Carbon Added Accounting

A practical accounting framework for Carbon Footprint Accounting and Carbon Circularity Accounting in complex supply chains

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Acknowledgements

Carbon Added Accounting
Background and principles of the CAA framework

January 2021

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Introduction

Carbon Added Accounting (CAA)™ is a practical accounting framework for Carbon Footprint Accounting and Carbon Circularity Accounting in complex supply chains. This document describes the background and principles of the CAA framework.

2 Carbon Footprint Accounting

Carbon Footprint Accounting (CFA) is the practice of recording and accounting of greenhouse gas (CO_{2e}) emissions.

There are multiple drivers for companies to improve their practice of recording and accounting of greenhouse gas (GHG) emissions.

The increased awareness of the impact on climate change has created the desire to be able to prove to customers and governments their performance in measuring and reducing GHG-emissions.

Governments have started to put a price on emissions, be it as a straightforward tax or more indirect in a trading scheme like ETS, or regulations regarding vehicle fuel efficiency.

National GHG emissions reduction programs and targets (such as the Dutch 'Klimaatakkoord', 2019) are being developed and converted into more detailed regulations and laws. Part of the Dutch Klimaatakkoord is a specific demand for the development and introduction of CFA in supply chains (paragraph C.3.4.6).

The European Green Deal proposes a Carbon Border Adjustment Mechanism as a mechanism to influence supply chain decisions in global supply chains.

The possibilities to tax emissions in supply chains are being investigated. In 2018 CE Delft published a detailed study on 'External Costs Charge, A policy instrument for climate change mitigation', exploring the possibilities and ramifications of taxation of emissions in global supply chains. The report shows that current international trade law (WHO-rules) limits the possibilities to implement such an external costs charge.
A widely implemented CFA practice in supply chains, that reduces the cost of monitoring and auditing may be part of a solution for this conundrum. Such a practice may also be the trigger for modification of WHO rules as the pressure to mitigate climate change rises.

This white paper does not explore or consider taxation issues: the focus is on a practical implementation of recording and accounting of greenhouse gas (CO_{2e}) emissions in supply chains.

The Green House Gas Protocol is the most prominent and widely referenced methodology to measure and manage GHG emissions.

2.1 Green House Gas Protocol

The World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) have developed the Green House Gas Protocol (https://ghgprotocol.org/as a standard to measure and manage GHG emissions. It aims to describe the accounting standards for GHG emissions. The Corporate Value Chain (Scope 3) Accounting and Reporting Standard allows companies to assess their entire value chain emissions impact and identify where to focus reduction activities (https://ghgprotocol.org/standards/scope-3-standard). The GHG Protocol Scope 3 Standard is a supplement to the GHG Protocol Corporate Accounting and Reporting Standard, Revised Edition (2004). The current edition of the Corporate Value Chain (Scope 3) Accounting and Reporting Standard (GHG Scope 3) has been published in September 2011.

2.2 Implementation barriers of the GHG Protocol in accounting

Although the GHG Protocol has been available for many years the standard has not been widely adopted in the practice of accounting systems and processes. The management theory of Supply Chain Management points to the difficulty and cost of gathering actual, comparable and auditable information from many geographically dispersed parties in global supply chains. The volatility of supply chains creates an additional barrier for implementation: tracking changes in supply chains is not easy to implement.

The alternative is to model the supply chain based on assumptions, and estimate emissions based on default factors.

3

Carbon Circularity Accounting

Carbon Circularity Accounting (CCA) is the practice of recording and accounting of the origin of materials used in products. It aims to record and account for if materials have been sourced from recycling, or if they are 'virgin'.

The benefit of CCA is two-fold

First of all, the GHG-emissions of using recycled materials can be significantly lower than the GHG-emissions of the same material from an original ('virgin') source. The material aluminum for example requires a lot of energy to be produced from ores the first time (('virgin'). However, the recycling of aluminum has a relatively much lower energy footprint. Tracking the origin of materials improves the quality of the CFA output in Scope 3 reporting.

Secondly it enables Carbon Tracking Systems (CTS) to be implemented based on auditable data. CTS tracks the sourcing of materials. CTS is vital for improving the effectiveness and chain effects of sustainable and circular measures (e.g. replacing fossil materials with biomass, recycled materials or CO_2 from other processes).

