
6	Transport emission & social cost assessment	Logistics	Song, 2016	x		x	x	x	x	x		x		x		x	x
7	(PAS) Publicly Available Specification 2050	Product	BSI Group, 2011	x		x	x		x	x	x	x			x	x	
8	Life cycle inventory dataset review criteria	LCIA Databases	Ciroth et al., 2020	x	x	x	x			x	x	x	x	x	x		
9	Beer Product Environmental Footprint Category Rules (PEFCR) June 2018	Product	EU Commission, 2018	x						x		x	x	x	x		x
10	BIER GHG Sector Guidance V4	Company/Product	BIER, 2018		x				x	x	x	x	x	x		x	x
11	Sectoral Decarbonisation Approach SBTi	Company	SBTi, 2015					x	x	x		x	x			x	
12	GLEC	Logistics	Smart-freightcentre, 2019	x	x		x	x	x	x	x	x	x	x	x	x	x
13	Product life cycle accounting and reporting	Product	GHGP, 2011	x	x	x	x	x	x	x	x	x		x	x	x	x
14	Greenhouse Gas Protocol Initiative Team	Scope 1 & 2	GHGP & Ranganathan, 2004	x	x	x	x		x	x	x	x		x	x	x	x
15	ISO - 14040	Product	ISO, 1997	Excluded													
16	ISO - 14044 (Based on EPA Guidance on Data Quality Assessment for LCI)	Product	ISO, 2006	x	x	x	x		x			x	x		x		
17	ISO - 14001	Environmental Management System	ISO, 2015	Excluded													
18	Annex C of ISO 14064-3	Environmental Management System	ISO, 2006	Excluded													

3. Methodology

This section covers the research design, followed by the case selection and applied methods.

3.1 Research design

The nature of the research problem should drive the choice of research strategy (Creswell, 2015; Denzin, 2009). When no literature body exists on a topic, exploratory research is needed (Karwan & Markland, 2006). Eisenhardt (1989) indicates that in such cases, this type of research contributes to the understanding of a phenomenon, which makes it a suitable research method for research of this nature (Morioka & Carvalho, 2016). In order to answer the research questions and generate new insights, a qualitative analysis has been undertaken. A single case study has been used for this research. '*The case study approach is a very popular and widely used research design in business research and some of the best-known studies in business and management research are based on this design*' (Engert & Baumgartner, 2016). Case methodology is particularly useful when studying a natural setting (Stake, 2013) and when few previous studies have been carried out in the research area (Benbasat et al., 1987). Therefore, the single case research strategy as described by Benbasat et al. (1987) is identified as the most applicable research method for this research. There were four steps of analysis (Figure 6). Firstly, an analysis of the existing literature identified initial validity categories. Secondly, based on the literature, document, and stakeholder analysis, identified validity categories and case study data analysis, a data validity criteria scheme for corporate carbon reporting has been developed. This was done by taking the initial empirical indicators as a starting point. For the sake of consistent use of terms in this research, these initial empirical indicators formed the first validity categories. Additional validity categories were added once identified in the stakeholder analysis. 16 Categories emerged of which 14 were found to be

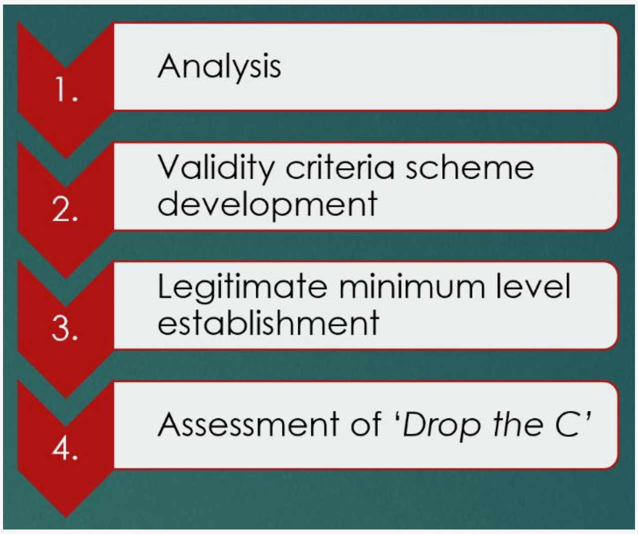


Figure 6: The four research steps in successive order.

validity categories. The 15 methodological documents were then analyzed and relevant descriptions of the 14 validity categories were aggregated. These descriptions were combined with the statements made by the interviewees to develop indicators that are relevant for a corporate context. Thirdly, a legitimate minimum level on this scheme has been established for each of the indictors. And fourthly, Heineken's '*Drop the C*' program has been assessed according to the validity criteria scheme, to see to what extent it meets the established legitimate minimum level.

It is important to note that the '*Drop the C*' program includes two carbon footprints. First, there is the PCF. This is the less elaborate one of the two and includes the biggest operating companies (OpCos) from which it then gets extrapolated to 100% of Heinekens operations (Table 4). Second, there is the company carbon footprint (CCF). This is the more elaborate version which also includes 'other carbon emissions', consisting of purchased goods and services, capital goods, business travel, commuting, upstream leased assets, and investments. The assessment will be focused on the PCF because this is the carbon footprint that can be compared to competitors. Besides that, Heineken also plans to make commitments towards the Science Based Target initiative (SBTi) based on their PCF.

Table 4: Heineken scope of the 2018 product carbon footprint, showing data coverage per supply chain stream (in percentage of volume sold; Heineken, 2019a).

	Agriculture	Malting and Adjuncts	Brewing and beverage production	Packaging	Logistics	Cooling	Other carbon emissions
2018 scope	Top-34	Top-34	All Operating Companies	Top-22	Top-20	Top-34	
Coverage per stream (of volume sold)	89%	89%	100%	87%	72%	91%	
Part of CCF	23%	5%	10%	29%	11%	10%	12%
Part of PCF	26%	6%	12%	33%	12%	11%	-

3.2 Case selection

In a single instrumental case study as described by Stake (1995), the researcher focusses on an issue, and then selects one bounded case to illustrate this issue (Creswell, 2015). Selection criteria for a case study should be well defined, considering the intentional choice of the case to be analyzed (Eisenhardt, 1989). Accordingly, the case was selected based on the following criteria: (a) strategic relevance of sustainability, proven by means of external documentation including mission, values, and sustainability reports; (b) LCSCM practices being applied along the firms supply chain; (c) willingness of the firm to partake in the research and facilitate interviewee sampling; and (d) willingness of the firm to grant access to internal documents relevant to the research. These four criteria were all met by Heineken N.V., their annual reports contain a sustainability chapter that describes their entire sustainability strategy and how this is incorporated in their overall strategy. The company has started their journey to reduce carbon emissions along their entire supply chain and they are about to take the next step by committing to the SBTi, which for Heineken means working towards an ambitious reduction target of 35% per hl sold, relative to 2018 for the entire supply chain. Furthermore, Heineken has been willing to partake in the research and to grand full access to all relevant internal documents as well as facilitating interviews with all relevant employees. This led to Heineken being a logic and suitable choice as subject of this research's case study.

3.3 Applied methods

Three sources for data collection which Creswell (2015) identified to work well with case study research, have been used. These sources are documents, papers, and semi-structured qualitative expert interviews.

3.3.1 Documents and papers

This research starts with a review of the scientific literature to get an overview of related theories that (partially) address the phenomenon under investigation. This includes theory regarding LCSCM, as well as private governance theory, greenwashing theory, and construct validation theory describing how measuring constructs can be validated in mere academic settings. Besides, existing methodologies as part of grey literature have been analyzed. Grey literature refers to literature published by governments, knowledge institutions and business actors which are not controlled by commercial publishers (Khan et al., 2019). Internal primary documents have been collected at Heineken, they served as reliable, tangible sources that shed a light on Heineken's supply chain structure and underlying measuring construct.

3.3.2 Qualitative semi-structured expert interviews

Interviews are among the most commonly used data collection methods, and the semi-structured version is the most frequently used interview technique in qualitative research (Kallio et al., 2016). This type of interviews is useful for generating knowledge and stimulating respondents' reflection on pre-selected topics (Justesen & Mik-Meyer, 2012). These topics and the related questions can be found in the interview guide in appendix A. The interviews were semi-structured, meaning that instead of following a structured order of questioning, the questions acted as a guideline along which the conversation is structured. This allowed the interviewer to follow topical trajectories that presented themselves during the interview. Eight stakeholder groups were identified. These groups were chosen to cover the entire spectrum of relevant stakeholders, to not miss out on potentially important perspectives that are only present in a specific stakeholder group. The identified groups are: Knowledge Institutions, Heineken, Supply Chain, Sector, NGOs, Government, Consultants, and Auditors.

Sampling strategy

The type of sampling used in this study is called snowball sampling. This sampling strategy entails that successive interviewees have been chosen based on people who know people who can serve as interviewees with high information power (Creswell, 2015). This strategy allows the researcher to utilize the network of experts on the topic to get in contact with valuable interviewees. Information power indicates that the more information the sample holds, relevant for the actual study, the lower number of participants is needed (Malterud et al., 2016). The first interviewees were chosen based on their experience with the phenomenon, job profile, accessibility, and willingness to partake in an interview. These interviewees were then asked if they knew other experts who would be willing to give an interview, which got the 'snowball' rolling. The strategy worked well since most of the conducted interviews were with people who got referred to the researcher by others who had been directly contacted. According to Corbin & Strauss (2010), saturation can happen with as few as eight interviews, but usually between 20 and 30 interviews are conducted before saturation is reached (Creswell, 2015). Given the high number of stakeholder groups (8), the author chose to conduct more than 30 interviews to get a good coverage. During the last interviews, the author was confident that saturation was reached despite lower information power of some of the interviews. The reached saturation indicated the author to stop data collection when in total, 46 people provided input. Table 5 on page 30 shows the distribution of the number of interviewees over the stakeholder groups, including a reference number that will be used in the results section to refer to the interviews without breaking up the text too much (R1 to R46). 35 interviews were conducted, of which four with two people at the same time and one with three people at once. Two people provided written input after requesting the questions to be sent to them via email instead of sitting down for an interview. Additionally, the researcher sat in on three meetings during which data validity in carbon management at Heineken was discussed. These were recorded as well and included in the transcribing and coding process. In total, this resulted in 11 hours, 59 minutes, and 40 seconds of recorded material. Interviews that have a duration of zero minutes were either interviewed simultaneously with the interviewee above, or they gave written input on the interview questions. All but one of the interviews were conducted over a period of two months, with the first interview conducted on the third of March and the second to last interview on the sixth of May. The last interview was conducted on the fifth of June, this interview had to be delayed due to late availability of the interviewee. The interview was still conducted because it improved the coverage in the Supply Chain stakeholder group.

Interview data analysis

Yin (2017) describes how coding can be useful in case studies to organize transcript data around specific propositions, questions, or activities. It provides the needed flexibility for modifications as the analysis progresses and allows interview segments from different respondents, but on the same topic, to be integrated. Therefore, all interviews have been transcribed and coded. Due to time restrictions, for three interviews with Heineken employees, the interviewer deviated from the regular interview guide and focused on the identified validity indicators to ask the employees how the data in their supply chain section scored in relation to the indicators. Including these codes into the validity indicator analysis would bias the findings. Therefore, these codes were excluded from the first part of the analysis and only included for establishing scoring criteria, a minimum level and assessing the *'Drop the C'* program. For this research, open, axial and selective coding as described by Corbin & Strauss (1990) was performed. NViVo 12 software was used for the coding process. Open coding was used to analytically break down the data. Axial coding entails 'a set of procedures whereby data are put back together in new ways after open coding, by making connections between categories' (Kendall, 1999). These procedures helped the researcher to organize and analyze the data more reliably. During the last step, selective coding, the codes which form the analytic core of the data were systematically related to other categories. This resulted in the integration and refinement of the categories (Kendall, 1999). For this research, a group of codes is considered to be a category when it is rooted in a minimum of six (15%) of the interviews. This minimum was pragmatically established based on the observation that no groups of codes rooted in four or five interviews occurred. Hence, six appears to be a realistic minimum amount. The categories acted as the foundation of the criteria scheme and were translated into 21 indicators to cover all the relevant aspects of data validity to be assessed. The scheme consists of three different assessment methods. Assessment happens either through yes/no answers, textual answers, or on an ordinal scale consisting of two or three steps. These scores can be assigned based on the established assessment criteria per indicator.

3.3.3 Research quality indicators

To ensure the quality of this research, measurement validity, reliability and internal and external validity of the findings as described by Bryman (2016) were pursued as well as data triangulation and member checking as described by Creswell (2015). External validity refers to the extent to which the findings can be generalized (Bryman, 2016). Experts from across the supply chain have been interviewed as well as experts working at knowledge institutions, consultancy firms, auditing firms, Heineken, the food and drink sector, the government and NGOs, to assure that the established validity criteria will be supported and widely applicable.

However, since the criteria have only been tested in a single case study, future research is needed to prove the generalizability. Reliability refers to the replicability and repeatability of the study (Bryman, 2016). To improve the reliability, this study clearly formulated the steps that were followed in the methodology and strictly stuck to them. Data triangulation has been applied by cross-referencing data from multiple sources including scientific and grey literature, interviews as well as internal and external policy documents. Through this triangulation the researchers bias was kept at a minimum, increasing the validity and corroboration of the findings (Creswell, 2015; Yin, 2009). Member checking involves taking data, analysis, interpretations, and conclusions back to the participant so that they could judge the accuracy and credibility (Creswell, 2015). This was done for the '*Drop the C*' assessment. All the identified insufficiencies and associated recommendations for each of the supply chain sections were ran past the employees that are responsible for the methodological documents and CF calculations of these sections. Furthermore, all the recommendations as well as insufficiencies related to the overall program were discussed with the global sustainable sourcing director. Lastly, interviews were recorded and transcribed to increase the traceability of the collected data and to transparently show how the results are grounded in the raw data.

Table 5: List of conducted interviews, attended meetings, and received written input, including the organization, job title, duration, date, and reference number.

Stakeholder	Organisation	Job Title	Duration	Date	Type	Reference
Knowledge Institutions	RUG	Sustainability program manager	40,38	10/03/2020	Interview	R1
	UU	Assistant Professor	13,12	12/03/2020	Interview	R2
	UU	Professor	28,28	17/03/2020	Interview	R3
	UU	Assistant Professor	21,11	18/03/2020	Interview	R4
Heineken	Heineken N.V.	HeiCF Launch Webinar	50,34	15/04/2020	Meeting	R5
	Heineken N.V.	Project Lead CRIS Supply Chain	44,17	16/04/2020	Interview	R6
	Heineken N.V.	SAT 2019 for HeiCF	33,25	16/04/2020	Meeting	R7
	Heineken N.V.	Project Lead CRIS Commerce	20,35	16/04/2020	Interview	R8
	Heineken N.V.	Senior Global Lead Safety & Environment	20,27	17/04/2020	Interview	R9
	Heineken N.V.	Global Production Circular Economy	45,02	20/04/2020	Interview	R10
	Heineken N.V.	CRIS Raw Materials	11,30	22/04/2020	Interview	R11
	Heineken N.V.	CFBM 18 Data Management Agri	50,44	22/04/2020	Meeting	R12
	Heineken N.V.	Global Lead Logistics	44,22	23/04/2020	Interview	R13
	Heineken N.V.	Digital Project Manager	28,29	28/04/2020	Interview	R14
Supply Chain	Intellegence for Business	Partner	19,52	14/04/2020	Interview	R15
	Euro Pool Group	Marketing Manager	11,23	21/04/2020	Interview	R16
	British American Tabacco	Former Factory Director Western Europe	27,30	30/04/2020	Interview	R17
	British American Tabacco	Environmental Risk & Performance Manager	52,07	05/06/2020	Interview	R18
Sector	Fonterra	President Fonterra Europe & Africa	14,29	08/04/2020	Interview	R19
	FrieslandCampina	Manufacturing Manager	22,16	14/04/2020	Interview	R20
	FrieslandCampina	Director Global Packaging Development	24,37	24/04/2020	Interview	R21
	FrieslandCampina	Sustainable Packaging Development	14,07	06/05/2020	Interview	R22
	Suiker Unie	Environmental Affairs Manager	8,57	24/04/2020	Interview	R23
	A-Ware	Manager Corporate Social Responsibility	18,01	30/04/2020	Interview	R24-25
	A-Ware	Corporate Social Responsibility Officer	0	30/04/2020	Interview	R24-25
NGOs	WRI	Climate Researcher	30,05	13/03/2020	Interview	R26
	WRI	Sustainable Land Use Project Lead	33,08	04/03/2020	Interview	R27-28
	WRI	Mobility and Transport Specialist	0	04/03/2020	Interview	R27-28
	WRI	Associate, Food Program	0	17/03/2020	Written input	R29
	WRI - GHGP	Senior Associate	18,35	20/03/2020	Interview	R30
Government	Minestry of Environment Mexico	General Director Policies for CC	21,23	12/03/2020	Interview	R31-32-33
	World Bank	ETS Team member	0	12/03/2020	Interview	R31-32-33
	World Bank	ETS Team member	0	12/03/2020	Interview	R31-32-33
	ENEA	Researcher	31,08	15/04/2020	Interview	R34
Consultants	Bayzoltan consultancy	LCA consultant	30,27	19/03/2020	Interview	R35
	Greendesk consultancy	LCA and CF consultant	18,59	20/03/2020	Interview	R36
	Abaleo consultancy	LCA, CF and CCF consultant	17,59	31/03/2020	Interview	R37
	Ecubo consultancy	LCA consultant	0	01/04/2020	Written input	R38
	Contactia	LCA and CF consultant	15,52	01/04/2020	Interview	R39
	Edge consultancy	Senior Sustainability Consultant	12,46	02/04/2020	Interview	R40
	Aspire Sustainability	Co-founder & Director	40,58	06/04/2020	Interview	R41-42
	Aspire Sustainability	Co-founder & Director	0	06/04/2020	Interview	R41-42
	Quentic GmbH	Senior Consultant CR	58,33	21/04/2020	Interview	R43-44
	Quentic GmbH	Head of Partner Management	0	21/04/2020	Interview	R43-44
Auditors	UU - Formely Deloitte	Former Deloitte Auditor	30,41	17/03/2020	Interview	R45
	EuGeos Limited	Accredited Verifier for EPD®	41,58	02/04/2020	Interview	R46
Total:	46	Total:	1019,67			

