Workshop Summary

Towards the Combination of CO_2-Calculation Methods

Results and Insights

Electro and Digital Industry Association

Content

Abstract

Target and Summary

There are several standards on how to calculate the carbon footprint of a single product (list not complete, just for example): ISO 14040-44, GHG Protocol, ISO 14025, ISO 14067, EN50963, PEF, Product Category Rules and Product Specific Rules e.g., TS 63058 from EPD program Operator. Each standard and methodology is within a single calculation consistent and valid, however discrepancies occur between them.
Nevertheless, it is not the target of this workshop summary to state on which standard should be used. Furthermore, it is to be mentioned that there are several directives in preparation which might have an impact on the standards in the future, e.g., eco-design, taxonomy, etc.
Hence, when combining multiple calculations, which are performed using different standards, some criteria may be different (e.g., system boundaries). As a result, the calculated values are often considered as not comparable. Moreover, since the assessment is generally performed by a single person, assumptions and modelling practices may differ as well.

Within the electro industry, the products are often complex systems consisting of an assembly of several articles from different companies. Since not all the companies are using a harmonized methodology to assess the carbon footprint of their own articles, assessing the carbon footprint of the complex system is difficult, as specific product carbon footprints may lead to a high uncertainty on the final result.

Dealing with uncertainties is common practice when environmental assessment is performed (uncertainty is defined in most of the standards listed above). Besides, whether the study aims at providing transparency on carbon footprint of the system or at comparing different designs and scenarios, uncertainty shall not be tackled the same way.

Indeed, when transparency is the goal, assessing a system carbon footprint using different sources of data is common practice, as long as the representativeness of the data source is improved (for instance, one practitioner will rather select an emission factor for a raw material that is representative of the technology used by the company within the good geographical region, even if it doesn't come from the same database than the emission factors used to assess electricity production of manufacturing phase).

On the other hand, when carbon footprint is performed to compare different scenarios, some calculation standards and the assumptions need to be harmonized in order not to bias the comparison (e.g., avoid double counting and exclusions).

In the summarized workshop a methodology on how to combine several articles within different calculation standards has been evaluated on a single control cabinet as proof of concept.
To estimate the impact of assumptions and resulting variations in the emission-factors, an example product has been defined and corresponding exemplary emission factors have been agreed on. By using multiple calculations with different standards and performed independently by different persons and companies, uncertainty in form of an error bar has been estimated. The result depends highly on the selected article and cannot be applied to other systems, however proof of concept and resulting recommendations to reduce the difference in the results have been determined.

As a result, the workshop summary shows how the different standards can be used to perform a common calculation for a complex product consisting of different components which are calculated each using different standards.
Even if transparency of environmental footprint shall eventually be undertaken for a full life cycle, a cradle-to-gate approach has been selected as a first step. Each component/product therefore needs to be calculated by the cradle-to-gate but additional information on the end-of-life should be provided to have valid calculation on the component-level.
When the emissions factors of each material and the boundaries are harmonized, the variation between four individual calculations with different calculation standards is less than 7% regarding the total emissions in CO_2 equivalents.

Focusing on carbon footprint is a first step to quickly identify best practices and foster harmonization, however assessment shall ultimately focus on several criteria covering additional relevant environmental aspects of the system (resources, water, air pollution…).

1 Overall Approach to Perform a CO_2-Calculation on a Control Cabinet

The ZVEI-Show-Case PCF@Control Cabinet introduces the concept of the Digital Product Passport for Industry 4.0 (DPP4.0) and demonstrates, how the established standards Identification Link (IEC 61406) and Asset Administration Shell (IEC 63278) can be used to identify products and grant different users access to relevant product information in a digital, machine-readable and interoperable format. To demonstrate the benefits of DPP4.0, it is used in the project to automatically calculate the cradle-to-gate product carbon footprint (PCF) of a control cabinet across the supply chain, see Illustration 1. To do that each participating company calculated the product carbon footprint of the products they supplied to the system integrator (manufacturer of the control cabinet) and made these values accessible via DPP4.0. For the calculation of the PCF of each product, the product manufacturers were responsible only for their own product and calculated the PCF values with their own chosen methods and standards. Therefore, the PCF values of the supplied product were calculated using different available standards such as ISO 14040, PEP Ecopassport, ISO 14067 and the GHG Protocol. In order to calculate the total PCF for the control cabinet, the system integrator summed up all provided PCF values of the supplied products and added the PCF value of the needed transports and assembly processes. With DPP4.0 this summation was automated simply by scanning the applied identification links on the products.