There is yet no equivalent of the GHG Protocol for CCA.

4 Carbon Added Accounting

CAA is an implementation of CFA and CCA: the GHG Protocol Scope 3, plus the circularity of materials used.

The framework aims to:

- lower the threshold to start, maintain and improve the accounting processes and systems;
- reduce the interdependency of actors in complex supply chains;
- lower the costs and administrative burden of CFA and CCA;
- allow a viral adoption curve, that can be started by any actor in supply chains and spread out upstream and downstream;
- allow for multiple levels of data quality simultaneously without sacrificing transparency;
- allow companies to use the Pareto principle in improvement of data quality, at their own pace;
- allow for integrated audits by local accountants.

The main system design principle is based on a process hierarchy. A process hierarchy allows individual actors to operate independently, while the network of independent actors acts as a system.

4.1 Process hierarchy versus functional hierarchy

Many system designs use a functional hierarchy: decompose a system into functions and subfunctions, with control at the top.

A process hierarchy decomposes system in multiple levels of processes:

- The design and development of processes, boundaries and interactions.
- The implementation and maintenance of developed processes.
- Event driven usage of available processes by independent actors.

In a process hierarchy the 'top' does not control the actions of actors or is aware of every event.

A simple example is found in everyday traffic: how to manage the safety of vehicles traveling on roads that cross each other? The functional hierarchy solution is to install a traffic management installation with traffic lights. The automated traffic management system decides how to operate the traffic lights, and the drivers of the vehicles are supposed to follow the commands given by the traffic lights.

A roundabout is the solution for the same challenge, but in a process hierarchy system design.
The hierarchy is:

- The process of design of types of roundabouts, and rules for implementation.
- The process for implementing approved designs of roundabouts locally, according to the rules.
- Event driven use of a roundabout by drivers of vehicles, interacting with each other within the rules and layout of the roundabout.

Note that this approach has the following advantages:

- The actual event driven execution is highly distributed and local, in the hands of the actors locally (drivers).
- There is no need for 'global' information to be able to operate: drivers need to be able to see each other and know the rules, no more.
- The decision to implement a roundabout can be made independently and locally.

A process hierarchy design in the practice of accounting is Value Added Tax (VAT).
The hierarchy is:

- The rules for VAT accounting are made by governments.
- The administrative processes and systems that handle VAT accounting are set up by an individual company.
- The VAT on an invoice sent by a supplier for a purchase is recorded in the accounting department, the VAT of a sale is calculated and incorporated in the invoice that is sent to customers, and monthly the resulting net VAT for the company is calculated and submitted to the tax authorities.

This VAT system design results in an accurate and flexible taxation of the value added in complex supply chains, which is easy to implement locally. The concept of VAT calculations has been an inspiration for the CAA design: a proven approach that can scale quickly.

The CAA design however does not focus on taxation as a goal: the goal is to be create an recording and accounting practice that allows for measurement and management of GHG-emission in supply chains.

The CE Delft study 'External Costs Charge, A policy instrument for climate change mitigation' (2018) explores a 'VAT-like' taxation system that assumes that such a CAA practice is feasible. At the same time such a CAA practice is deemed impractical and too costly, which leads to the consideration of other taxation options.
A practical and affordable CAA practice would potentially lead to a different conclusion.

4.2 CAA design principles

4.2.1 Transport of goods combined with the transport of information

In supply chains the logistics function manages the flow of goods and/or materials between locations that perform some transformation of the input and create value added output: transformations like mining ore of agriculture, refining, manufacturing or processing, assembly, storage and break-bulk, retail, and so on. The basis unit of calculation is a transformation site, combined with the transport to the next step in a supply chain.

The process starts when a transformation site, for example a manufacturer of beer purchases goods and raw materials (inputs). The inputs are required to manufacture beer and put the beer into bottles or kegs for subsequent transport to wholesalers. The transport of goods or materials involves picking up goods at one location and delivering them to the next location. The GHG-emissions of a particular combined transport activity[1] can be allocated to every item transported, based on the COFRET allocation principles. This is well understood and defined and implemented in practice already[2]. The transporter is required to allocate GHG-emissions of transport activities to each individual transport order line item (origin-destination, type and quantity of goods).