4. Background chapter

In this chapter there will be a description of the global beer brewing sector. Beer is one of the oldest alcoholic beverages, with early evidence of beer production dating back to the Sumerians in the Middle East around 5000 years ago (Andrews, 2018). Since then a lot has changed and the beer industry has grown consistently to become one of the biggest industries in the world, with the market having reached $500 billion at the end of 2017 (Business Wire, 2019). In recent years, this growth has been driven mainly by developing countries such as Brazil, China, and India. At the same time, growth in traditional markets such as North America and Europe flattened out. All over the world the market share of craft beers is increasing as a result of consumers prioritizing both beer taste and style as well as the green image of craft brewers more (Ness, 2018). Across the sector action is being taken to lighten the environmental burden of beer production. Main areas of focus are reducing material usage in packaging, as well as increasing recycling rates, reducing water usage, increasing wastewater recycling, and lowering energy consumption. Brewing is inherently a water and energy-intensive process, which makes finding ways to reduce the usage of both a sound strategy from a business perspective. Brewers and their suppliers often have a one-way dependency relationship and they are generally bound to each other by economic contracts. Due to this one-way dependency, it is often difficult to include environmentally friendly elements in these contracts without risking losing the supplier (R10). This makes establishing common business goals regarding the environment between the corporate responsibility and other management departments a prerequisite to implement LCSCM (Nishitani et al., 2016).

5. Results

This chapter starts off by presenting the outcome of the stakeholder and document analysis. It will first describe which validity categories were identified, followed by how the categories influence each other. Afterwards each category is described individually, and it will be explained how indicators were translated from the categories. The outcome is then consolidated into the data validity assessment scheme. The chapter moves on to present how the minimum level per indicator is established for the single case study, how Heineken's '*Drop the C'* program scores on the developed criteria scheme and if this meets the established minimum level. Finally, through the assessment of '*Drop the C'*, recommendations will be made as to how Heineken can best improve the validity of their carbon management program.

5.1 Validity categories

From the selective coding process, 16 categories emerged that were rooted in six or more interviews. The evidence for the categories was distributed over the different stakeholder groups (Figure 7). The categories were mentioned in a number of interviews ranging from a minimum of 6 (Allocation) to a maximum of 28 (Goal and Scope) out of the total of 35 interviews. The total number of references per indicator in all interviews combined ranged from 7 (Allocation) to 100 (Verification). Opinions on the validity categories among different stakeholder groups were very consistent. On average every criterium was mentioned by 22 out of 39 interviewees. In total, 82 references were made to one or more of the methodological documents identified and analyzed in this study.

There were no significant contradictions in statements concerning any of the categories. Consultants described criteria in most detail and were able to give the clearest examples both for LCA research as well as for a company specific setting. Most of the consultants had hands on experience with conducting carbon footprint studies for companies, which they referred to frequently. Some interviewees criticized the practice of carbon management overall. They stated that carbon management only focusses on one aspect of sustainability and that it takes away the focus from other sustainability aspects like biodiversity, water scarcity, deforestation and waste pollution (R2; R34). However, when asked if carbon management is an adequate tool to aid carbon reductions, they considered it to be so.

The 'CF – CCF – PCF' category consists of all the references to characteristics of different types of carbon footprints including weak and strong points, and examples of how different carbon footprints can or should be calculated. The 'Allocation' category solely consists of references stating how allocation is still a hot topic in carbon management that causes problems. The problem that occurs is when there are factories in the supply chain that produce multiple products that are not all part of the carbon footprint under consideration (e.g. Coca Cola cans and Heineken cans). In this case it would be wrong to assign all the emissions to only a share of the products that are being produced in the factory. Therefore, allocation of the emissions needs to happen to the different products. This is a process that generates a lot of discussion. This discussion however falls outside of this research focus. The 'CF – CCF – PFC' and 'Allocation' categories helped to get a deeper understanding of carbon management at companies but are not directly related to validity assessment of carbon management programs. Therefore, they were not considered during the validity scheme development. The remaining 14 categories are directly related to data validity and will from here on be referred to as validity categories.

There were significant differences in the informational density of the interviews. The interviews in the stakeholder groups of Auditors, Consultants and Heineken relatively had the highest informational density. Followed by the interviews with Knowledge Institutions, NGOs, and Supply chain. Interviews with the Sector and the Government relatively contained the least informational density.

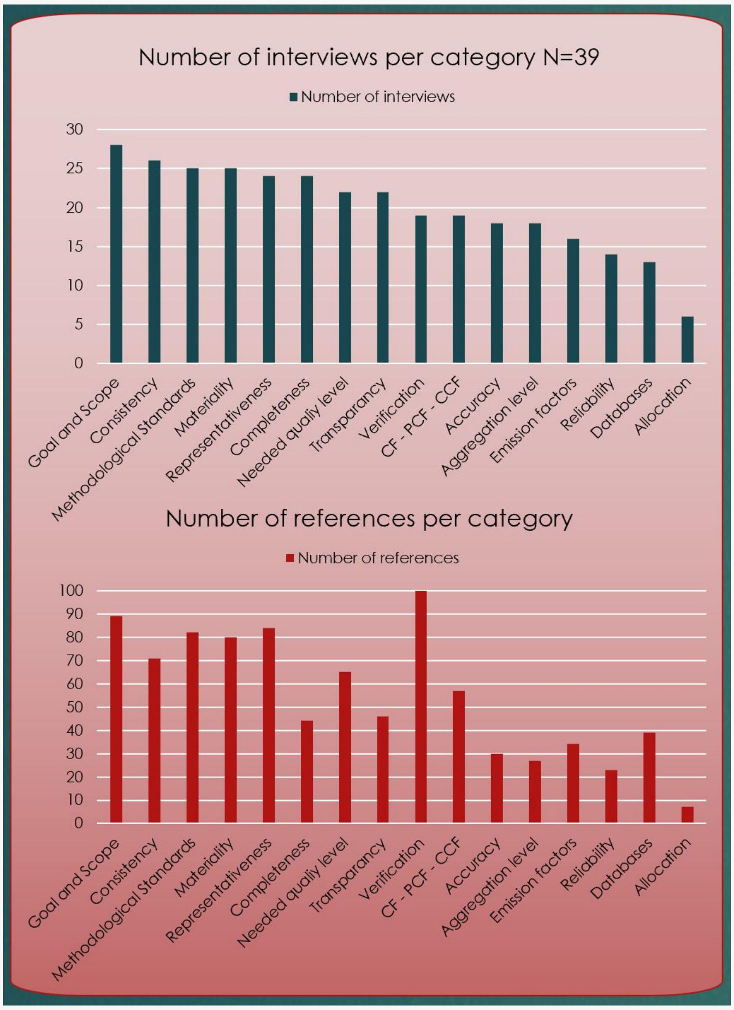


Figure 7: Graph showing the number of interviewees that mentioned the main coding categories (top), graph showing the number of references of the main coding categories (bottom)

5.2 Data analysis: Interplay of validity categories

Figure 8 shows how during the analysis the fourteen validity categories have been divided in three tiers. Tier 1 consists of the two highest level categories: consistency and transparency. These are important to consider at every stage of the validity assessment and for that reason influence all Tier 2, 3A, and 3B categories. The second tier consists of aggregation level and needed level of data validity. Both these categories revolve around a specific level that needs to be reached which is dependent on the context of the validity assessment. Tier 3A contains the categories that collectively make up the aforementioned context and therefore have a direct effect on the Tier 2 categories. Finally, Tier 3B consists of all the categories that are directly related to the data validity of the primary and secondary data that the company collects for their carbon management program. A summary of the full coding scheme can be found in Appendix B.

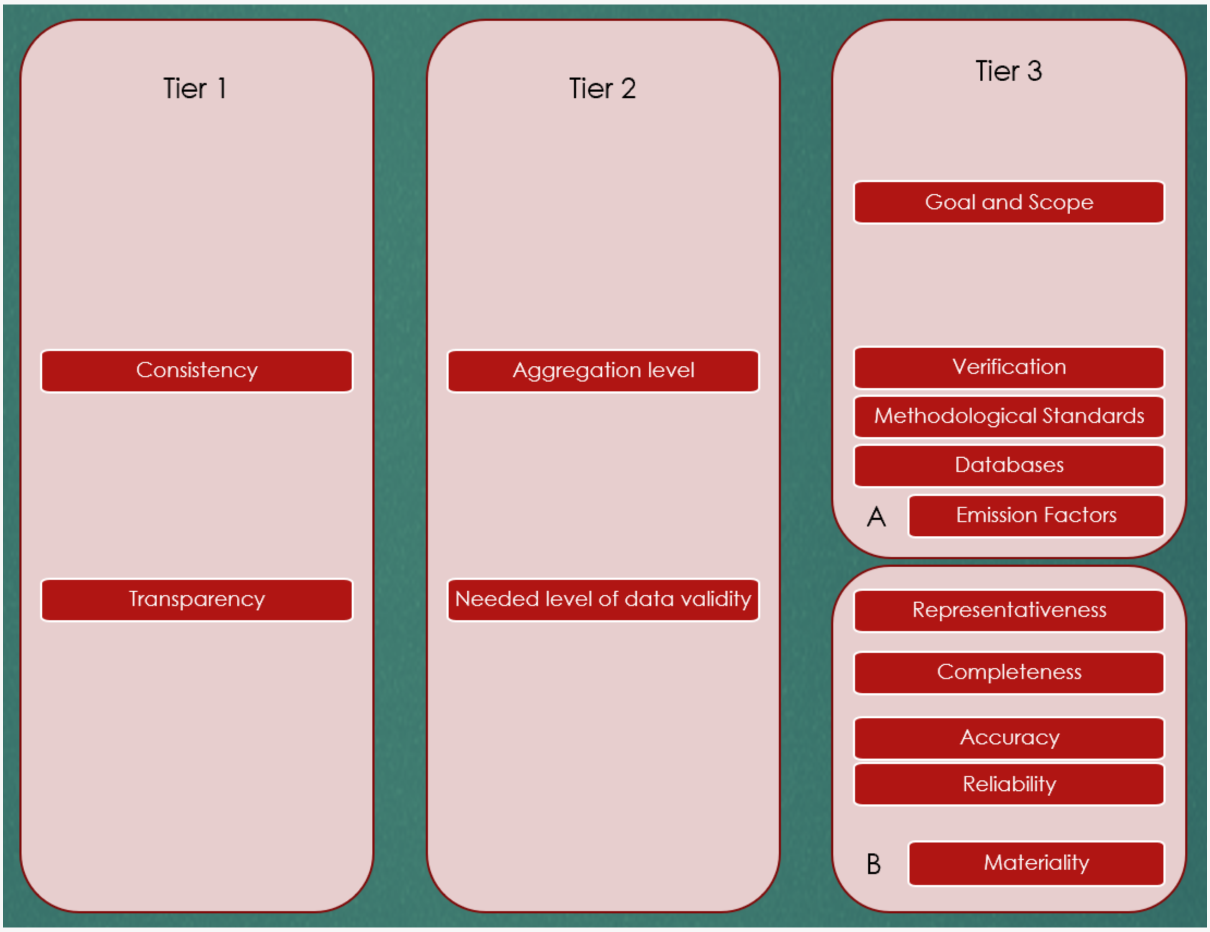


Figure 8: Division of the 14 validity categories over three tiers.

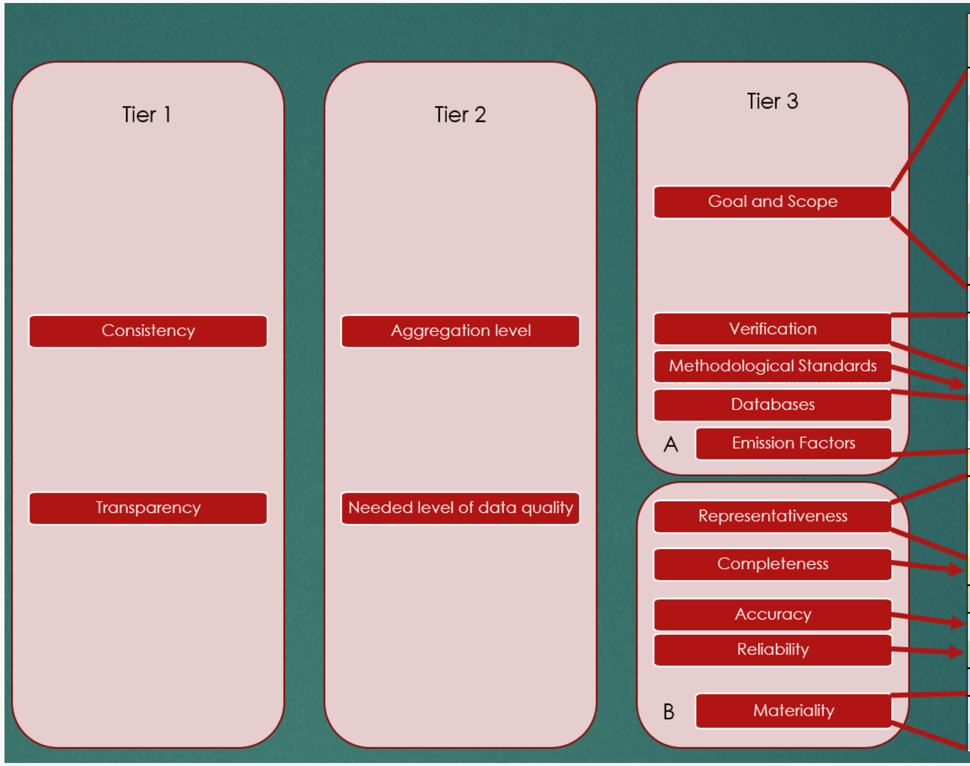
5.3 From validity categories to indicators

The combined results of the stakeholder and document analysis have been brought together in one validity criteria scheme. The 14 validity categories have been translated into 21 indicators that were identified as relevant for data validity assessment of supply chain carbon emissions. In Figure 9, the red lines and arrows originating from the Tier 3A and 3B categories show which indicators have emerged from these categories. The three columns under 'Values' show how the indicators can be assessed overall as well as on consistency and transparency. Furthermore, three columns are added under 'Scope' to show whether an indicator concerns a procedure and/or data and if all of the supply chain sections need to be assessed individually for this indicator or if it suffices to only assess the program overall. The indicators can be grouped in five main themes: Complete goal and scope disclosure, In- and external verification, Representativeness, Data accuracy and reliability, and Materiality. The following paragraphs will cover each of the validity categories and describe how they are translated into one or more indicators. For each of the indicators, criteria have been established that can be used for the assessment of the measuring construct of a carbon management program. This will be used to answer the main research question *'What are appropriate criteria to assess the validity of the measuring constructs of carbon management programs?'*.

5.3.1 Consistency

Companies evolve over time; they acquire new business and at the same time they can sell parts of their own business. This can have a major impact on the consistency and comparability of the CCF on a year to year basis (R10; R17; R26). A company needs to account for that to try and keep the consistency as high as possible. When acquiring new business this is often challenging because emission data from previous years might not be available, meaning that the benchmark cannot be recalculated. The company can choose to use benchmark data for the acquired business to recalculate the baseline year or they can choose to exclude the acquired business from the baseline and disclose on this (R10). Both have an impact on the comparability of the reference year to the baseline and should therefore be assessed (R34).

An important notion was that the aim for consistency in the disclosed data should not outweigh continuous improvement of the carbon footprint (R18). This means that when an improvement in for instance data accuracy or representativeness can be realized, this should be done despite it lowering the consistency compared to previous years. This validity criterium is incorporated into the validity criteria scheme as an aspect that needs to be assessed for all indicators. It forms one of the three assessment columns in Figure 9. For all the indicators it should be assessed if the information on which the assessment is based is considered to be consistent compared to the baseline year and/or previous years.



Complete goal and scope disclosure	Values			Scope		
	Overall	Concistency	Transparancy	Procedures	Data	Per Section
[1] Intended audience and purpose of activity	Yes/No	Yes/No	Yes/No	X	X	
[2] Disclosure methodology	Yes/No	Yes/No	Yes/No	X		X
[3] Reference- and baseline period	Yes/No	Yes/No	Yes/No	X		
[4] Reference- and baseline system boundaries	Yes/No	Yes/No	Yes/No	X		
[5] Reference- and baseline system completeness	Yes/No	Yes/No	Yes/No	X		
[6] Reference- and baseline technology	Yes/No	Yes/No	Yes/No	X		X
[7] Reference- and baseline functional unit	Yes/No	Yes/No	Yes/No	X		
[8] Reference- and baseline disclosure volume	Yes/No	Yes/No	Yes/No	X		
In- and external verification						
[1] Internal verification process	1..3	Yes/No	Yes/No	X		X
[2] External verification process	1..2	Yes/No	Yes/No	X		
[3] Methodological documentation	1..3	Yes/No	Yes/No	X		X
[4] Data aquirement documentation	1..3	Yes/No	Yes/No	X		X
[5] Assumption justification	1..3	Yes/No	Yes/No	X		X
Representativeness						
[1] Technological representativeness	1..3	Yes/No	Yes/No		X	X
[2] Temporal representativeness	1..3	Yes/No	Yes/No		X	X
[3] Geographical representativeness	1..3	Yes/No	Yes/No		X	X
[4] Completeness of data coverage	1..3	Yes/No	Yes/No		X	X
Data accuracy and reliability						
[1] Accuracy of the data	1..3	Yes/No	Yes/No		X	X
[2] Reliability of the data	1..3	Yes/No	Yes/No		X	X
Materiality						
[1] System boundaries in line with goal and scope	1..3	Yes/No	Yes/No	X		X
[2] Disclosed carbon footprint in line with goal and scope	1..3	Yes/No	Yes/No	X		

Figure 9: Translation of validity categories into validity criteria indicators. The middle column 'Values' shows how the indicator can be assessed. The column to the right 'Scope' shows if an indicator is related to procedures and/or the data as well as if the indicator should be applied on the carbon management program overall or also for each supply chain section individually.

5.3.2 Transparency

In multiple contexts throughout the interviews, references to the importance of transparency were made. It is for instance important to transparently disclose the quality of the acquired data (R3; R16; R34; R40; R46), how the data is acquired (R5; R14; R24-25), which assumptions are made (R10; R11; R13), which methodology is used (R16; R19; R45), and how the validity of the report is assured. This is important because it allows auditors to do their job properly and at the same time shows the general public how the carbon footprint is established which allows a complete picture to be formed (R43-44). Furthermore, it is also important to disclose all the above in a transparent manner to be able to engage the organization and assure that the responsible managers can buy into the reduction targets (R5; R17). In other words, transparency is important throughout the entire process of the measuring activity. For this reason, transparency makes up another one of the three assessment columns under 'values' in Figure 9, next to the columns 'overall' and 'consistency', and it needs to be assessed for all the 21 indicators individually.

5.3.3 Aggregation level

The preferred aggregation level differs among audiences (R46). An interviewee explained that if you are reporting to a global audience, reporting in a complete way on the right aggregation level is important. Because general public will be interested in the whole picture. On the other hand, if you are talking to a local NGO, they will more likely be interested in all the emissions that are impacting them, on a local disaggregated level (R43-44). The right aggregation level depends on the contextual information as collected through the eight indicators under complete goal and scope disclosure. Usually, methodological standards prescribe the desired aggregation level, making this level case specific. Aggregation level can range from very aggregated (e.g. only compiling emissions for entire OpCos), to very disaggregated (collecting data for all individual emission streams). The desired aggregation level will be established in '5.4 Minimum validity level establishment'. This level in turn influences the needed level of data validity for the indicators under 'representativeness' and 'accuracy and reliability'.

5.3.4 Needed level of data validity

Various interviewees mentioned that when you are assessing the data validity of CM activities, it should not be forgotten that the goal is to reduce the carbon footprint. Not to end up with a perfect data set (R2; R34; R41-42; R43-44). The purpose of carbon management is, as mentioned before, to get insight in your emissions to enable you to execute reduction strategies effectively. What gets measured, gets done is how interviewees put it (R16; R45). Data needs to be 'fit for purpose', meaning that there is no one size fits all when data validity is concerned (R18; R37; R43-44; R45; R46). The data only needs to be of sufficient quality to capture the effects of reduction strategies. What this level of quality is, depends on the chosen aggregation level. This does however not mean that you cannot establish a minimum level of data validity. Only, this minimum level needs to be case specific instead of generic. With this case specificity comes the importance to get a clear and complete picture of the context of the measuring activity. This picture is needed for the validator to establish the needed level of data validity and overall validity (R36; R45; R46). This will have to be determined and considered for all the emissions streams that are in scope when the minimum level for the indicators under 'representativeness' and 'accuracy and reliability' are set, which will be done in paragraph 5.4.

5.3.5 Goal and scope

To know which data validity is needed, first it needs to be clear what the goal and scope of the measuring activity is (R2; R3; R34; R36; R43-44; R45). The goal refers to the aim of the carbon management program. This aim is usually to provide insight into the magnitude of the companies' carbon emission sources that allow the company to take adequate reduction measures (R5; R17). The scope of the measuring activity refers to the boundaries of the program. The scope shows which emission streams are taken into consideration in the measuring activity and which ones are left out (R10; R13; R18; R22).

Another important reason for all contextual information to be disclosed and incorporated when establishing the minimum validity level for the assessment, is that in a qualitative assessment exercise, subjectivity cannot fully be avoided (R18; R43-44). By clearly disclosing on which information the minimum level is based, you allow the audience of the assessment to form an opinion on the level of subjectivity (R43-44).

The first contextual aspect to identify is the intended audience. Who will be looking at the results of the data, and what do they want to see? In the case of CCF measurement and reporting, this audience is twofold. Firstly, companies are exposed to increasing amounts of pressure to reduce their emissions from external stakeholders like governments, investors, NGOs and society as a whole (R13; R43-44). As a response, many companies are setting their own targets (R5; R16; R17; R19; R20) or they intend to comply with targets set in the sector (R24-25). At the same time, to mitigate the pressure exerted on the company, progress towards the set targets needs to be communicated in a clear and transparent way (R5; R34; R43-44).

One interviewee experienced that if he could measure emissions in a way that was relevant to people in the business, the chance of making progress towards reduction targets was higher (R17). Another interviewee mentioned that it is important to have a tool in place that can help to drive the sustainability agenda (R5). Both refer to the second audience, internal company stakeholders, the employees ultimately responsible to achieve carbon emission reduction.

Table 6: Complete goal and scope disclosure related indicator description and assessment.

Complete goal and scope disclosure		
[1] Intended audience and purpose of measuring activity		
Description	**Transparancy**	**Scope**
The group(s) of people to which the measuring activity is intended to be communicated towards.	Yes/No	Procedures & Data
Assessment	**Consistency**	**Scoring**
If stated: Yes, otherwise: No.	Yes/No	Text
[2] Disclosure methodology		
Description	**Transparancy**	**Scope**
The methodological standard(s) with which the measuring activity is aligned with.	Yes/No	Procedures & Per Section
Assessment	**Consistency**	**Scoring**
If stated: Yes, otherwise: No.	Yes/No	Text
[3] Reference- and baseline period		
Description	**Transparancy**	**Scope**
The period of time that is considered for both the reference- and the baseline period.	Yes/No	Procudures
Assessment	**Consistency**	**Scoring**
If stated: Yes, otherwise: No.	Yes/No	Text
[4] Reference- and baseline system boundaries		
Description	**Transparancy**	**Scope**
The system boundaries that are considered for both the reference and the baseline.	Yes/No	Procedures
Assessment	**Consistency**	**Scoring**
If stated: Yes, otherwise: No.	Yes/No	Text
[5] Reference- and baseline system completeness		
Description	**Transparancy**	**Scope**
The degree of coverage that is reached for the system within the reference- and baseline system boundaries.	Yes/No	Procedures
Assessment	**Consistency**	**Scoring**
If stated: Yes, otherwise: No.	Yes/No	Text
[6] Reference- and baseline technology		
Description	**Transparancy**	**Scope**
The technologies represented in the reference- and baseline system.	Yes/No	Procedures & Per Section
Assessment	**Consistency**	**Scoring**
If stated: Yes, otherwise: No.	Yes/No	Text
[7] Reference- and baseline functional unit		
Description	**Transparancy**	**Scope**
The functional unit used for the reference and the baseline.	Yes/No	Procedures
Assessment	**Consistency**	**Scoring**
If stated: Yes, otherwise: No.	Yes/No	Text
[8] Reference- and baseline disclosure volume		
Description	**Transparancy**	**Scope**
The total volume for which the carbon emissions are disclosed for both the reference- and the baseline system.	Yes/No	Procedures
Assessment	**Consistency**	**Scoring**
If stated: Yes, otherwise: No.	Yes/No	Text

The same interviewee pointed out that if you can find a single way of communication that satisfies all stakeholders, that would be ideal. However, he also stated that this comes with certain challenges (R17). The main challenge is that certain stakeholder groups demand of companies to report in a specific way. The UK government is an example of a stakeholder group that demands reporting in a specific way. They want companies to report emissions per unit of profit or revenue. Whereas most companies prefer to report emissions per volume sold. The latter is better comprehendible for the general public, one of the other audiences (R17).

Once the intended audience is identified, it is then important to set a fitting goal and scope. Usually the goal and scope are set in accordance with one or more reporting standards. For carbon measurement, the main reporting standards are the Product Environmental Footprint Category Rule (PEFCR) and the GHGP (R1; R9; R22; R26; R34; R36; R39). For the former, sectoral interpretations exist (R9). In total, 18 different standards, guidance documents or other type of methodology related documents were referred to during the interviews as suggestions to investigate for validity indicators. Table 6 contains the eight indicators that are identified in the 15 methodological standards that were accessible for this research in relation to the goal and scope. This table and the tables to follow for the remaining indicators all contain a brief description of the indicator, what the scope of the indicator is as well as how it can be assessed and scored based on text and yes/no answers or numerical values. In the case of numerical values, the table includes the criteria on which the value can be determined. These eight indicators are considered necessary and sufficient for a validator to establish the needed data validity and aggregation level. This was based on their occurrence frequency in the methodological documents as well as their collective ability to provide a full contextual picture for a validator.

5.3.6 Verification

In corporate settings when it comes to carbon management, often nobody assesses the data validity, everyone focusses on getting the data (R14; R16). It is however very important for companies that their audience considers the carbon footprint to be a reliable and valid representation of the companies' impact (R34; R43-44).

Internal verification process

Verification improves the reliability of data (R43-44; R45; R46). Every intervention step increases the risk of additional errors in a dataset (R5). Therefore, the more manual intervention happens in the data flow, the more verification is needed to assure data reliability (R45). Table 7 contains the description of this indicator and how it can be assessed. Furthermore, verification can also guarantee that the data acquirement methodology stays in line with the reporting methodology (R9; R38; R41-42).

Table 7: Internal verification process indicator description and assessment.

[1] Internal verification process		
Description	**Transparancy**	**Scope**
The degree to which the internal data verification procedures of the main company in scope are dependable.	Yes/No	Procedure & Per Section
Assessment	**Consistency**	**Scoring**
1. Measurement(s) validated by at least two internal employees, with documented method, compliant with relevant standard(s).	Yes/No	1..3
2. Measurement(s) validated by one internal employee, with documented method, compliant with relevant standard(s).		
3. Unverified measurement(s)		

External verification process

External verification is only relevant when the intended audience of the measurement activities is outside of the main organization (R41-42). In that case external verification increases data reliability (R21; R30; R31-32-33; R38). As one interviewee mentioned *"People get upset about paying money to people to verify. I don't quite know why, if you want a good answer, you need it to be checked"* (R46). The reliability of the carbon footprint increases through external verification because it takes away the possibility of the verification process being biased (R43-44). For this to be the case however, it is important that the party conducting the audit is in no way directly linked to the company (R45). Table 8 contains the description of the external verification indicator and how it can be assessed. At the same time, it is impossible for a validator to check if all the data has been verified. Given the fasts amounts of data that go into the CF of a company the size of Heineken, it would be way too time intensive and thus costly to let an external validator go over all the data. Instead the internal verification procedures can be looked at. This allows the auditor to indirectly check the reliability of the data (R45).

Table 8: External verification process indicator description and assessment

[2] External verification process		
Description	**Transparancy**	**Scope**
The degree to which the external data verification procedure of the main company in scope are dependable.	Yes/No	Procedure
Assessment	**Consistency**	**Scoring**
1. Third party verified measurement(s), by an independend and accredited verification entity, with documented method, compliant with relevant standard(s).	Yes/No	1..2
2. Measurement(s) not verified by independend and accredited third party.		

5.3.7 Documentation

For the sake of transparency as well as to facilitate consistency in methodology and data acquirement over the years, adequate documentation is important. This should include the organizations carbon footprint methodology, which databases and emission factors are used as well as the means of primary data acquirement in a precise manner (R1; R5; R6). Table 9 and 10 contain the description of the three indicators in which these three validity categories were translated as well as the criteria that can be used to assess them. A single source of truth, meaning that everything can be found in a single place, can help to improve the transparency (R5). All of this becomes even more important with an increasing company size. Big companies usually split their supply chain in different sections (e.g. agriculture, raw material processing, production, …) to be able to keep a good overview (R5; R17; R20; R24-25). For some of these sections, supplementary methodologies exist. These methodologies are aimed to cover specific means of data acquirement and calculations that are only applicable to that part of the supply chain (Greene & Lewis, 2019). For this reason it is often helpful to have separate sections or methodological documents for each section of the supply chain (R5).

Table 9: Methodological and data acquirement documentation indicators description and assessment.

[3] Methodological documentation		
Description	**Transparancy**	**Scope**
The degree to which the overall methodology as well as any specific extra methodology per category are fully documented.	Yes/No	Procedure & Per Section
Assessment	**Consistency**	**Scoring**
1. The overall methodology as well as any specific extra methodology per category are fully documented. **2.** The overall methodology as well as any specific extra methodology per category are documented. Some parts are not complete or missing, however company shows continues improvement over the years. **3.** The overall methodology as well as any specific extra methodology per category are poorly documented.	Yes/No	1..3
[4] Data acquirement documentation		
Description	**Transparancy**	**Scope**
The degree to which the means of data acquirement per category are fully documented.	Yes/No	Procedure & Per Section
Assessment	**Consistency**	**Scoring**
1. The means of data acquirement per category are fully documented. **2.** The means of data acquirement per category are documented. Some parts are not complete or missing, however company shows continues improvement over the years. **3.** The means of data acquirement per category are poorly or not at all documented.	Yes/No	1..3

Assumption justification

Making assumptions when collecting carbon emission data from across a supply chain is inevitable (R1; R3; R10; R12; R13; R16; R45). This however does not have to impact the validity of the carbon footprint if the assumptions are justified, and if these justifications are documented in a transparent way (R2; R34; R38).

Table 10: Assumption justification indicator description and assessment.

[5] Assumption justification		
Description	**Transparancy**	**Scope**
The degree to which the assumptions made per category are fully documented and justified.	Yes/No	Procedure & Per Section
Assessment	**Consistency**	**Scoring**
1. All identified assumptions are fully documented and justified.	Yes/No	1..3
2. Assumptions per category are documented. Some are missing; however, company shows continues improvement over the years.		
3. Assumptions per category are poorly or not at all documented.		

5.3.8 Representativeness

This validity category is translated into three indicators, technological, temporal, and geographical representativeness.

Technological representativeness

Here the mere technological aspect of primary data is covered. It is about if the data measured was measured based on processes that use the same technologies as stated in the goal and scope of the measuring activities (R14; R46), or that average values measured in other processes used to produce the same product are used to represent the emissions of the actual process instead (R35; R36). A process can be carried out using a variety of technologies, older

Table 11: Technological representativeness indicator description and assessment.

[1] Technological representativeness		
Description	**Transparancy**	**Scope**
The degree to which the primary and secondary data reflects the same technologies as stated in the goal and scope of the measuring activities.	Yes/No	Data & Per Section
Assessment	**Consistency**	**Scoring**
1. The technologies of the primary and secondary data fully correspond with the real-life situation as stated in the goal and scope of the measuring activity.	Yes/No	1..3
2. The technologies of the primary and secondary data do not fully correspond with the real-life situation as stated in the goal and scope of the measuring activity.		
3. The technologies of the primary and secondary data do not correspond with the real-life situation as stated in the goal and scope of the measuring activity.		

technologies usually are less efficient and will result in higher emissions (R2; R10; R13; R35; R46). This can result in a discrepancy between the amount of emissions the data show and the amount that is emitted in the real-life situation (R46). This first form of representativeness is most relevant if the carbon footprint calculations are not based on primary activity data since in that case finding secondary data representing the exact same combination of technologies as the real-life situation is rare (R41-42). Table 11 contains the description of the indicator that resulted from this category as well as the criteria that can be used to assess it.