The transporter contracted by the supplier picks up the goods to be transported at the manufacturing location and transport the goods to the beer manufacturer.

This transporter delivers each line item at the destination, adds the allocated GHG-emissions of the transport activity to the line item and delivers the information to the beer manufacturer[3]. The beer manufacturer receives and stores the input and records the embedded GHG and circularity information as delivered.

4.2.2 Allocating input information to output information

A recipe of the manufacturing process delivers the allocation mechanism for the calculation of the embedded GHG-emissions and circularity of an output. Recorded data on inputs and energy is used to calculate the embedded GHG-emissions and circularity.

The calculation consists:

- allocation of embedded GHG emissions and circularity of inputs[4] used;
- allocation of GHG emissions of energy used;
- allocation of 'depreciated' GHG emissions and circularity of investments (assets used);
- adding the allocated information to a specific total.

The accounting system supplies the data per order that needs to be shipped to a specific customer. The transporter contracted by the beer manufacturer picks up the goods to be transported at the manufacturing location and transport the goods to the customer.

This transporter delivers each line item at the destination, adds the allocated GHG-emissions of the transport activity to the line item and delivers the information to customer. The customer receives and stores the input and records the embedded GHG and circularity information as delivered.

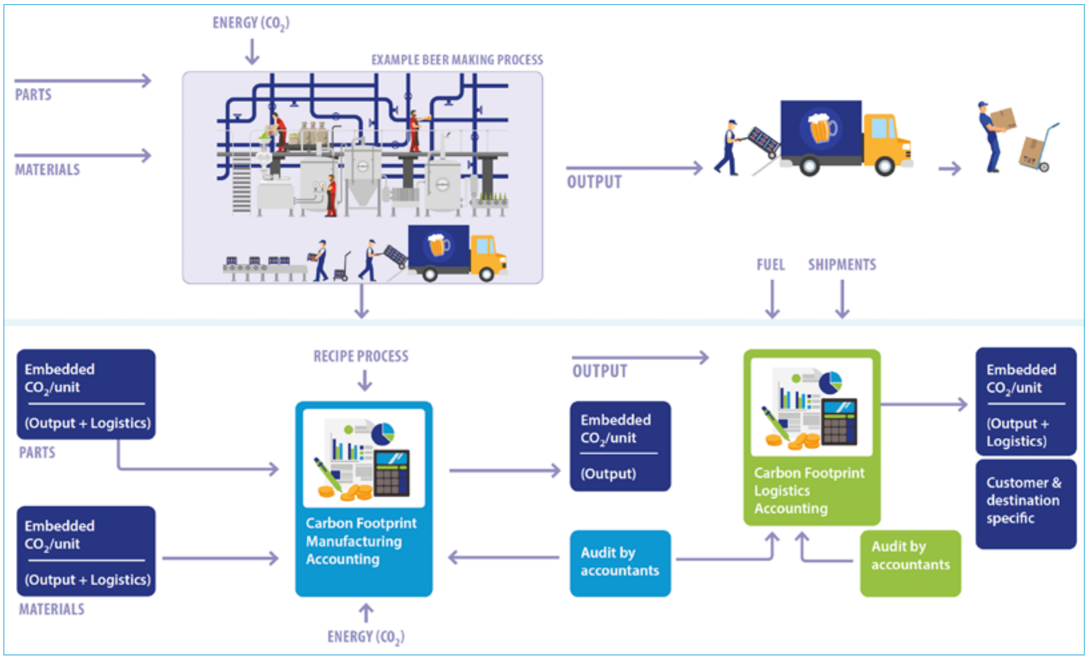
1 *E.g. a truck that makes an efficient roundtrip, picking up and delivering goods at many stops, for multiple clients simultaneously.*

2 *E.g. www.bigmile.eu*

3 *The alternative is that the original manufacturer receives the allocated transport data from the subcontracted transporter, proceeds to add everything up, and sends the data to their customer.*

4 *The reality of beer manufacturing adds a minor complexity: yeast creates CO_2 during fermentation. It is easy to incorporate this in practice.*

Allocating input information to output information



4.2.3 Data quality

The design principle of CAA is that multiple data quality levels can be used simultaneously.

A data quality level is a meta-data descriptor attached to any number which value represents an input or output to the calculation.