Technological representativeness is especially relevant for companies aiming to improve their carbon footprint. Abatement measures commonly involve the application of newer technologies (R46). Companies actively tender suppliers that employ more efficient technologies in their processes (R6). This makes it important to have the exact technologies represented in your data to capture progress (R17).

Temporal representativeness

The importance of temporal representativeness depends heavily on the measuring activity. As (R46) pointed out *"Something that is quite difficult to deal with is the idea of temporal correlation, …, there are processes in the economy which are almost unchanged for 20 or 30 years. Operating a quarry really has not changed a lot. Because there is nothing much to change. Operating a plant that produces let's say, hard disk drives, this has probably changed enormously in like the last 5 years. Even within things that you think are required in a standard, that are easy to deal with, still temporal correlation is quite tricky. When does it matter, when does it not matter?"*.

The answer to this question is that it always matters when a corporate carbon footprint is concerned. Companies are not stagnant. Production volumes differ depending on the demand for their products (R10). In supply chain spheres therefore, data quickly gets outdated and will represent the real-life situation to a lesser extent. For this reason, it is important to know the age of the data to get a good idea of how well it still represents the real situation (R13).

Table 12: Temporal representativeness indicator description and assessment.

[2] Temporal representativeness		
Description	**Transparancy**	**Scope**
The degree to which the primary and secondary data reflects the same period as stated in the goal and scope of the measuring activity.	Yes/No	Data & Per Section
Assessment	**Consistency**	**Scoring**
1. The period of the primary and secondary data fully corresponds with the period stated in the goal and scope.		
2. The period of the primary and secondary data does not fully correspond with the period stated in the goal and scope.	Yes/No	1..3
3. The period of the primary and secondary data does not correspond with the period stated in the goal and scope.		

Table 12 contains the description of the indicator in which this category is translated as well as the criteria that can be used to assess this indicator. For companies, gathering yearly up to date primary activity data is usually not a problem within their own operations (R14; R19; R20; R23; R24-25).

However, when data needs to be gathered for parts of the supply chain outside of the company's own direct control, it gets more difficult (R13; R17; R23). For instance, in logistics, the subcontractors that Heineken employs, need to gather data for emissions resulting from heating of warehouses. This data needs to be collected from many different entities from which Heineken rents these warehouses. This quickly becomes a time consuming exercise (R13). Secondary data can often be updated less frequently because its representativeness usually does not decline as fast (R29; R30). Whether this is the case does need to be assessed for all the used secondary data. In the case of secondary data, sometimes it is also not possible to get up to date data. If you for instance look at national glass or PET recycling rates (used for the end of life calculations of the carbon footprint), these statistics are published on a yearly basis, lagging behind approximately 3 years (R14).

Geographical representativeness

The geographic location of where the data has been measured can have an influence on the representativeness for several reasons. Regional climate conditions, production conditions and average level of employee training are examples of variables that can significantly influence emission factors for a geographical area. In one of the interviews (R11; R13; R18; R37), this significance was illustrated with the following example *"[…] if you buy barley in Brazil or France, the difference is a factor 10. Because in Brazil deforestation is considered, which results in a lot of extra emissions"* (R11). Table 13 contains the description of the indicator in which this category is translated as well as the criteria that can be used to assess this indicator.

Table 13: Geographical representativeness indicator description and assessment.

[3] Geographical representativeness		
Description	**Transparancy**	**Scope**
The degree to which the primary and secondary data reflects the same geographic locations as stated in the goal and scope of the measuring activities.	Yes/No	Data & Per Section
Assessment	**Consistency**	**Scoring**
1. The geographic location of the primary and secondary data fully corresponds with the geographic location stated in the goal and scope.	Yes/No	1..3
2. The geographic location of the primary and secondary data does not fully correspond with the geographic location stated in the goal and scope.		
3. The geographic location of the primary and secondary data does not correspond with the geographic location stated in the goal and scope.		

5.3.9 Completeness

When collecting data across an entire supply chain, it is impossible to get 100% data coverage. The completeness of data coverage of a specific emission stream is highly dependable on the existence of a carbon management system. If such a system is present, usually almost 100% complete data can be collected. While if it is not present, sometimes it is not feasible to acquire any data at all.

These inevitable gaps in data can be accounted for in several ways. The most common ways are: 1) to use benchmark data, 2) data from previous years, to extrapolate or 3) to exclude the emission streams for which the data is missing (R2). All these ways of accounting for gaps in data have an influence on the carbon footprint validity and should therefore be considered when a validity assessment is made. Primary activity data is always preferred over estimates or industry averages. In the process of data collection, the aim should be to use as few assumptions as possible (R26; R35). This is usually easily achieved when a company's own operations are concerned (R15; R40; R41-42). Table 14 contains the description of the indicator in which this category is translated as well as the criteria that can be used to assess this indicator. The number of unavoidable assumptions increases when the number of third parties that are involved in the data collection process increases (R23). The notion was made that the more complete the sample is, the more representative the carbon footprint results will be (R27-28).

"If you are talking about completeness of data, if you are a company operating at let's say 50 sites around the globe. You have gathered and verified data from 47 sites, so only 3 are missing. Does this prevent you from publishing a sustainability report? It could be, if the missing data is of high importance, for instance if the corporate head office is among the missing ones. However, if they are 3 very small operating companies, then it could be fine to leave them out and make a statement about this. But to be able to do this companies need to be very clear about what they want to achieve with the reporting" (R43-44).

Besides, some interviewees pointed out that for multinational companies there are no valid reasons to miss data for emission sources like the head office in the quote above (R17; R31-32-33; R36; R41-42). It can be that data for material emission sources is missing, but in the case of a multinational company, this can be solved by measuring it (R34). On the other side interviewees mentioned how conducting more measurements is more costly (R26). As well as that companies are not always in the position to demand the needed data from suppliers. This can happen when companies are dependent on suppliers that are not dependent on that company, which results in an unbalanced power relationship (R10; R18). However, these only become valid reasons not to acquire missing data for non-material sources (see 5.3.11) that can be accounted for through extrapolation (R9; R38).

Table 14: Completeness of data coverage indicator description and assessment.

[4] Completeness of data coverage		
Description	**Transparancy**	**Scope**
The degree to which the calculations for the different emissions streams per category of the supply chain are based on primary data.	Yes/No	Data & Per Section
Assessment	**Consistency**	**Scoring**
1. 90% or more of the data of the material emission streams in a category are primary data. The remaining data is accounted for in a valid way.	Yes/No	1..3
2. 60-89% of the data of the material emission streams in a category are primary data. The remaining data is accounted for in a valid way.		
3. Less than 60% of the data of material emission streams in a category are primary data. Or remaining data is not accounted for in a valid way.		

5.3.10 Data accuracy and reliability

The next two validity categories cover the more technical aspects of data validity, the assessment of the measurement accuracy and reliability.

Accuracy of the data

Measurements can be done on different levels of accuracy. Rounding data up to lower levels of accuracy (e.g. from mg to kg) is valid when the additional accuracy exceeds the needed accuracy as stated in the goal and scope of the measuring activity (R12; R14; R43-44; R45; R46). The other way around is a lot trickier to do without misleading your audience, you need to be very clear about the significantly increasing error margins (R43-44; R46). When collecting data from across the supply chain, data is inevitably being measured in a multitude of different units and on different scales. Many conversions are needed, making it is easy to lose the original level of accuracy out of sight (R14). Data should be sufficiently accurate to capture the carbon reductions and enable intended users to make decisions with reasonable confidence that the reported information is credible (GHGP, 2011b).

If for instance a chair manufacturing company has the ambition to lower the carbon footprint of every part of the chair by 10% over the next few years, this company will have to measure the emissions for all parts very accurately and maintain a high level of aggregation throughout the carbon management program. Whereas, if the ambition is instead to lower the overall emissions of the company’s operations by 10% over this same time period, it will suffice for the company to collect aggregated carbon emission data for entire parts of their supply chain. As long as absolute carbon reductions are still captured by these numbers.

Therefore, it is important to check the roots of the data to make sure that the level of accuracy corresponds to, or is higher than, the level of accuracy in which the final carbon footprint is reported and whether this level of accuracy is high enough to capture carbon emission reductions (R15). This way you can ensure that the reported GHG emissions are not systematically higher than or lower than actual emissions and that uncertainties are reduced as far as practicable (R43-44). Table 15 contains the description of this indicator and how it can be assessed.

A key challenge is that increasing accuracy due to continuous improvement of the carbon management in a company, usually causes a carbon footprint to go up. An example of this is when Heineken started to collect actual consumed amounts of fuel for their transportation emissions. This improved the accuracy of their calculations. However, it caused their logistics emissions to go up significantly (R10). Even though it is not supposed to be this way, it is hard to justify an increasing CF to your superior managers when your target is to reduce (R10).

Another challenge arises when you receive weight measures for products from multiple sources, and they do not match. For instance, a supplier states that their delivered cans weigh 10gr each. Yet, when they arrived at the OpCo, they measured the weight to be 8gr. It can be that the batch of cans at the supplier had a coating, whilst the batch that arrived at the operating company did not have a coating. These differences can be important but are very hard to check in retrospect (R14).

Finally, different accuracy levels can be appropriate for different emission streams in the supply chain. In the attended CFBM meeting, a discussion took place where it was mentioned that for many materials like filtration aids, measuring in kgs is appropriate because you are talking about small quantities (R12). Whereas, when barley or malt is concerned, this is not practicable anymore due to the vast volumes. For those materials tons is a more appropriate metric, despite its lower accuracy (R12).

Table 15: Accuracy of the data indicator description and assessment.

[1] Accuracy of the data		
Description	**Transparancy**	**Scope**
The degree to which a sufficient accuracy level is reached to be able to report on the same accuracy level as stated in the goal and scope of the measuring activity.	Yes/No	Data & Per Section
Assessment	**Consistency**	**Scoring**
1. A sufficient accuracy level is reached for all data for all emission streams.	Yes/No	1..3
2. A sufficient accuracy level is reached for all data for all the material emission streams (for a definition of material streams, see 5.3.11).		
3. A sufficient accuracy level is not reached for all the material emission streams.		

Reliability of the data

This specific reliability indicator is most applicable if the main organization collects data from parties that are outside their own direct influence. In these cases, the data collection methods and verification procedures of those third parties can differ from those of the main organization and should therefore be assessed separately (R17; R45). Table 16 contains the description of this indicator and how it can be assessed. What experts in the industry identified is that the data validity from third parties heavily depends on their carbon management maturity (R6; R13; R17; R18). Often, third parties need to manually transfer the data from their own systems into the system of the reporting company. Especially at inexperienced third parties, this manual intervention can lead to errors in the data (R5; R13).

Table 16: Reliability of the data indicator description and assessment.

[2] Reliability of the data		
Description	**Transparancy**	**Scope**
The degree to which the sources, data collection methods, and verification procedures of the organization conducting the measurements are dependable.	Yes/No	Data & Per Section
Assessment	**Consistency**	**Scoring**
1. Measurements from a credible source within own operations or supply chain or measurements from an internationally accepted database or a database prescribed by the relevant standard.	Yes/No	1..3
2. Measurements from a source within own operations or supply chain for whom credibility is likely but uncertain, or measurements from credible but not internationally accepted databases.		
3. (Un)justified estimation or measurements from a noncredible source.		

5.3.11 Materiality

Materiality is a concept within auditing and accounting relating to the significance of an amount, transaction, or discrepancy. Information is material if its omission or misstatement could influence economic decisions made by the audience of the measuring activity (Doxey et al., 2020). As an example, we can take Duco. Duco works in a restaurant where he makes seven hour shifts and earns 10€ per hour (70€ per shift). On top of that he receives two euro per hour in tips (14€ per shift). Duco wants to buy EarPods (cost 150€) before the end of the week. He has decided that he wants to earn all the money for the EarPods through working at the restaurant this week and will take up the exact number of shifts to earn 150€. If Duco only considers his hourly wage, he will conclude that he needs to work three shifts to earn enough money (210€). If, however, Duco also considers the tips he receives, he will only need to work two shifts (168€). The consideration of the tips influences the decision Duco will make. Hence, the tips are material. In this example, the tips would be non-material if it would be only 0.50€ per hour (3.50€ per shift). In that case, Duco would have to take up three shifts regardless of whether he considers his tips. The same applies to CM, where usually a cut off is set at 5%. Every emission source exceeding 5% of the total is considered to be 'hourly wage', and everything smaller than 5% is considered to be '0.50€ per hour tips'.

In carbon management it is important to focus on where it matters (R4; R9; R19; R20; R21; R36; R45). There is the danger of getting into a closed loop where before the purpose is fully known, you want to already know what level of data validity is needed. But you cannot do this without knowing the exact purpose (R43-44; R45; R46). Materiality is the way to break this circle by identifying the purpose of carbon management in such a way that the data validity can be assessed.

System boundaries in line with goal and scope

As mentioned before, the system boundaries need to be described as part of the goal and scope of a measuring activity (R2; R24-25; R46). It then becomes important to strictly stick to those boundaries to avoid misleading your audience (R36). Additionally, when covering different stages of the supply chain, setting strict system boundaries and sticking to them is paramount to avoid double counting of emissions (R12; R22). Table 17 contains the description of this indicator and how it can be assessed. Finally, to allow comparison of different CF measuring activities, these boundaries need to be aligned with one another. For this reason, guidance on setting system boundaries is provided in the methodological standard you use (R27-28).

Table 17: System boundaries in line with goal and scope indicator description and assessment.

[1] System boundaries in line with goal and scope		
Description	**Transparancy**	**Scope**
The degree to which the system boundaries encompass all significant emission sources as stated in the goal and scope of the measurement activity per category.	Yes/No	Data & Per Section
Assessment	**Consistency**	**Scoring**
1. System boundaries are fully in line with goal and scope.	Yes/No	1..3
2. System boundaries only slightly deviate from goal and scope, deviations are justified.		
3. System boundaries significantly deviate from goal and scope, or slight deviations are not justified.		

Disclosed carbon footprint in line with goal and scope

Within the established system boundaries, it is important to give a comprehensive overview of the emissions for all the included emission streams. A tradeoff exists between data completeness and data validity (R10). Smaller entities are less mature in carbon management and will often not have a dedicated employee with the right training on the job. They report on their emissions once a year, meaning that often it is a retraining exercise for the responsible employee because they have not worked with carbon data for a long time (R12; R17). Therefore, a balance needs to be found between an as complete as possible data coverage and keeping the data validity on a sufficient level. For this reason, the SBTi has set requirements for the data coverage (Linthorst et al., 2015). These are to be used as a minimum data coverage by any organization that commits to SBTi (Linthorst et al., 2015). Table 18 contains the description of this indicator and how it can be assessed. This indicator is not to be confused with 'Completeness of data coverage'. Here it is about the percentage of emissions covered and whether it is in line with the goal and scope. Whereas completeness of data coverage is about the percentage of these covered emissions that are represented by primary data.

Table 18: Disclosed carbon footprint in line with goal and scope indicator description and assessment.

[2] Disclosed carbon footprint in line with goal and scope		
Description	**Transparancy**	**Scope**
The degree to which the carbon footprint encompasses all significant emission sources as stated in the goal and scope of the measurement activity.	Yes/No	Procedure
Assessment	**Consistency**	**Scoring**
1. Materiality level as prescribed by the relevant standard has been reached. (SBTi prescribes at least 95% of emission in own operations (scope 1 and 2) and at least 66.6% of emissions in supply chain (scope 3).	Yes/No	1..3
2. At least 90% of emissions in own operations (scope 1 and 2) are covered, at least 50% of emissions in supply chain (scope 3) are covered.		
3. Less than 90% of emissions in own operations (scope 1 and 2) are covered, less than 50% of emissions in supply chain (scope 3) are covered.		

5.4 Minimum validity level establishment

This section is dedicated to answering the first sub-research question:

Sub-RQ 1. On the developed criteria scheme, what is a legitimate minimum validity level?

The first thing that was mentioned by most of the interviewees when asked for legitimate minimum levels for specific indicators was that it depends on the context (R2; R3; R34; R36; R43-44; R46). During the interview with one of the co-authors of Ciroth et al. (2020), a discussion took place regarding the context in which criteria are applied. He mentioned *"What is the context in which we apply this set of criteria? The big problem is that if you say it is economy wide. Then you start to segment things, for data in this sector a good threshold is 3, for another one it could be 5. It does not seem to be possible to say, an adequate threshold everywhere is A or B"* (R46).

Aggregation level and needed level of data validity

In the case of Heineken, since they are based in Europe, the mandatory disclosure methodology is identified to be the product environmental footprint category rule (PEFCR). This methodology together with its sectoral interpretation for the beer and beverages industry describe which emission sources should be included (BIER, 2018; European Commission, 2018). The latter dedicates a chapter specifically to beer brewers and describes in detail which processes should be included for each supply chain section (BIER, 2018). This means that a high level of disaggregation is expected from brewers if they want to comply with the PEFCR. For Heineken, this will be used as the minimum.

Regarding needed level of data validity this then means that all the collected data needs to be of sufficient quality to give a representative and honest view on all the emission sources mentioned in the sectoral interpretation. This will be leading when setting minimum levels for the data validity related indicators later on.

Complete goal and scope disclosure

To determine what is to be used as a minimum level for a specific assessment, full contextual information is paramount. For this reason, information on all the points under 'Complete goal and scope disclosure' needs to be disclosed by the company. For the intended audience and purpose of the activity, the period, system boundaries, system completeness, technology, functional unit, and disclosure volume, this means that it needs to be aligned with the PEFCR. However, Heineken has recently announced to commit to the SBTi as well, meaning that the audience and purpose of '*Drop the C*' need to align with the intended audience and purpose of this methodology too. The SBTi methodology can be seen as an extension to the PEFCR that is focused at setting ambitious reduction targets calculated through a science-based method. Therefore, this does not change anything for the other seven indicators in this main theme.

In- and external verification

There is a causal relationship between the amount of manual intervention in the data flow and the needed level of validation and verification. The more manual intervention takes place, the more internal validation is needed, and the more important external verification is. In the case of Heineken, the dataflow from suppliers to the '*Drop the C*' databases usually involves two manual interventions (R10). One at the source when the data is put into the system of an OpCo, and one when the data is transferred from the system of the OpCo to Heinekens system (R10). For this reason, it is important that measurements are validated by at least two internal employees, with a documented method, compliant with relevant standard(s) (R46). This documentation is important because it is what external auditors rely on. The auditors that were interviewed explained how it is impossible for them to check all the millions of datapoints behind a program like '*Drop the C'*. Therefore, their audit is based on the carbon management systems and procedures within a company (R45). For this same external auditing, the importance of documentation can be extended to the entire methodology, data acquirement and assumptions. Therefore, the minimum for all three is set at transparent documentation per category. Some parts can be not complete or missing as long as the company shows continuous improvement over the years.

One interviewee mentioned: *"It is really important that the reports you publish are considered trustworthy. To achieve this, you need to put procedures in places to take the eyes away of the company and how they are doing it. Because there is a standard saying how you should do it. This standard is accepted by a certain group of stakeholders that are representing the world of this topic. Otherwise, whatever you would do, it would never be enough"* (R43-44).

With these 'procedures' the interviewee was referring to external verification, because for a company, this is the only way to prove that you have objectively met the requirements of the used standard (R43-44). Which is why the minimum level for external verification is set as third party verified measurement(s), by an accredited and independent verification entity, with documented method, compliant with relevant standard(s).

Representativeness

The high level of complexity in an extensive supply chain of companies like Heineken is acknowledged by the interviewees. The exact corresponding technologies, time periods and geographic locations are always considered to result in the most valid data. However, the interviewees pointed out that this is not always possible for all parts of the supply chain and that for those parts it is important to keep in mind that the goal of carbon management is to reduce carbon emissions and not to measure your emissions perfectly everywhere. Therefore, as a minimum level for technologies, time period and geographic location of the measured data, it does not fully have to correspond with the technologies, time period and geographic location stated in the goal and scope, as long as this and the impact of it is clearly documented. The impact of the lower representativeness should not exceed the point that the progress towards the targets in '*Drop the C'* are not captured by the data anymore, since that would jeopardize the purpose of the program.

Completeness of data coverage is considered very important. The goal of '*Drop the C'* is to show the intended audience the entire CCF and PCF. Once materiality is considered and the company has determined which emission streams are to be measured, this should be done in an as complete fashion as possible. Therefore, for these emission streams, the minimum level is set at 90% or more of the data to be primary data. The remaining data needs to be accounted for in a valid way.

This high level of completeness is chosen for all material streams in '*Drop the C*' considering the importance of these emission streams relative to non-material streams (See example in 5.3.11). Heinekens size and the high carbon management maturity of most of Heinekens top suppliers make it possible to reach this level of completeness. However, in smaller and less mature companies working with small and immature suppliers, this minimum level can be impossible to reach. In that case the minimum level should be adjusted based on the context of that company.

Data accuracy and reliability

Regarding accuracy of the data, clear links are made with materiality. The focus should be on the biggest emission streams, those need to be measured most accurate. For the remaining smaller streams, it should still always be preferred to reach the same accuracy as for the material streams. However, the use of average data and justified estimates are more accepted here. Therefore, as a minimum level, a sufficient accuracy only needs to be reached for all data representing all the material emission streams (See 5.3.11).

In a dynamic company like Heineken, the supplier base is constantly evolving. In 2019, the number of suppliers that were added and removed from the supplier base exceeds 10.000 (R14). It is impossible to guarantee and validate the credibility of the carbon emission data provided by all the suppliers in a supplier base that evolves so rapidly. All these suppliers are involved in the production of over 300 different kinds of beers, ciders, and soft drinks. In these production processes, many adjuncts are involved for which emission factors cannot be found in internationally accepted databases like EcoInvent (R18). This led to the minimum level being set at measurements from a source within own operations or supply chain for whom credibility is likely but uncertain, or measurements from credible but not internationally accepted databases. Nonetheless, putting in effort to randomly sample suppliers and check their reliability is important and should be part of the internal verification procedure.

Consistency is identified as the key indicator to assure comparability over the years and with other PCFs. CCFs should not be compared with one another since companies always differ in size and their absolute emissions cannot directly be linked to their performance. Yet, they can be compared to CCFs of the same company in the past to track improvements in performance over time. To assure that you keep comparing apples with apples, and not apples with oranges or pears, a high level of consistency needs to be achieved. Therefore, the disclosed data needs to be at least 95% consistent with the baseline and relative to previous years, or additional percentage of changes in disclosed data represents justified improvements compared to the baseline (e.g. if data becomes available for the first time for an emission source >5% of the total, the inclusion of this data represents an improvement of the CF compared to the baseline and previous year and is justified).

Materiality

The system boundaries need to be in line with the goal and scope of '*Drop the C*'. Since the program is aligned with the PEFCR methodology, the system boundaries need to be aligned with this methodology too. However, the PEFCR states regarding the system boundaries that these can differ for specific companies. Deviations from the system boundaries stated in the category rule are accepted if they are clearly disclosed and justified in the company methodology.

In the case of Heineken, for the disclosed CF to be in line with the goal and scope, it needs to be both aligned with the PEFCR and the SBTi. The PEFCR does not state requirements for materiality of the CF, it only covers how the CF should be measured and which sources should be accounted for. The SBTi, since it is focused on setting science based targets for a company, does have clear requirements regarding the materiality of the CF. SBTi prescribes to include at least 95% of emission in own operations (scope 1 and 2) and at least 66.6% of emissions in supply chain (scope 3). Hence, this is used as a minimum level for '*Drop the C*'. This is the last indicator for which a minimum level had to be established. An overview of all the established minimum levels per indicator is shown in Table 19.

Table 19: Data validity criteria scheme with minimum levels.

Complete goal and scope disclosure	Min. Values			Scope		
	Overall	Concistency	Transparancy	Procedures	Data	Per Section
[1] Intended audience and purpose of activity	PEFCR/SBT	Yes	Yes	X	X	
[2] Disclosure methodology	PEFCR	Yes	Yes	X		X
[3] Reference- and baseline period	Yes	Yes	Yes	X		
[4] Reference- and baseline system boundaries	Yes	Yes	Yes	X		
[5] Reference- and baseline system completeness	Yes	Yes	Yes	X		
[6] Reference- and baseline technology	Yes	Yes	Yes	X		X
[7] Reference- and baseline functional unit	Yes	Yes	Yes	X		
[8] Reference- and baseline disclosure volume	Yes	Yes	Yes	X		
In- and external verification						
[1] Internal verification process	1	Yes	Yes	X		X
[2] External verification process	1	Yes	Yes	X		
[3] Methodological documentation	2	Yes	Yes	X		X
[4] Data aquirement documentation	2	Yes	Yes	X		X
[5] Assumption justification	2	Yes	Yes	X		X
Representativeness						
[1] Technological representativeness	2	Yes	Yes		X	X
[2] Temporal representativeness	2	Yes	Yes		X	X
[3] Geographical representativeness	2	Yes	Yes		X	X
[4] Completeness of data coverage	1	Yes	Yes		X	X
Data accuracy and reliability						
[1] Accuracy of the data	2	Yes	Yes		X	X
[2] Reliability of the data	2	Yes	Yes		X	X
Materiality						
[1] System boundaries in line with goal and scope	2	Yes	Yes	X		X
[2] Disclosed carbon footprint in line with goal and scope	1	Yes	Yes	X		

5.5 Scoring Drop the C

Information on '*Drop the C*' related to all the 21 indicators was collected and can be found in Appendix C. Based on this information, the program was scored according to the established minimum validity level per indicator. The outcome is summarized in Table 20, where you can see how the program scored overall as well as for the 6 supply chain sections individually where relevant.

Table 20: Scoring table of the Drop the C program, red shows major insufficiencies and yellow shows minor insufficiencies. S stands for score, C for consistency and T for transparency. For fields containing N/A, it is not applicable to assign a score for the specific supply chain sections.

Complete goal and scope disclosure	Overall			Supply Chain Section: Agriculture			Raw materials processing			Beverage production			Packaging materials			Logistics			Cooling		
	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T
[1] Intended audience and purpose of activity	Missing	No	No		N/A			N/A			N/A			N/A			N/A			N/A	
[2] Disclosure methodology	GHGP (3) | PEFCR | SBTi	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes
[3] Reference- and baseline period	Yes	Yes	Yes		N/A			N/A			N/A			N/A			N/A			N/A	
[4] Reference- and system boundaries	Yes	Yes	Yes		N/A			N/A			N/A			N/A			N/A			N/A	
[5] Reference- and baseline system completeness	Yes	Yes	Yes		N/A			N/A			N/A			N/A			N/A			N/A	
[6] Reference- and baseline technology	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
[7] Reference- and baseline functional unit	Yes	Yes	Yes		N/A			N/A			N/A			N/A			N/A			N/A	
[8] Reference- and baseline disclosure volume	Yes	Yes	Yes		N/A			N/A			N/A			N/A			N/A			N/A	
In- and external verification																					
[1] Internal verification process	1	Yes	No	1	Yes	No	1	Yes	No	1	Yes	No	1	Yes	No	1	Yes	No	1	Yes	No
[2] External verification process	1	Yes	Yes		N/A			N/A			N/A			N/A			N/A			N/A	
[3] Methodological documentation	1	Yes	Yes	1	Yes	Yes	1	Yes	Yes	1	Yes	Yes	1	Yes	Yes	1	Yes	Yes	1	Yes	Yes
[4] Data aquirement documentation	3	Yes	No	3	Yes	No	3	Yes	No	1	Yes	Yes	3	Yes	No	3	Yes	No	1	Yes	Yes
[5] Assumption justification	3	No	No	2	Yes	No	3	Yes	No	1	Yes	Yes	2	Yes	No	3	No	No	3	Yes	No
Representativeness																					
[1] Technological representativeness	1	Yes	Yes	2	Yes	Yes	1	Yes	Yes	1	Yes	Yes	1	Yes	Yes	2	Yes	Yes	1	Yes	Yes
[2] Temporal representativeness	1	Yes	Yes	1	Yes	Yes	1	Yes	Yes	1	Yes	Yes	1	Yes	Yes	1	Yes	Yes	1	Yes	Yes
[3] Geographical representativeness	1	Yes	Yes	2	Yes	Yes	1	Yes	Yes	1	Yes	Yes	1	Yes	Yes	1	Yes	Yes	1	Yes	Yes
[4] Completeness of data coverage	1	Yes	No	1	Yes	No	1	Yes	No	1	Yes	Yes	1	Yes	No	1	Yes	No	1	Yes	No
Data accuracy and reliability																					
[1] Accuracy of the data	2	Yes	Yes	3	Yes	Yes	2	Yes	Yes	2	Yes	Yes	2	Yes	Yes	2	Yes	Yes	2	Yes	Yes
[2] Reliability of the data	2	Yes	Yes	2	Yes	Yes	2	Yes	Yes	1	Yes	Yes	2	Yes	Yes	2	Yes	Yes	2	Yes	Yes
Materiality																					
[1] System boundaries in line with goal and scope	1	Yes	Yes	1	Yes	Yes	1	Yes	Yes	3	Yes	No	3	Yes	No	3	No	No	1	Yes	Yes
[2] Disclosed carbon footprint in line with goal and scope	1	Yes	Yes		N/A			N/A			N/A			N/A			N/A			N/A	

5.5.1 Drop the C assessment

This section will be used for a deep dive into Table 20 and will provide a more elaborate description of why the '*Drop the C*' program scored insufficient for specific indicators. This will also provide an answer to the second sub research question, which for convenience sake is repeated below.

Sub-RQ 2. What is the validity of the measuring construct of Heinekens' '*Drop the C*' program?

The measuring construct of '*Drop the C*' is very mature and made a big step forward with the introduction of the HeiCF tool. This tool that allows anyone who is interested to get a good overview of Heineken's carbon footprint, both on companywide and OpCo specific level, boosts the validity of the program by increasing the overall transparency and consistency of the program. A similar level of transparency and consistency was only observed at SuikerUnie. However, all beet farmers supplying SuikerUnie are part of the company and as the SuikerUnie employee pointed out that means that their member farmers are mandated to use their system. In the case of Heineken, when they buy hops for instance, they buy it from traders, and in this process, they do not have access to primary farmers. This makes it very tricky to get the data from the source (R23). Given this high complexity that Heineken needs to deal with in order to collect data throughout their supply chain, they are doing a very good job and show the serious ambition to base their entire CF on primary data within the next few years.

The maturity of '*Drop the C*' is reflected in the scores, overall sufficient scores are obtained for all but one of the indicators in the first main theme, complete goal and scope disclosure. The program scores well for disclosure methodology because the entire program is aligned with the PEFCR. An insufficiency is identified for 'intended audience and purpose of the activity'. In the annual report both the product and company carbon footprint are published. The product carbon footprint is explained as *"The Product Carbon Footprint includes CO_2 emissions from all the activities linked to making and selling our products, through the entire "barley to bar" value chain. … Our model incorporates six phases in the life cycle of a beverage: agriculture, malting and adjuncts, beverage production, packaging, logistics, cooling."* (Heineken, 2019a).

The Company carbon footprint is explained as *"In the alignment with Science Based Targets Initiative we extended our Product Carbon footprint into a Company Carbon Footprint. Compared to our Product Carbon Footprint, the Company Carbon Footprint includes 'other carbon emissions' that are relevant. These other emissions represent in total 12% to the Company Carbon Footprint"* (Heineken, 2019a).

The statement made regarding Heinekens goal is that they are committed to reducing the impact across the entire value chain by 2030, in line with the SBTi. However, the only target mentioned in the *'Drop the C'* section of the 2018 annual report is to have 70% renewable energy in production by 2030 (Heineken, 2019b). Hence, a clear goal for the entire carbon footprint is missing. Furthermore, the actual SBTi commitment, that has not yet been externally communicated, is made on a slightly smaller subset of the PCF, not on the full CCF as stated in the quote above. To avoid misleading the audience, this should be rectified on the Heineken website as well as in the annual report. Both of these insufficiencies are brought to the attention of Heineken's Global Sustainable Sourcing Director and are expected to be resolved in the next financial year.

It is important to note that what Heineken refers to as their PCF deviates from how the term is used in academic literature as well as in the methodological documents. In the latter, the term PCF refers to the carbon footprint of a single specific product (e.g. a bottle of desperados sold in the Netherlands; BIER, 2018). Heineken however uses the term to refer to the average carbon footprint in kg CO_2eq/hl sold for the aggregated total of all the beers, ciders, and soft drinks they produce. This CF shares a lot of characteristics with what in literature is referred to as a CCF. Yet, it excludes important emission sources that are part of a CCF like employee commuting, business travel, and investments. For this reason, from an academic perspective it would therefore be most applicable to talk about a hybrid version between the two. For this research, this hybrid version will be referred to as an aggregated product company carbon footprint (APCCF).

For the main themes 'Representativeness', 'Data conformance, correctness, and reliability' and 'Materiality', the program scores sufficient overall with only insufficiencies in specific sections of the supply chain. For 'In- and external verification and transparency', the program scores well on the verification indicators but less on the documentation indicators. In the case of data acquirement documentation and assumption justification, many of the supply chain sections score insufficient. Another inconsistency noted is that in the annual report it states that Heinekens methodology is aligned with the three different standards from the GHGP (Corporate Scope 1 and 2; Corporate Scope 3; and product), the EU Beer product environmental footprint pilot, and the PEFCR. Yet, in none of the methodological documents except for logistics, the GHGP Corporate (Scope 3) standard is mentioned. On top of that, in the logistics document, the GLEC is mentioned as an additional standard that the methodology is aligned with, which is not mentioned in the annual report. For consistency and transparency reasons, the standards mentioned should be harmonized. Finally, it is important for Heineken to take continuous improvement of their methodology more serious. As will be described in more detail further in this chapter, a number of important tables and assumptions that were included in the previous year were left out of the 2018 methodology.