The meta-data descriptor defines the mix of data quality levels for each calculated number. By definition each number has a mix of inputs with their own data quality levels, resulting in a new mix of data quality levels.

Four data quality levels have been defined, based on practical applications:

Gold+	based on fine-grained detailed measurements at least daily;
Gold	based on measurements, aggregated in less than a month;
Silver	based on measurements or indirect estimates, aggregated over a year;
Bronze	based on generic default values publicly available.

In a meta-data descriptor of a number/value the combination of data and the algorithm for calculation of the value also defines the new mix of data quality levels: the algorithm for calculation the main value is also applied to the data quality inputs.

The percentages of data quality always add up to 100 %.
For example:

- 100 default number for a given input
  Meta-data 0% G+, 0% G, 0% S, 100% B

- 150 calculated from multiple inputs
  Meta-data 10% G+, 25% G, 25% S, 40% B

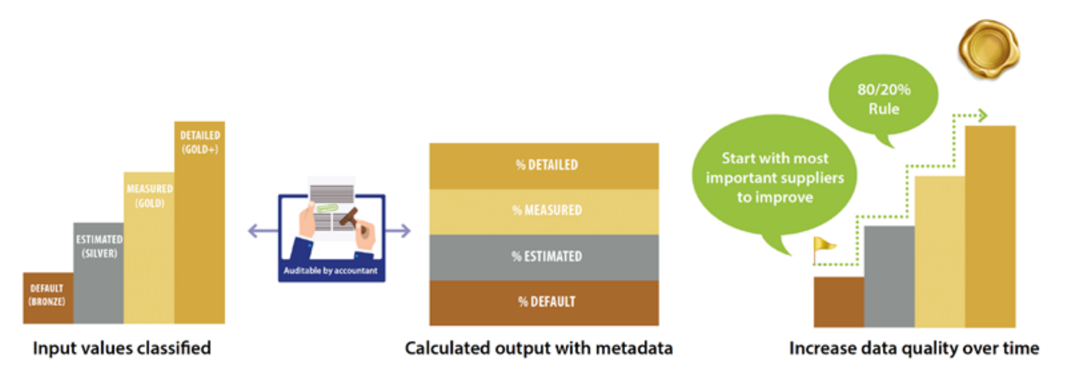
The meta-data percentages are calculated alongside the number in the same calculation procedures (according to the recipe used in production), mixing inputs into a new result.

In a simple example:

- 2 ingredients are combined and mixed
  - 25 % of ingredient A, with 100 % Gold+ data quality
  - 75 % of ingredient B, with 100 % Bronze data quality
- The result is a mix with a meta-data descriptor as follows
  - 25 % Gold+
  - 75 % Bronze

More complex calculations can easily be derived from this principle:

Transparancy of data quality (auditable)



The benefit of the data quality descriptor is two-fold:

- it allows for an individual start and improvement process;
- it makes the auditing of results much easier.

In reality, especially at the start of the implementation of CAA by a particular manufacturer, it is unlikely that most (or any) part or material deliveries are accompanied by data on embedded GHG and circularity. Allowing anybody to start with defaults lowers the threshold to start.

An explicit data quality descriptor that is recalculated when a new number is generated makes it much easier for auditors to check the results: it is explicitly visible when assumptions have been used instead of measurements, or when detailed measurements have been used instead of aggregates.