This means that even though the overall validity is still sufficient, it has decreased compared to 2017. It is important for Heineken to reverse this trend and start improving again. This all results in the overall recommendations as shown in Text Box 2.

Recommendations Overall

- Be more elaborate on which assumptions are made
- Be more explicit about the scope of the supply chain sections, mention which operating companies are in scope and what the emission/volume coverage is
- Be more precise about which sources are used and what the system boundaries are
- Communicate clear targets for the carbon footprint that are in line with the Science Based Target initiative
- Consistently state which methodological standards the Heineken methodology is aligned with throughout all methodological documents
- Focus on continuous improvement
- Rectify the statement mentioning to which carbon footprint the Science Based Target initiative commitment is made on the website and in the annual report
- Transparently describe how the acquired data is internally verified

Text Box 2: Overall recommendations for Heineken to improve the validity of 'Drop the C'.

Agriculture

In this first section of Heinekens supply chain, two issues were identified. The first one is related to the technological representativeness. Heineken based their agricultural emissions on country market mixes calculated with the Blonk Crop Mix tool (Blonk Consultants BV). These values do not represent the exact agricultural technologies deployed on the actual farms that supply Heinekens malteries, but are country wide averages. From a technological and geographical representativeness angle this is acceptable because the effects of using these values are clearly explained in the agriculture methodology. However, the values will not capture carbon reductions on farms that will be part of Heinekens farmer carbon reduction projects. Hence, from an accuracy point of view this is insufficient. To make this step towards higher accuracy, Heineken should move from using secondary data (country averages) to primary data (farm specific data).

In the case of data acquirement, the agriculture methodological document describes generically how the data is acquired. However, it lacks specification for all the different sources. This makes it impossible to get a clear view of which sources are covered by primary data and for which sources secondary data are used. The type of data that was used had to be found out through an interview with the Heineken employee responsible for this supply chain section as well as by joining the CFBM 18 data management meeting. The 2017 report does include a table listing the included emission sources and the type of data used. Given that this table is a clear requirement mentioned in the BIER sectoral interpretation of the PEFCR, this table should be reincluded in successive versions of the methodological document (BIER, 2018). Also, the internal verification procedure conducted by Heineken Global Procurement every year is not described. Devoting a paragraph to this procedure would improve transparency. The 2017 report uses hyperlinks to transparently reference to the used and publicly available reporting documents. This no longer happens in 2018 document, even though it would be a good practice and increase transparency. The use of hyperlinks could be applied in all the methodological documents.

Furthermore, the guide describes how country of cultivation data was unavailable in the Spend Analysis Tool and that Heineken was unable to link the sourcing country with the operating company that delivered the raw materials. It mentions which country market mix emission factor is assigned when the country of cultivation is known. However, the guide does not mention how this problem of unavailable data on country of cultivation is dealt with.

With respect to assumption justification, agriculture scores sufficient. The biggest assumptions made related to the use of the country mixes are justified in the methodology. During the interview and during the meetings, some less impactful assumptions were identified that are made when harmonizing and aggregating all the data into the HeiCF agricultural database. These assumptions are not currently justified in the methodology, which leaves room for improvement. Besides, the methodology document mentions for emission factors used for sugars, fruits and other raw materials that *"a mix of different sources and assumptions was used. For specific values and sources, please see the Excel sheet '17. Cultivation' in the CFBM14 model"*. This type of chain referencing, where a reference is made to another document that contains further references to where the data actually comes from, severely jeopardizes transparency. To avoid this, the mentioned excel sheet should be added to the methodological document as an appendix and uploaded to the same HeiCF online environment where the methodological documents can be found.

Lastly there are some minor points of attention. In the table of contents, the second chapter is named '2. CF18 changes to calculation methodology'. Whereas the chapter itself further down is named '2. CF18 calculation methodology' and only mentions two points of data acquirement. This chapter can be more fully utilized and include all changes in calculation methodology as well as changes in assumptions made compared to the previous year. When referring to logistics, distribution is used instead. The document should stick to logistics since this encompasses a broader set of activities than distribution. No references should be made to 'EU approved data sets', instead reference should be made to the specific data sets used. All of this results in the overall recommendations as shown in Text Box 3.

Recommendations Agriculture

- Be more explicit about the scope '*Scope is cultivation of ingredients for beverage production*', add that 34 operating companies are included, representing 89% of emissions. And that the carbon footprint is extrapolated from 89% to 100%
- Correct chapter title of chapter 2 and make it more complete
- Describe how the unavailability of country of cultivation data from the spend analysis tool is dealt with
- Do not refer to 'EU approved data sets' but state which exact data sets are used and reference to those
- Increase accuracy for on farm data, move from secondary to primary data
- Reinclude hyperlinks to publicly available reporting documents and datasets
- Reinclude updated table listing all relevant emission sources and extend to include whether they are in scope and if primary or secondary data is used
- Stick to a single source of truth, upload supporting excel files to the HeiCF online environment
- Where distribution is mentioned, change to logistics to avoid confusion

Text Box 3: Recommendations for Heineken to improve the validity of the agriculture part of 'Drop the C'.

Raw materials and processing

This supply chain section scores sufficient for all indicators except data acquirement documentation and assumptions justification. In the case of data acquirement, the methodology includes a detailed list of all the different emissions sources and whether they are in scope. However, for the sources in scope, it does not mention if this source is represented by primary or secondary data. This information was included in the same table of the previous year's methodology. No reason was identified as to why this was excluded for the 2018 CF. When it comes to assumption justification, only a single assumption is mentioned in both the 2017 and the 2018 methodology. This assumption is the ratio used to calculate the amount of malted grains which are produced from 1 ton of unmalted grains. 0.8 is used as ratio, which is justified because it is in the range of 0.78 to 0.84 as indicated by an expert at the Zoeterwoude brewery (S. de Cock, personal communication, 2012). Despite this expert insight being eight years old, this value can be considered representative because techniques used to malt grains have not changed significantly (Heineken, 2020). No other assumptions are mentioned, while through one of the interviews and the CFBM 18 meeting, more assumptions that were made came to light. The additional assumptions concerned the way of how input data was harmonized and validated (e.g. data for used amounts of raw materials are drawn from the spend analysis tool (SAT), sometimes the units are missing for numbers in this tool, for which assumptions are made). These assumptions should be justified in the methodology of the following year.

When it comes to the used sources for emission factors, the document clearly refers to specific sources. Only with regard to the malting process it is stated that for malting plants not owned by Heineken, a default emission factor for malting is used. This factor stems from the PEFCR pilot for an average malting process using '*EF compliant datasets as background data*'. This is a non-transparent way of referencing because it is impossible for the reader to know which source is used precisely. All of this results in the recommendations as shown in Text Box 4.

Recommendations Raw materials and processing

- Always reference to specific source, also for average malting emission factor
- Be more explicit about the scope *'The scope of this GHG reporting guideline focuses on malting, and on the processing of 9 raw materials'*, add that the focus is on top 25 malteries, representing over 99% of the emissions and 89% of volume sold
- Include justifications for all the assumptions made in the data gathering process
- Reinclude table that lists for each emission source if it is covered by primary or secondary data

Text Box 4: Recommendations for Heineken to improve the validity of the raw materials and processing part of 'Drop the C'.

Beverage production

Here, Heinekens scope 1 emissions are represented. These emissions have been in the focus of sustainability reporting for over a decade now and it has therefore matured more compared to the other supply chain sections (Heineken, 2020). This is also reflected in the scores. In the methodology the GHGP Corporate Scope 3 standard is also not mentioned, but for this section that is less relevant because it mainly concerns scope 1 emissions. However, still this section does also include certain scope 3 emissions, for which the methodology should be aligned with the GHGP Corporate scope 3 standard. To improve the system completeness, the water plant in the flow chart should be changed from grey to green to correctly indicate that this emission source is included (Figure 10, page 67). The same applies for upstream emissions of fossil and renewable fuels. These are not currently listed in the list of emission sources that indicates for all relevant sources whether they are in scope. Yet, they are in scope and should therefore be added to the list. Also, refrigerant losses could be added to the flowchart since it is a specific emission source that is included in the CF. However, this source is not prescribed by the BIER sectoral interpretation and is therefore an optional addition. Imported CO_2 for soft drinks is listed as in scope, but it is also included in table 2 as justified for exclusion of attributable processes. This discrepancy should be clarified.

Beyond that, top scores are reached for all indicators in the main themes 'Representativeness' and 'Data conformance, correctness, and reliability'. These scores can be attributed to some extent to the Brewery Comparing System (BCS). This mature system has been running for over ten years. All breweries that are in scope (Breweries that Heineken owns or has a majority share in), are used to the system and fill in all their activity data in a harmonized way. This data is validated by the plant manager before it is sent to the global office monthly. It is then validated by the global responsible function on trend deviations, which if identified are double checked with the brewery (Heineken, 2020).

On the last main theme, Beverage production also scores high. Data acquirement is clear because all the data used is primary data and no assumptions need to be justified because no assumptions are made. Only, Pjotr van Oeveren and Dough Witherspoon are used as source for energy consumption of Kieselguhr production, who should be justified as credible sources.

Finally, a description of changes compared to the previous year was part of the 2017 methodological document. This shows awareness of importance of continuous improvement and should therefore be reincluded. All the above is summarized in recommendations as shown in Text Box 5.

Recommendations Beverage Production

- Add upstream emissions of fossil and renewable fuels to the list that states whether emissions are in scope or not, these emissions are in scope
- Be more explicit about the scope '*The scope of this GHG reporting guideline is beverage production (beer, cider, soft drinks and (packed) water)*', add that all operating companies with production sites for any type of drink are included, covering 100% of volume sold
- Reinclude description of changes compared to previous year
- Include refrigerant losses in flowchart
- In table 1: Imported CO_2 for soft drinks is listed as in scope, but also included in table 2 as justified for exclusion of attributable processes, clarify this discrepancy
- Justify use of Pjotr van Oeveren and Dough Witherspoon as credible source
- Update flowchart to make 'Water plant' green since this is included in the calculations and thus in scope

Text Box 5: Recommendations for Heineken to improve the validity of the Beverage Production part of 'Drop the C'.

Packaging materials

The main insufficiencies identified for this supply chain section are the system boundaries, data acquirement documentation and assumption justification. The offices are excluded from the system by Heineken, while it is prescribed to be included by the PEFCR. This is odd given that the offices are included in the Raw materials and processing and Beverage production supply chain sections (Figure 10, page 67). An explanation for this was asked for to the employee responsible for the packaging carbon footprint methodology. However, she had only moved into her current position after the 2018 CF was calculated and could not give a certain explanation. The last two insufficiencies are the same as for Agriculture. A table is present that lists the different emission sources and whether they are in scope. The table caption states that it includes specification of data type, but information on the type of data used (primary or secondary) is missing. This should be included because it is a requirement mentioned in the BIER sectoral interpretation of the PEFCR (BIER, 2018).

Most assumptions are transparently justified, only the same assumptions made during the harmonization of the data were identified in interviews. These are also not included in the methodology for packaging materials. When it comes to data acquirement, a step forward can be made for referencing to the data sources. The packaging methodology relies heavily on a European dataset that has been put together for the PEFCR project. This dataset called 'CFF_Default_Parameters_March2018' is referred to in the methodology in 8 different ways (PEFCR guidance values, EC PEF Guidelines version 6.3, European Commission's EF compliant datasets, EC PEFCR guidelines, PEFCR average values, EF compliant life cycle database (PEFCR), PEF compliant datasets, PEFCR guidance version 6.3). For transparency and consistency reasons, references to this dataset should be made in a single and clear way, ideally with a link to where on the European Commission's website it can be found.

Finally, the methodological document states *'Recycle rates for Aluminum cans and Glass bottles in Europe were updated based on new datasets provided by FEVE and EAA early 2019, which provide data for the year 2016. Correction factors were again applied to the 2016 recycle rates to make them PEF compliant'*. This, however, is not what was done. After a deep dive into the data it became evident that also here 'CFF_Default_Parameters_March2018' values were used in the CFBM. FEVE and EAA data was also collected, but not used for the final calculations. This resulted in a packaging materials specific list of recommendations (Text Box 6).

Recommendations Packaging materials

- Add to scope that top-22 operating companies are included, covering 87% of the volume sold
- Add to table '*emissions in scope or out of scope and specification of the data type*' the specification of data type
- Describe changes compared to previous year
- Justify deviations from the PEFCR methodology, knowledge on deviations gets lost with employee rotation otherwise
- Rectify statement made regarding which recycling rates for aluminum cans and glass bottles were used
- Reference adequately to the same dataset in one clear way
- Where '*European commission's EF compliant datasets*' is mentioned, be explicit about which dataset

Text Box 6: Recommendations for Heineken to improve the validity of the packaging materials part of 'Drop the C'.

Logistics

Despite the data coverage with 72% of the total being sufficient, an inconsistency was identified between the annual report and the data coverage used internally. The annual report states that the 72% represents the top 20 OpCos, whereas internally the top 17 is used. The latter is a more up to date scope and should be used consistently throughout the company.

Besides this inconsistency, the system boundaries used by Heineken seem to be far off from the ones prescribed in the PEFCR. According to the logistics methodology, Heineken excludes company and non-company owned vehicles, non-company warehouses, the last mile, as well as the utility (Figure 10, page 67). The methodological document of 2017 includes a list of all relevant emission sources and whether they are in or out of scope. This list claims that the above-mentioned sources were included in the 2017 carbon footprint. In combination with the document stating *"Inputs not mentioned in this report are excluded from the scope of the 'Logistics' CO_2 KPI but are reported as part of the total Heineken footprint"*, causes a lot of confusion because it is not stated which inputs are referred to here. These inputs and changes in scope compared to last year should be described to give the reader a clear picture of what the current scope is.

Regarding data, the general way of acquirement is mentioned, and all data sources are referenced to. Only a clear list of covered emission sources and whether they are covered by primary or secondary data is missing, whilst this was included in the previous year's methodology and is also described in the BIER sectoral interpretation of the PEFCR as a requirement (BIER, 2018). Furthermore, several assumptions made in the 2017 methodology are also no longer mentioned in the 2018 methodology. This resulted in a logistics specific list of recommendations (Text Box 7).

Recommendations Logistics

- Add to scope that top 17 operating companies are in scope at and add that this covers 72% of the consolidated volumes
- Describe which inputs are excluded for the logistics CO_2 KPI but included for the total Heineken carbon footprint
- Reinclude an updated table with attributable processes that are excluded plus justification
- Reinclude an updated table with specific data sources and whether primary or secondary data was used
- Reinclude the missing 2017 assumptions or justify why they are left out in 2018

Text Box 7: Recommendations for Heineken to improve the validity of the logistics part of 'Drop the C'.

Cooling

This category scores well overall. The only insufficiency identified is related to the assumption justification. Similarly, as with Agriculture and Packaging materials, some of the assumptions made whilst validating and harmonizing the input data are not justified in the methodology. Besides that, there are only some minor transparency related points. As with the other supply chain sections, the emission coverage that is in scope should be mentioned. Some units in figures and some sources are missing, and the numbers in table 5 of the document do not add up.

Lastly, a reference is made to an old excel file that is part of a previous year's carbon footprint baseline model. To stick to a single source of truth and to improve transparency, this file should be updated and uploaded to the HeiCF web application. Cooling specific recommendations are shown in Text Box 8.

Recommendations Cooling

- Add to scope that 34 operating companies are included, covering 91% of the cooling carbon footprint, then extrapolated to 100%
- Do not refer to old excel files, update files and upload them to the HeiCF web application where the methodological documents can be found as well to keep a single source of truth
- For national grid emission factors, refer to the source
- In Figure 4, add the unit
- The total purchased fridges and total MWh/yr in table 5 are incorrect. 2018 values are added to the list but not to the total amount, this should be corrected

Text Box 8: Recommendations for Heineken to improve the validity of the cooling part of 'Drop the C'.

Summary

Heineken's CM program scores sufficient for most of the indicators. Major insufficiencies were only found for five of the indicators, three of them apply to the overall program and two of them apply to one or more specific supply chain sections. Where in the supply chain these insufficiencies are identified is visualized in Figure 10. This figure further shows which emission sources are in- or excluded by Heineken and whether that is in accordance with the PEFCR. The minor insufficiencies that were identified for a total of eight indicators are not depicted in Figure 10 but are incorporated in the recommendations to Heineken. The figure further shows in between which supply chain section Logistics is involved (indicated by the box with a truck icon), as well as where the boundary lies between typical scope 1 & 2, and typical scope 3 emissions (indicated by emission stream boxes being inside or outside of the big semi-transparent boxes). Finally, the red arrows show where a flow of energy or material is present from one process to another.