4.3 Viral adoption and continuous improvement upstream and downstream

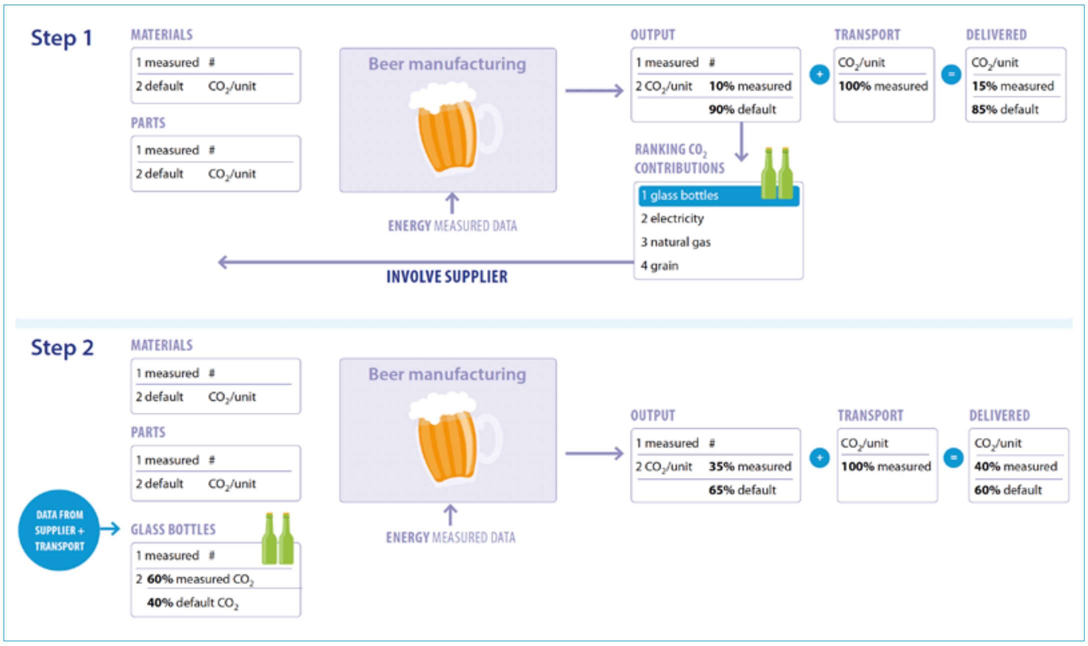
The CAA framework is designed to be initiated by any individual manufacturing at will. After the first iteration a continuous improvement process can be implemented, with effects upstream and downstream.

For example, the beer manufacturer has decided to start the first iteration with defaults for the input, measured data for energy, and measured allocation data of transport.

The calculated result will show through Pareto analysis the factors that contribute the most to the GHG-emissions or circularity of materials. In this example the focus is on GHG-emissions, and glass bottles appear to be the major contributor.

The beer manufacturer starts to involve his supplier, who agrees to implement the same CAA accounting framework. The result is that these inputs improve in data quality, leading to an improvement of the data quality of the output.

Continuous improvement process

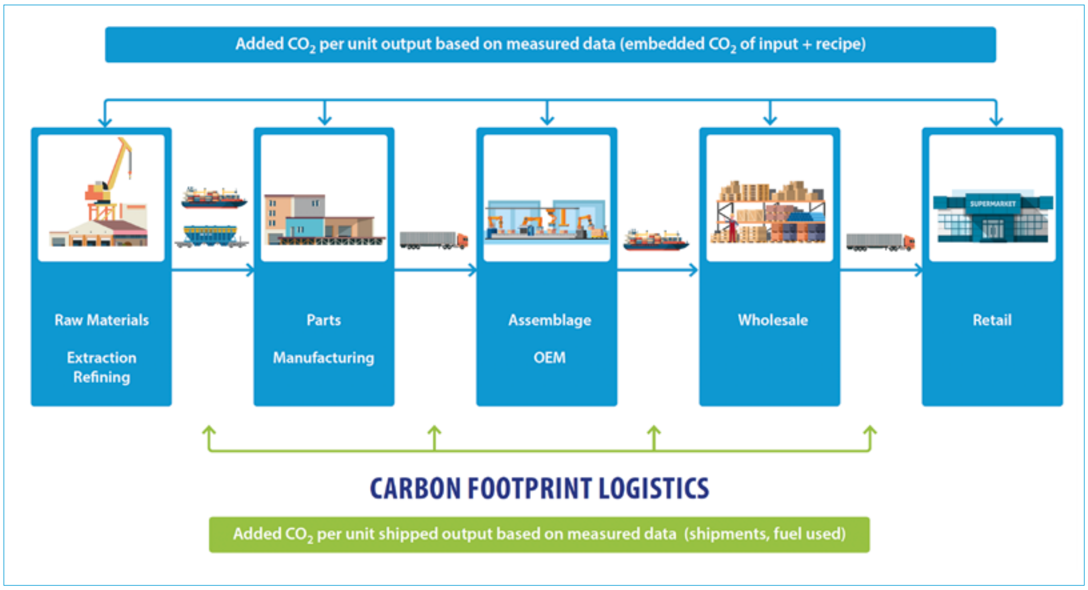


The beer-manufacturer starts to supply GHG-emission data to its customer. This most likely will lead to an increased demand for this data from customers, and pressure from suppliers on other manufacturers to follow suit.

5 CAA in a complete supply chain

The implementation of CAA in a complete supply chain only requires individual actors to do local CAA accounting and transfer information, much like VAT accounting. Complex volatile supply chains can easily be accommodated.

Complete supply chain



6 Implementation of Carbon Added Accounting

The implementation of Carbon Added Accounting consists of two basic elements, being:

1. Having the essential elements in place, and
2. Having the accounting procedures clear.

And as defined further, neither step is complicated nor requires significant investments.

6.1 Essential elements

Getting started with Carbon Added Accounting requires a few steps to go by. These steps are as follows (and detailed further):

- Management commitment;
- A continuous improvement plan;
- An Accounting information system;
- The Carbon values per material used;
  - Including circularity data.
- The quality assurance of the carbon values per material;
- The Product Recipe(s).

6.1.1 Management commitment

The responsibility for implementing the GHG protocol starts at the top in order to have the essential elements in place and the accounting procedures clear. Management can provide the conditions to make a start with CAA and subsequent improvements. The usage of CAA runs throughout the company. From supplier selection to product placement and marketing. Hence, without management support the ultimate goals are unachievable.

6.1.2 Continuous improvement plan

By analyzing CAA results, information becomes available to improve both GHG outcomes in alle three scopes as well as data quality. This can be used to continuously improve the carbon performance throughout the organizations' processes. As information gets more detailed and accurate, organizations will eventually consider network effects (with suppliers and customers) for the benefit of the entire supply chain.

6.1.3 Accounting information system

The practical implementation of CAA can be realized within any regular administrative system. Hence little extra investments are needed to get started and to base CAA on. Within the regular accounting system, the general ledger provides the option for registration the positions and flows of Carbon values per GL account and usage of cost base classification for the reliability level of the different data qualities distinguished.

Alternatively, separate accounting software could be used, specifically designed for this application.

6.1.4 Carbon values per material used

For the materials and energy used the emission factors (CO_2equivalent) and/or circularity of the content must be collected. For many industries, such emission factors are provided in reports available through the internet. However, in some cases there are not any unambiguously sources.
The same applies to the circularity of the content.

The approach is to start with the best available level of information, even if that implies that there is no credible source at the moment. The transparency given by the data-quality metadata is an important management tool to focus efforts a better data position, where it counts.

6.1.5 Carbon value quality assurance

As CAA calculations are more widely implemented, there will be an increasing demand for carbon value quality assurance. This to increase the quality of such calculations as well as the reliability of benchmarks. And as the data quality level increases the data quality of the product created is (logically) increasing as well.

6.1.6 Product recipe(s)

The CAA methodology uses product recipes to allocate carbon (in all three GHG scopes) to end products. This provides the manufacturer insight in the carbon generated to produce specific products. In the case of series production, carbon can also be allocated to production batches. And depending on the measurements available, carbon can even be detailed down to specific production phases, production machines on a day to day basis (or even more detailed). As a result, the manufacturer receives the information needed for (continuous) improvements.

6.2 Accounting procedure

The accounting procedure comes down to the separate distinguishable flows within production:

- Raw material;
- Utilities;
- Labor;
- Machine usage (capital goods).

The critical elements of the accounting procedure are described shortly per flow.

6.2.1 Raw materials flow

Raw materials are accounted for against the carbon value and distinguished data quality classes as carbon stock (balance sheet item) when purchased (either delivery or invoiced). Creation of the product reduces the carbon stock into a separate account for usage following the production recipe of the product. The split in data quality classes is followed here as well.
It is advised to use the fifo system in order to show the development of the carbon values as well as data quality.

6.2.2 Utilities flow

For utilities the two-step system, registering the purchase and the production separately, is used as well.
It is advised to use separate accounts for the different utilities in order to maintain a transparent view.