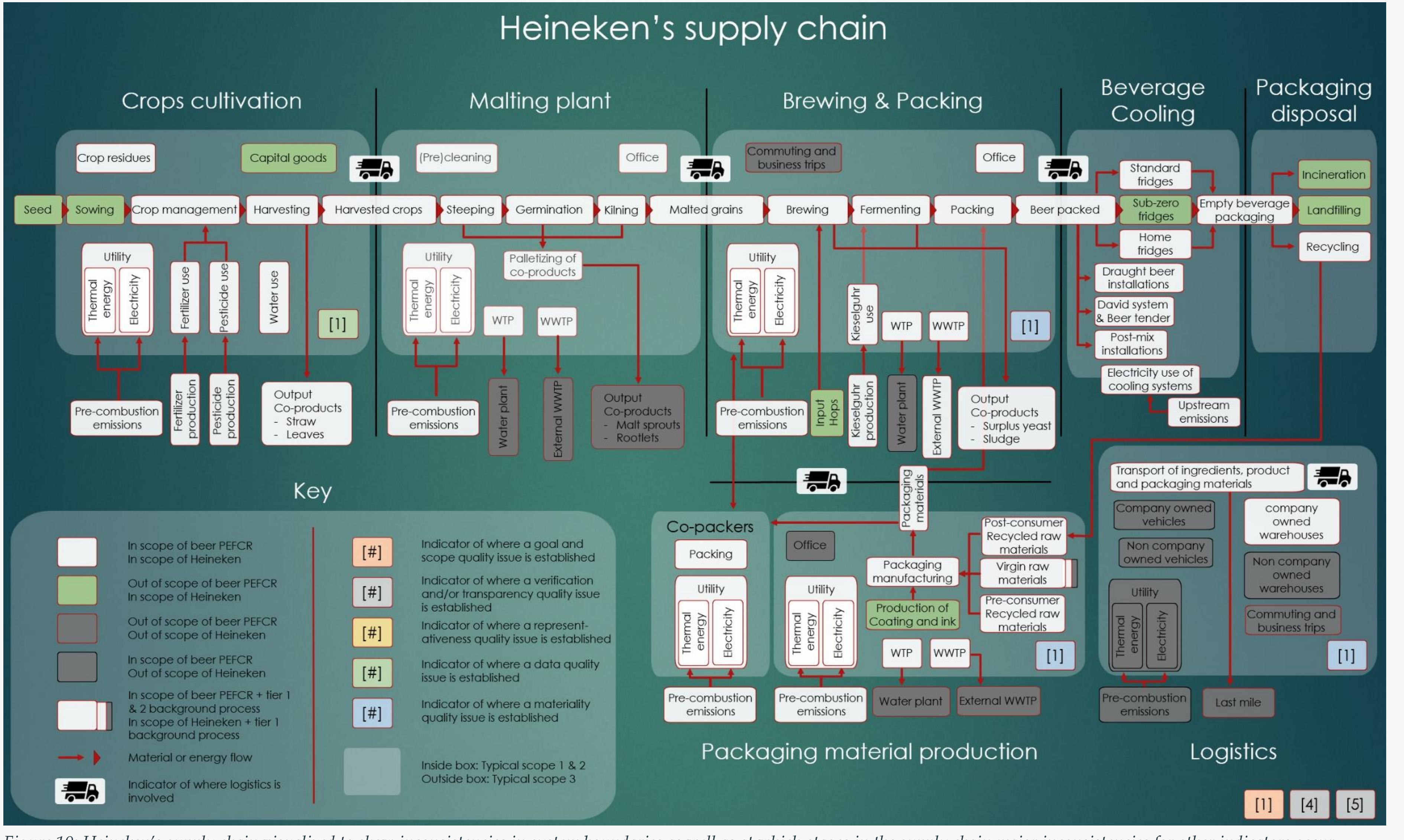


Figure 10: Heineken's supply chain visualized to show inconsistencies in system boundaries as well as at which stages in the supply chain major inconsistencies for other indicators occur.

6. Discussion

The present thesis was designed to develop an assessment scheme that can be used to assess the data validity level of carbon measurement programs of companies. This section presents the discussion on the insights that can be gained on the research question. First, it will be discussed how the findings fit into the theoretical context. Second, the limitation of this study will be discussed. This section ends with future research recommendations.

6.1 Theoretical implications

This thesis proposes a set of assessment criteria for CM programs. A generally accepted approach for CM programs was lacking so far. Fibbing, no proof and vagueness were initially identified in theory to be the three most applicable of the seven greenwashing sins as described by Dahl (2010). This is confirmed by the interview results and reflected in the assessment scheme by the overall assessment criteria of transparency and consistency. High transparency and consistency both help to avoid committing either of these three sins (Delmas & Burbano, 2011; Marquis et al., 2016).

Several aspects are new in the presented scheme compared to existing schemes for assessment of carbon measurement activities outside of the company context (Ciroth et al., 2020; UNEP et al., 2011; Weidema & Wesnæs, 1996). All the assessment criteria have been established specifically to be applied in a company context. Furthermore, this thesis includes the single case study of Heineken's '*Drop the C*' program that is used to illustrate how thresholds can be established for the indicators based on the company specific context.

Multiple interviewees pointed out the importance of making the right considerations with regard to the level of aggregation of the assessment scheme. For this research, the five themes have been chosen to try and make the scheme sufficiently disaggregated, without making it too cumbersome to apply. For instance, the Global Guidance Principles provides very elaborate guidance for LCA databases. However, besides it being focused on LCA databases instead of organizations and their supply chain, these principles are not applicable to entire organizations due to its high level of detail and alignment with ISO. ISO demands from its users such a level of detail that is only achievable on a product, database, or single carbon management system. It is not feasible to assess entire organizations on alignment with ISO.

This study adds new insights to the research field of LCSCM. As described in the results section, the CF that Heineken has made as a result of their commitment towards SBTi, from a theoretical perspective is a hybrid version of the PCF and CCF that for this research is called APCCF. To link this finding with the current theory by Acquaye et al. (2018) on carbon monitoring levels, the hybrid level can be plotted in between the Product level and Firm level (Figure 11). The case study of Heineken suggests that carbon footprint levels in practice are not as black and white as the current theory suggests. The area between the product and firm level might have to be interpreted as a grey area in which companies can be located more towards the product or firm level based on their specific system boundaries. This grey area is the result of practicality considerations in the industry. For a company it is impossible to influence their entire supply chain to reduce carbon emissions. Certain emission streams like non-company owned warehouses or the distribution from those warehouses to stores, bars and restaurants are almost completely out of the control of the company (R13). This is why the SBTi has set more lenient cut of thresholds for a company's supply chain (33.4%) compared to the 5% for a company's own operations (SBTi, 2018). A company like Heineken that commits to SBTi to set science-based targets for their CF, will create a carbon footprint that is both compliant with SBTi and practicable. This results in an APCCF that is located somewhere in the gray zone between the PCF and the CCF.

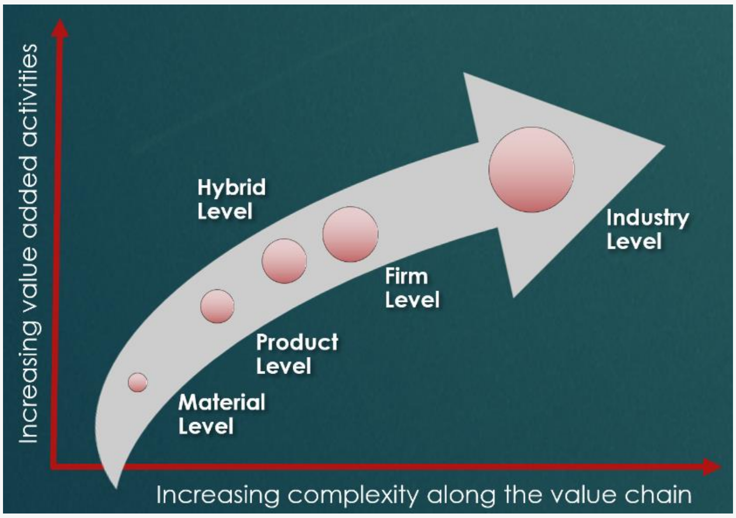


Figure 11: Different levels of carbon footprint plotted based on value chain complexity vs. number of value-added activities with the addition of the Hybrid level. Adapted from Acquaye et al. (2018).

A lower than expected number of interviewees mentioned most or all of the criteria. On average every criterium was mentioned by 22 out of 39 interviewees. A possible explanation for this is the abundant referencing to methodological documents by the interviewees. As mentioned in the results, 82 references were made to one or more of the methodological documents. These references can explain the lower than expected mentioning of the other criteria because indirectly many of these criteria were referred to by referring to these methodological documents that describe a number of criteria.

Accuracy and precision are two data characteristics that can easily get mixed up. For this research's assessment scheme, accuracy was deemed relevant whereas precision was not. The reason why will be illustrated with the following example. Accuracy represents the closeness of agreement of the measured value and the value which is accepted as a conventional true value (Abraham, 2010). As an example, the conventional first five digits for the true value for π are 3.1415. The level of accuracy describes how many digits you can show, without deviating from the true value further than the standard deviation. In this way, a measured value for π of 3.14449 can be reported as 3.144 and be considered accurate. Whereas if it is reported as 3.1444, it is no longer accurate because the number deviates too far from the true value on this level of accuracy. It is important to take this into consideration when assessing carbon management data validity since when in this example the mitigation measures would have an impact on the measured number in the range of 0.0001-0.0004, this is not captured and a more accurate measuring tool is needed.

Precision on the other hand describes the degree of scatter among multiple measurements of the same value (Abraham, 2010). A high level of precision is needed to make the measurements reproducible. For this studies assessment scheme, this is not deemed relevant as it is impossible to assess based on a single measured value. For this reason, precision has been left out this research's assessment scheme. Furthermore, a sufficiently high level of precision is considered to be assured by using acknowledged measuring tools.

The finding that data collection can be hampered when a one-way dependency relationship exists between the company and the supplier is supported by literature. Swami & Shah (2013) demonstrates how achieving environmental sustainability requires a coordinated effort from multiple supply chain members. Building on this research, Touboulic et al. (2014) explored the effect of different power relationships on the coordination and found that dependence power relationships in which the reporting company is dependent can hamper the coordination. When this study's assessment scheme is applied to a small company with the aforementioned dependency relationship with its supplier, it will be important to keep this power relationship in mind during the assessment. In such a case, recommendations can be made to aim for a balanced cooperative relationship with the supplier and convince them of the benefits of pursuing a sustainability carbon reduction agenda. Such a balanced relationship will result in the best sustainability and economic performance (Chen et al., 2017).

6.2 Limitations

There were two types of limitations for this research, circumstantial and bias related. These limitations together with the impact they had on the research will be covered below.

6.2.1 Interview limitations

Saturation in the interviews was confidently reached with respect to the validity categories. However, for the indicators that were translated from these categories, the assessment criteria were also based on the information distilled from the interviews. Saturation in respect to the assessment criteria for each of the indicators from a company perspective was not reached since the interviews did not allow for enough time to dive into the level of detail where possible assessment criteria were discussed for each of the categories.

The uneven distribution of interviewees over the different stakeholder groups could have led to biased results. This is not considered to be the case because there were no significant differences in opinions amongst the stakeholder groups in relation to the validity criteria.

6.2.2 Circumstantial limitations

The inaccessibility of the ISO standards was a limitation for this study because these standards are globally accepted and have matured over a long time. The perspective of ISO on data quality for individual products (ISO 14040 and ISO 14044) as well as environmental management systems (ISO 14001) could have acted as a valuable addition to the document analysis, capturing an additional important perspective and with that potentially making this study's criteria scheme more comprehensive. This limitation was partially counteracted by including a section from the EPA Guidance on Data Quality Assessment for LCI Data in the document analysis. This section clearly describes what ISO 14044 states regarding data validity indicators. In this way the perspective from the ISO standards was still included to some extent.

Another perspective that was hard to cover was that of experts at companies in the supply chain as well as in the sector. It proved to be very challenging to reach the real expert at these companies. In the end enough experts were reached, but in the process also a couple of people were interviewed that were familiar with the topic but cannot be considered to be real experts. This led to some of the interviews in these stakeholder groups to be lower in information power compared to if only real experts would have been interviewed. Furthermore, the maturity of the carbon management programs of some of these companies had an impact on the information power of the interviewees. During some of the interviews from these stakeholder groups it became evident that the companies were mainly focusing on scope 1 and 2 reporting and that scope 3 reporting was still in its early phases. This led to the interviewees not being able to answer some of the asked questions on the level of detail that other interviewees reached.

6.2.3 Bias related limitations

The interviewer bias during coding was limited by the multiple phases of which the coding process consisted as well as the iterative nature of the process. Going over the codes at a later moment with a fresh look helped to filter out biased codes and biased aggregation of nodes. Future research on this topic can further decrease the impact of this limitation by including additional coders.

The scheme can be slightly biased towards companies that are structurally similar to Heineken. This is the case because of the specific Heineken stakeholder group, the analysis of internal documents as well as Heineken turning out to be a former client of some of the interviewees at other organizations. For instance, the former auditor at Deloitte as well as the Euro Pool Group used to have Heineken as a client. This led them to take Heineken as a specific example when answering certain interview questions.

6.3 Future research recommendation

The first areas where future research would be beneficial builds upon the limitations. In this research, the developed validity assessment scheme has only been tested in a single case study. Future additional case studies applying this scheme would help to tests the broader applicability of the scheme on companies both in and outside of the food and beverage sector. Furthermore, the current scheme is developed for an in-depth assessment of a single company. To be applied on multiple cases at once, the scheme would benefit from automation of indicator assessment for those indicators that do not need human expert judgement. Examples are the contextual indicators under the 'Complete goal and scope disclosure' main theme and external verification. These are the simpler indicators that algorithms these days can pick up from methodological documents on and do the assessment for us. Research into how this can be achieved could increase the effectiveness of the assessment.

Some of the interviewees stated that automated carbon management systems can positively influence the validity of the carbon management program by decreasing the number of interventions needed in the data flow (R4; R12; R5). Research on the effect of automated carbon management systems on the validity of the carbon management program would be valuable, especially because such systems will be applied by an increasing number of companies in the near future.

Finally, and most importantly, research is needed into how data validity assessment can be incorporated in the global standards. To facilitate comparability, all companies disclosing through the PEFCR, SBTi or any other global standard should ideally assess their data validity in the same way. Data validity assessment is an integral part of the UNEP global guidance for life cycle assessment databases (UNEP et al., 2011). Similarly, data validity assessment should be an integral part in the standards for corporate carbon footprint disclosure like the GHGP standards, or carbon management systems like the ISO 14001 standard.

7. Conclusion and recommendations

With over 20% of global greenhouse gas (GHG) emissions resulting from approximately the 2500 largest companies in the world and an increasing public awareness of the importance of making our societies more sustainable, the importance of carbon management is hard to miss. This increasing public awareness also calls for a higher validity in company carbon management programs in order to avoid greenwashing acquisitions.

Thus far, an assessment scheme dedicated to the validity assessment of corporate carbon management programs was lacking. Therefore, in order to answer the research question, two sub research questions were defined to facilitate answering the main research question. The first one being:

RQ. What are appropriate criteria to assess the validity of the measuring constructs of carbon management programs?

In combination with an extensive document analysis and 35 interviews, the carbon measurement data validity assessment scheme was developed. 14 Validity criteria emerged that were translated into 21 validity criteria indicators. These 21 indicators have been grouped in five main themes and collectively are believed to allow a validator to assess a carbon management program on all relevant validity aspects. These five themes are: Complete goal and scope disclosure, In- and external verification, Representativeness, Data accuracy and reliability, and Materiality. When conducting any form of assessment there is always the question of what a fitting minimum level is. For this research, this resulted in the second sub research question:

Sub-RQ 1. On the developed criteria scheme, what is a legitimate minimum validity level?

In the case of corporate carbon management program assessment, there is no one size fits all for a legitimate minimum validity level. The minimum data validity level is highly dependent on the context that is set out in the goal and scope of the program. Therefore, complete disclosure on all the goal and scope related indicators is important. The validity level for all the primary and secondary data related indicators should at least meet the level that is specified in the goal and scope of the program. More manual intervention in the data flow requires more internal verification. External verification needs to happen yearly by an independent third party. It is very important for data acquirement documentation and assumption justification to be done in a complete as possible matter, both to allow external auditors to do their job properly as well as to allow the general public to get a complete picture of the carbon footprint.

For the three types of representativeness in the context of '*Drop the C*', this means that the data needs to be representative enough to capture changes in emissions related to the reduction goals of the program. For completeness this means that the dataset should be complete enough to form an honest representation of the entire companies' operations, not to mislead the audience. For '*Drop the C*' this level is set at 90% of data for all the material emission streams per category to be covered with primary data.

When it comes to accuracy, the most important thing is that the measured data needs to be accurate enough to capture progress towards the reduction goals of the program under consideration. Measurements from a source within own operations or supply chain for whom credibility is likely but uncertain, or measurements from credible but not internationally accepted databases are considered to meet a minimum level of reliability.

System boundaries need to be aligned with those prescribed in the methodology on which the measurement activity is based, in the Case of Heineken these are the PEFCR Guidance V3 and three standards from the GHGP. SBTi prescribes at least 95% coverage of emissions in own operations (scope 1 and 2) and at least 66.6% of emissions in the supply chain (scope 3). Since Heineken has committed to SBTi, this is used as a minimum level for '*Drop the C*'. These minimum levels bring us to the second sub research question:

Sub-RQ 2. What is the validity of the measuring construct of Heinekens' '*Drop the C*' program?