6.2.3 Labor usage

Labor usage includes all labor providing services to the company which are not dealt with already within the raw material, utilities and capital goods for as far as contributing (in)directly to the products created. Hence it includes payroll staff, staff hired as well as services used (such as lawyers, auditors etc.). And is split in the data quality classes as well.
The carbon footprint per hour used per period is the base for the first step of the two-step system. Obviously, the direct labor should have a markup for the indirect labor. Based on the recipe the usage can be calculated and entered.
It is advised to split the accounts for direct and indirect accounts in order to follow these flows separately.

6.2.4 Accounting for emissions from capital goods

The GHG protocol allocates capital goods emissions to the year of purchasing. This choice would distort CAA calculations, as results would not become comparable over years, or between manufacturers. Therefore, in CAA depreciation of CO_2_as_a_stock is advised.

Capital goods used are basically a product created for its application, used over many years. Hence either the supplier should supply the carbon footprint (and quality classes) including installation on the production location or the company establishes a calculation by themselves. The total carbon footprint is recorded as a stock element. The total carbon footprint is then recalculated to either a time element or a mechanical action. Through the recipe the usage is administered.

For reference: the (not supported) section of the GHG Protocol standard.

This category includes all upstream (i.e., cradle-to-gate) emissions from the production of capital goods purchased or acquired by the reporting company in the reporting year. Emissions from the use of capital goods by the reporting company are accounted for in either scope 1 (e.g., for fuel use) or scope 2 (e.g., for electricity use), rather than in scope 3.

In financial accounting, capital goods (sometimes called 'capital assets') are typically depreciated or amortized over the life of the asset. For purposes of accounting for scope 3 emissions, companies should not depreciate, discount, or amortize the emissions from the production of capital goods over time. Instead companies should account for the total cradle-to-gate emissions of purchased capital goods in the year of acquisition, the same way the company accounts for emissions from other purchased products in category 1. If major capital purchases occur only once every few years, scope 3 emissions from capital goods may fluctuate significantly from year to year. Companies should provide appropriate context in the public report (e.g., by highlighting exceptional or non-recurring capital investments).

6.2.5 CAA analysis

Carbon Added Accounting gives insight in the following:

- Carbon footprint stocks per separate flow;
- Controls to monitor complete allocation of the carbon purchased (raw materials, utilities, manpower and machines) to the products;
- Complete recognition of the data quality classes for carbon stock and usage;
- The carbon footprint per product produced with its respective quality classes;
- An auditable CCA system.

5 Source: https://ghgprotocol.org/sites/default/files/standards_supporting/Chapter2.pdf

7 Addendum 1: example

The case is to manufacture 1.750 kg concrete using different raw materials, utilities and men hours. Machines & materials are excluded in this simplified example.

The recorded CO_2 footprint of the inputs to be used in the recipe for concrete is as follows.

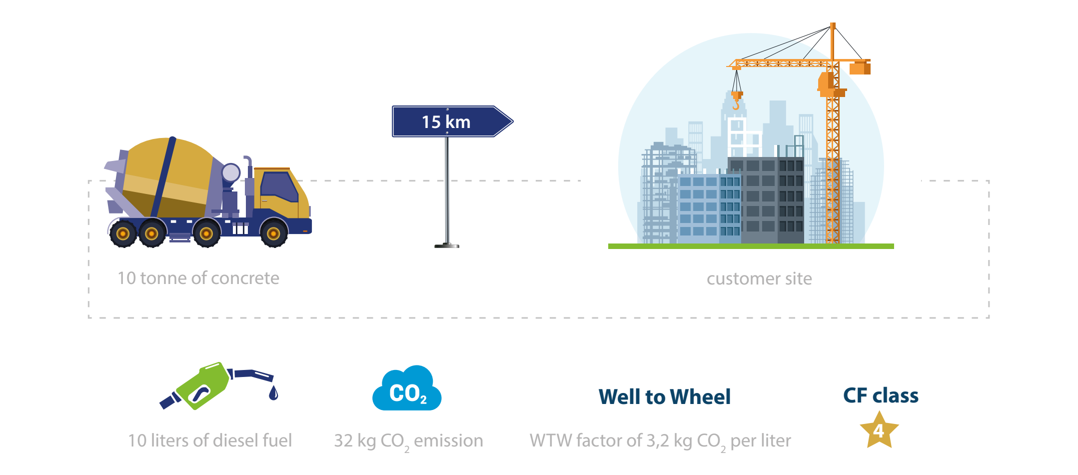
In this case the manufacturer has chosen to label the Data quality levels as 1 to 4, where 4 is Gold+ and 1 is Default.

Item	CO_2 (grams) per CF class					
	Per	1	2	3	4	Total
Sand	m^3	1.900	520	0	0	2.420
Gravel	m^3	2.067	233	0	0	2.300
Cement	kg	583	168	0	0	751
Water	m^3	260	0	0	0	260
Gas	m^3	0	0	0	1.884	1.884
Electricity	KwH	0	0	0	405	405
Labour	hr	0	0	800	0	800

For 1750 kg cement the total footprint is:

Item	Quantity for 1750 kg concrete	CO_2 (grams) per CF class					
		Per	1	2	3	4	Total
Sand	0,50	m^3	950	260	0	0	1.210
Gravel	0,75	m^3	1.550	175	0	0	1.725
Cement	325,00	kg	189.500	54.575	0	0	244.075
Water	0,16	m^3	42	0	0	0	42
Gas	1,00	m^3	0	0	0	1.884	1.884
Electricity	100,00	KwH	0	0	0	40.500	40.500
Labour	0,75	hr	0	0	600	0	600
Total		1.750 kg	192.042	55.010	600	42.384	290.036
		Per tonne	**109.738**	**31.434**	**343**	**24.219**	**165.735**

A ton of concrete does thus have a footprint of 165,7 kg CO_2 (109,74/31,43/0,34/24,22).
10 tonne of concrete is subsequently transported to a customer site, 15 kilometers away. The roundtrip requires 10 liter of diesel fuel, which produces 32 kg of CO_2 emissions with a WTW factor of 3,2 kg CO_2 per liter. The 32 kg CO_2-emissions have a CF class of 4.



The delivered concretre therefore has a footprint of 168,9 kg (109,74/31/43/0,34/27,42).

The cement CF class 1 number makes a significant impact on the quality of the total outcome. Improving the data quality of that input would improve the data quality of the output.

A major advantage of this method is thus easy setting of targets for improvements keeping track of progress.

Administration

It is possible to integrate the registration and calcution is any regular accounting software.

Specific actions to realise the continuous administration are:

- Create separate general ledger accounts for CF accounts per purchasing group such as Materials, Water, Gas, Electricity. These are balance sheet accounts.
- Create separate general ledger accounts for CF usage per the same purchasing groups as above. These accounts are P&L accounts.
- Make separate general ledger accounts within the balance sheet and the P&L account for CF usage of Machines and the supporting Materials as well as for men hours.
- Include (if possible) the CF scores per class within the materials base and include automatic entries based on the recipe.
- In order to divide the entries per CF class f.i. the cost places of cost bearer classification can be used or even through separate general ledger accounts as well of course.

The actual administration is done through:

- Entering the CF value related to purchases of goods into the balance sheet account for this purpose (In the example below the light blue boxes). If accounts are made on supplier level the totals per supplier can be maintained as well.
- Entering the production CF values to the respective P&L accounts (split in their CF class values) and credited to the related balance sheet account.

The entries do follow this pattern:

Raw materials		Utilities Water		Utilities Gas		Utilities Electra		Men		CF Total	
CF Purchase		CF Purchase		CF Purchase		CF Purchase		CF Purchase		CF in Stock	
500.000	247.010	50	42	2.000	1.884	40.000	40.500		600	542.050	289.436
CF Usage		CF Usage		CF Usage		CF Usage		CF Usage		CF Usage	
192.000		42		-		-		-		192.042	
55.010		-		-		-		-		55.010	
-		-		-		-		600		600	
-		-		1.884		40.500		-		42.384	

This results in:

- A clear value of the CF value within the Raw material stocks (252.99 kg).
- A control mechanism to indicate whether the Raw materials CO_2 was fully allocated to the production
- A control mechanism to indicate whether all use of CO_2 from water, gas and electricity has been fully allocated to the production as the balance sheet account should be zero at the of a reporting period.
- Not included in the example is a control mechanism to show the use of CO_2 for fixed assets and supporting maintenance etc per period and thus throughout their lifetime.

Adding circularity can be done as an extension of this method.

Data integrity and audit

The integral registration of inputs and outputs allows auditors to assess the data integrity and data quality of the output statements, as a part of their regular audit.

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