In order to assess the validity of Heineken's '*Drop the C*' program, the developed assessment scheme was used. '*Drop the C*' scores high overall. The biggest deficiencies were found for transparent and complete documentation of data acquirement and assumption justification. As well as discrepancies between used system boundaries and prescribed system boundaries by the PEFCR. Even though the overall validity of the program was found to be high, a slight decrease in validity compared to the previous year was observed. It is important for Heineken to break this trend and make sure that they keep improving their validity over the years rather than reduce it. The assessment resulted into main recommendations for Heineken to improve their carbon footprint programs validity (Text Box 9).

These conclusions and the aforementioned practical implications contribute to a wider social relevance and increasing demand for valid carbon disclosure. All in all, this research thus provides new insights for the general public, food and beverages industry, and government policymakers alike, into what are important indicators to assess data validity of carbon management programs. Given that carbon reduction can only be achieved successfully when based on valid measurements, this is an important step forward towards carbon neutral societies.

Recommendations Overall

- Be more elaborate on which assumptions are made
- Be more explicit about the scope of the supply chain sections, mention which operating companies are in scope and what the emission/volume coverage is
- Be more precise about which sources are used and what the system boundaries are
- Communicate clear targets for the carbon footprint that are in line with the Science Based Target initiative
- Consistently state which methodological standards the Heineken methodology is aligned with throughout all methodological documents
- Focus on continuous improvement
- Rectify the statement mentioning to which carbon footprint the Science Based Target initiative commitment is made on the website and in the annual report
- Transparently describe how the acquired data is internally verified

Text Box 9: Main recommendations for Heineken to improve 'Drop the C' validity.

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7. Appendix

7.1 Appendix A: Interview Guide

Helplines to reach more detail
Can you describe that? **Can you give an example?** **Can you elaborate on that?** **Can you please explain further?** **Can you please give an example?** **Can you explain how that works?** **Can you think of any additional examples?**

Theme	**Main question**	**Sub questions**
Opening	Hello, thank you for agreeing to this interview!	- Overview of the purpose of the study - Confidentiality agreement - Is it okay if I record the interview?

Demographic info	To begin with I'd like to get to know you a bit better.	- Current job
		- Affinity with sustainability
		- Affinity with SCM
		- Affinity with CM and CF
		  - Do you think CM is important?
		  - What do you know about CF methods?
		  - Do you think CF is a good method for carbon emission measurement?

Construct validity indicators	What are validity indicators that you use to assess carbon emission data validity?	- What are important aspects of data that determine its validity? - How do you avoid inaccurateness in carbon emission measurement data? - How do you assure trust the carbon emission measurement data? - How do you assure unambiguity in carbon emission measurement data?
Construct validity criteria scale	What could be criteria for the indicators?	- What is the highest / lowest data validity you have worked with? *- Reliability, Completeness, Time, Geography, Technology, ~newly identified indicator~*
Minimum level on validity criteria scale	What do you think would be a legitimate minimum level on the scale for carbon emission data validity for data used in carbon management?	- What do you use as a minimum level for data validity for you to use it? *- Reliability, Completeness, Time, Geography, Technology, ~newly identified indicator~*

~ Thank you for participating! ~

7.2 Appendix B: Selective coding scheme

14/07/2020 15:18

Code Summary

Thesis Interview Transcripts Selective Coding Scheme

14/07/2020 15:18

File Type	Number of Files	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded
Node					
Nickname: **Nodes\\(06) Needed level of data quality**					
Classification:					
Aggregated: **Yes**					
Document	22	65	3,893	79	
Nickname: **Nodes\\(09) Verification process**					
Classification:					
Aggregated: **Yes**					
Document	19	100	4,713	129	
Nickname: **Nodes\\(11) Dis-aggregation**					
Classification:					
Aggregated: **Yes**					
Document	18	27	1,932	43	
Nickname: **Nodes\\(12) Emisson factors**					
Classification:					
Aggregated: **Yes**					
Document	16	34	1,984	54	

14/07/2020 15:18

File Type	Number of Files	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: **Nodes\\(14) Databases**

Classification:

Aggregated: **Yes**

Document	13	39	2,196	55	

Nickname: **Nodes\\Data quality indicators**

Classification:

Aggregated: **Yes**

Document	39	335	20,879	490	

Nickname: **Nodes\\Data quality indicators\(02) Consistency**

Classification:

Aggregated: **Yes**

Document	18	42	3,702	81	

Nickname: **Nodes\\Data quality indicators\(03) Materiality**

Classification:

Aggregated: **Yes**

Document	25	80	5,101	120	

Nickname: **Nodes\\Data quality indicators\(05) Completeness**

Classification:

Aggregated: **Yes**

Document	24	44	2,244	58	

File Type	Number of Files	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: **Nodes\\Data quality indicators\(07) Representativeness**

Classification:

Aggregated: **Yes**

Document	24	84	4,810	112	

Nickname: **Nodes\\Data quality indicators\(08) Transparancy**

Classification:

Aggregated: **Yes**

Document	14	30	1,901	50	

Nickname: **Nodes\\Data quality indicators\(10) Accuracy**

Classification:

Aggregated: **Yes**

Document	18	30	2,109	41	

Nickname: **Nodes\\Data quality indicators\(13) Reliability**

Classification:

Aggregated: **Yes**

Document	14	23	955	26	

Nickname: **Nodes\\Data quality indicators\Nobody assesses data quality, everybonde just wants information**

Classification:

Aggregated: **No**

Document	1	1	24	1	

14/07/2020 15:18

File Type	Number of Files	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: **Nodes\\Data quality indicators\Sometimes double counting for barley**

Classification:

Aggregated: **No**

Document	1	1	33	1	

Nickname: **Nodes\\Methodology**

Classification:

Aggregated: **Yes**

Document	40	304	16,770	407	

Nickname: **Nodes\\Methodology\(01) Goal and Scope**

Classification:

Aggregated: **Yes**

Document	28	89	4,874	116	

Nickname: **Nodes\\Methodology\(02) Consistency**

Classification:

Aggregated: **Yes**

Document	15	29	2,049	44	

Nickname: **Nodes\\Methodology\(04) Methodological standards**

Classification:

Aggregated: **Yes**

Document	25	82	4,049	117	

14/07/2020 15:18

File Type	Number of Files	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: **Nodes\\Methodology\(08) Transparancy**

Classification:

Aggregated: **Yes**

Document	12	16	1,008	23	

Nickname: **Nodes\\Methodology\(15) CF - PCF - CCF**

Classification:

Aggregated: **Yes**

Document	19	57	2,535	62	

Nickname: **Nodes\\Methodology\(16) Allocation**

Classification:

Aggregated: **Yes**

Document	6	7	657	13	

Nickname: **Nodes\\Methodology\Others**

Classification:

Aggregated: **Yes**

Document	13	24	1,598	32	

Nickname: **Nodes\\Others**

Classification:

Aggregated: **Yes**

Document	9	25	1,466	30	

7.2 Appendix C: Drop the C full assessment table

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Complete goal and scope disclosure	Values	Procedures	Scope Data	Per Category	Overall (external reporting)	Agriculture (Internal reporting)	Raw Materials Processing (Internal reporting)
[1] Intended audience and purpose of activity	Text	X	X		General Public - Showing carbon footprint? Real target missing	OpCos and internal stakeholders	OpCos and internal stakeholders/auditors
[2] Disclosure methodology	Text	X		X	GHGP (3) + PEFCR	2018: GHGP (2) + BIER + PEFCR	2018: GHGP (2) + BIER + PEFCR
[3] Reference- and baseline period	Yes	X			Both 2018	Both 2018	Both 2018
[4] Reference- and baseline supply chain boundaries	Yes	X			In table of AR19 appendix	See methodology document 2018, reference and baseline are both 2018	See methodology document 2018, reference and baseline are both 2018
[5] Reference- and baseline system completeness	Yes	X			In line with the Greenhouse Gas (GHG) Protocol, carbon footprint calculation covers our products and other activities, including employee commuting and work-related travel, capital goods and investments. | Product carbon footprint excludes other emissions (12%)	In accordance with BIER sectoral guidance + seeds/sowing/captical goods and outputs	In accordance with BIER sectoral guidance + justificaiton of excluded sources
[6] Reference- and baseline technology	Yes	X		X	Not mentioned	Common material group (CMG) classification used	Common material group (CMG) classifcation used
[7] Reference- and baseline functional unit	**Yes**	X			kg CO2e/hl sold (not produced)	tonne CO2	tonne CO2
[8] Reference- and baseline disclosure volume	**Yes**	X			2017: 6.1 kg CO2 eq/hl in production. 2018: 15.4M tonnes CO2/68.1 kg CO2/hl (2017 data) / 2019: 65.6 kg CO2-e/hl (2018 data).	% of total emissions	% of total emissions
In- and external verification and transparancy							
[1] Internal verification process	1	X		X	Internal global audit team does big yearly audit	Responsible function (CRIS) does thurough audit, global audit team checks the function	Responsible function (CRIS) does thurough audit (10 months in december, last 2 months in January), global audit team checks the function
[2] External verification process	1	X			Internal verification process is audited by Deloitte, limited level of assurance is issued	N/A	N/A
[3] Methodological documentation	1	X		X	0	Yes	Yes
[4] Data aquirement documentation	3	X		X	0	Yes, no list of specific sources coverend and if it is based on primary data or not | HeiCF does include source for EF (AFP V4, blonk crop mix tool and RIVM database) | raw adjuncts & other emission factors from 'CF17 Raw materials emissoin factors'?	Yes, list with all included sources, only does not list per source if it is based on primary data or not.
[5] Assumption justification	3	X		X	0	Assumption for using country market mix disclosed. Assumptions made when harmonizing SAT data not disclosed	Assumptions made whilst harmonizing SAT data not disclosed
Representativeness							
[1] Technological representativeness	1		X	X	0	Cultivation technology based on country mix using Blonk crop mix tool	All processes at supplier level taken into account
[2] Temporal representativeness	1		X	X	0	Yearly up to date data available	Yearly up to date data available
[3] Geographical representativeness	1		X	X	0	Data is supplier country market mix specific	Data is processing facility specific
[4] Completeness of data coverage	1		X	X	For every category: Parts of operations in scope not mentioned in methodology documents	90% of volumes (34 OpCos - 89% of total) Extrapolated to 100% --> Focus on Barley, Mais, Sugar cane (90% of volume) --> Focus on Barley (over 50% of emissions) | Collected data almost complete	34 Opcos - 89% of emissions, extrapolated to 100%. Focus on top 25 Malteries (over 99% of emissions)
Data conformance, correctness and reliability							
[1] Accuracy of the data	2		X	X	0	Farmer program reductions not directly captured due to use of country mix (only indirectly when country mix is updated by Blonk)	High enough to track CO2 emissions
[2] Reliability of the data	2		X	X	0	Databases EU acknowledged | Activity data from SAT, mature financial tool, only vendor location missing, done based on unreliable allocation files	Databases EU acknowledged | Activity data from SAT, mature financial tool, only vendor location missing, done based on unreliable allocation files
Materiality							
[1] System boundaries in line with goal and scope	1	X		X	Yes	Goals is entire supply chain in accordance with ghgp, system boundaries in accordance with BIER total supply chain boundaries	Goals is entire supply chain in accordance with ghgp, system boundaries in accordance with BIER total supply chain boundaries
[2] Disclosed carbon footprint in line with goal and scope	1	X			Our strategy – 'Drop the C' – aims to significantly and systematically reduce our emissions across the entire value chain by 2030 | On the site, all 6 supply chain categories are included	N/A	N/A

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Beverage Production (Internal reporting)	Packaging Materials (Internal reporting)	Logistics (Internal reporting)	Cooling (Internal reporting)
OpCos and internal stakeholders/auditors	OpCos and internal stakeholders/auditors	OpCos and internal stakeholders/auditors	OpCos and internal stakeholders/auditors
2018: GHGP (2) + BIER + PEFCR	2018: GHGP (2) + BIER + PEFCR	2018: GHGP (3) + GLEC + BIER + PEFCR	2018: GHGP (2) + BIER + PEFCR
Both 2018	Both 2018	Both 2018	Both 2018
See methodology document 2018, reference and baseline are both 2018	See methodology document 2018, reference and baseline are both 2018	See methodology document 2018, reference and baseline are both 2018	See methodology document 2018, reference and baseline are both 2018
Almost entirely in accordance with BIER sectoral guidance, only water plant is excluded, INPUT Hops is added	In accordance with BIER sectoral guidance + production of coating and ink included + packaging disposal further specified	Differs from BIER sectoral guidance, excludes non company owned warehouses, only includes glass bottles and cans as packaging materials and malt, adjuncts and juices as ingredients, excludes utilities	In accordance with BIER sectoral guidance, slightly more specified
100% hard data, 1:1 perfect technology representation, reported in BCS (Brewery comparison system)	Well represented, only country electricity mix calculated based on data from 2 of 4 material suppliers because only 2 could supply the data	High. Only small gain to be made by more suppliers disclosing fuel volumes to capture fuel optimalization measures	Two types of refridgerants and LED lighting | draught beer, David system and Post-mix installations
tonne CO2	tonne CO2	tonne CO2	tonne CO2
% of total emissions	% of total emissions	% of total emissions	% of total emissions
Brewery manager/OpCo supply chain manager checks monthly data. Responsible function (Senior Global Lead Circular Economy) does audit (minor effort because very robust tool in place, breweries experienced), global audit team checks the function	Responsible function (Digital Project Manager) does thurough audit, global audit team checks the function	Responsible function (Global Lead Logistics) does thurough audit, global audit team checks the function	Responsible function (CRIS) does thurough audit, global audit team checks the function
N/A	N/A	N/A	N/A
Yes	Yes	Yes	Yes
Yes, also lists per source if it is based on primary data or not. Also appendix describing downstream emission factors and their sources. In HeiCF EF sources are missing, unclear which sources from methodology apply to which factors in HeiCF.	Yes, list with all included sources, only does not list per source if it is based on primary data or not. | source for EF is 'EF compliant LCI database' and 'PEFCR Guidance V6.2' seems to be based on hot air.	Yes, no list of specific sources coverend and if it is based on primary data or not | EF not mentioned, sources unknown, also not in HeiCF	Yes, also lists per source if it is based on primary data or not. | on EF PEFCR guidance V6.3 is mentioned, and FEVE and EAA. First one can't be
Yes, assumption for co-packers emissions is explained and justified	Assumptions well justified, only assumptions made whilst harmonizing SAT data not disclosed	Some assumptions mentioned in CF17 methodology are no longer mentioned in CF18, unknown if they are still made	Assumptions made whilst harmonizing SAT data not disclosed
100% because all data from actual processes in BCS	Medium, data extracted from SAT, MDM and CIL, exact production location cannot yet be validated (allocation files are very inaccurate)	High. Only small gain to be made by more suppliers disclosing fuel volumes to capture fuel optimalization measures	Only two types of refridgerants and LED prescribed by Heineken | Crosscheck of fridge data base with beforehand agreed uppon volumes | No check on unit level
Monthly up to date data available	Yearly up to date data available	Yearly up to date data available	Yearly up to date data available
Data is brewery specific	Data is packaging material specific, geography is irrelevant	Irrelevant because trucks efficiency due to elevation differences are out of scope	Data is fridge specific, geography is irrelevant because the effect of usage is out of scope
100% in BCS, all the OpCos with production sites. That can be breweries, soft drink plants, water plants or cider plants, they are all included.	Top 22 OpCos with production sites. | Primary focus on glass bottles and cans, which accounts for about 70% of the packaging carbon footprint. For the remaining packaging materials a calculation exists, but this is a more simplified formula	Top 17 OpCos (72% of consolidated volume) | Annual report states top-20?	34 OpCos (Over 90% of footprint for cooling, then extrapolated to 100%) | Home cooling excluded (hard to influence) | of 90%, approximately 80% is hard data, 20% is benchmark data
High due to BCS, low for co-packaging due to lacking realistic data	Material sources based on primary data, so high enough	Highest achievable level, measuring in km and litres, litres only sometimes missing	Allocation files are up to 30% inaccurate, fridge is KPI and this is based on primary data, so high enough
High due to BCS	Databases EU acknowledged | Activity data from SAT, mature financial tool, only vendor location missing, done based on unreliable allocation files	High due to BCS	Databases EU acknowledged | Activity data from SAT, mature financial tool, only vendor location missing, done based on unreliable allocation files
Goals is entire supply chain, system boundaries in accordance with BIER total supply chain boundaries - except for water plant - offices often but now always...	Goals is entire supply chain, system boundaries in accordance with BIER total supply chain boundaries - except for office and tier three material production	Goals is entire supply chain, system boundaries not in accordance with BIER total supply chain boundaries (the way it is depicted in the methodology document)	Goals is entire supply chain, system boundaries in accordance with BIER total supply chain boundaries
N/A	N/A	N/A	N/A