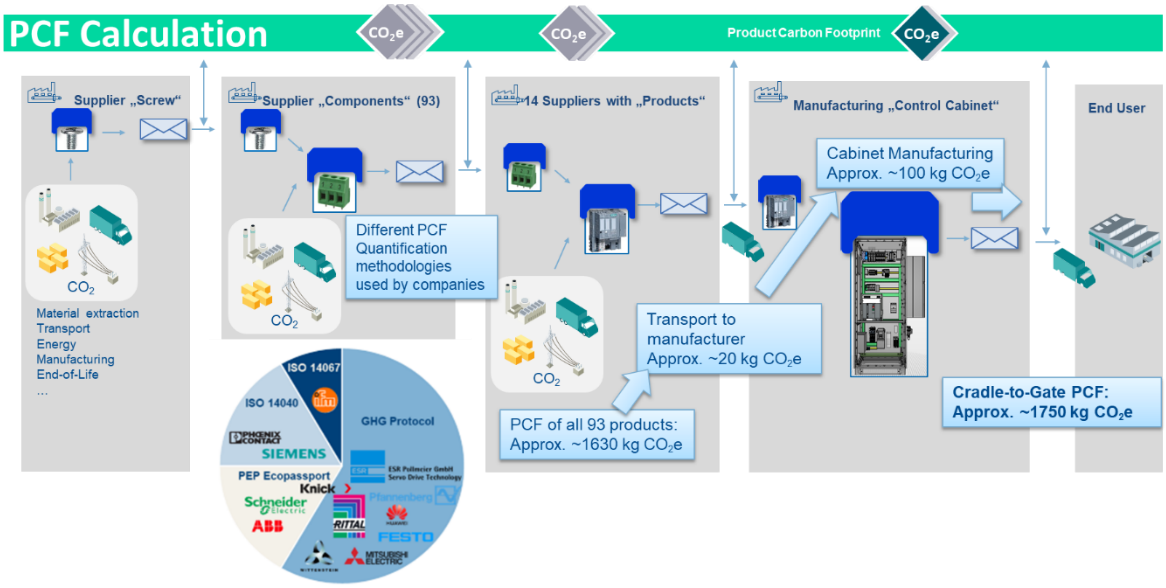

Illustration 1: Exemplary value chain of the ZVEI-Show-Case PCF@Control Cabinet

2 ZVEI Example Product

2.1 Using an Imaginary Product in Order to Identify Assumptions and Definitions

To simplify the exercise, an imaginary product has been defined by the participants of the Workshop and the respective working group in the ZVEI-Show-Case. The bill of materials presented below gathered common materials and components used in EEE products. Associated emissions factors for each material and activity have been agreed upon as well to narrow down the comparison of calculation to standard deviation only.

The materials and emission factors in Table 1 are imaginary but were agreed on for a common calculation

Material	Amount	Carbon Footprint Value
Plastics	100 g	7 kgCO_2 per kg
Metal (Fe)	50 g	2,4 kgCO_2 per kg
Aluminum	80 g	10 kgCO_2 per kg
Copper	20 g	6 kgCO_2 per kg
Diode (0,2 W)	3 Pieces / 5 mg	0,01 kgCO_2 per piece
Resistors	1 Piece / 2 mg	0,01 kgCO_2 per piece
PCB	50 cm^2	56 kgCO_2 per m^2
Wires	100 cm	10 kgCO_2 per m^2
Packaging	8 g	3 kgCO_2 per kg

Table 1: Materials and emission factors of the exemplary product

Furthermore, the transportation and needed energy has been agreed upon to reduce the unclear estimations as much as possible, as seen in Table 2.

Processes	Details	Carbon Footprint Value
Transportation	1000 km by Lorry	88 gCO_2 per ton and km
Transportation	10000 km by ship	20 gCO_2 per ton and km
Total Electricity Consumption	10 kWh	520 kgCO_2 per MWh

Table 2: Processes and emission factors of the exemplary product

Using this set of information, three independent calculations with different standards have been performed to identify the remaining estimations necessary to be able to calculate the product carbon footprint of the exemplary product.

2.2 Narrowing Down the System Boundaries

To avoid double counting when declaring the upstream and downstream values of several articles in an automatic way, the carbon footprints used for this pilot have been limited to the cradle-to-gate approach. Cut-off rules may be specific depending on the standard selected by the participants.

As the production and value chains at the current time are very flexible and often stressed by external effects, a representative time range should be used to calculate the amounts of material and energy used. Even the mode of transportation might vary within one year.

2.3 Using Averages and KPIs

When calculating the carbon footprint many different standards and Indicators can be used and each methodology will be within the defined boundaries consistent. To be comparable, a common frameset for the use of average data and indicators such as carbon footprint in terms of global warming potential must be made.

For the workshop and the exemplary product EF3.0 including the Global warming potential 100 (GWP 100) was used. All biogenic materials should therefore have no emissions at the End of Life but on the other hand those materials may not have a negative factor in the cradle-stage as well. Considering this ruleset, the final user of the control cabinet will not have to think about any open burdens at the end of the life of the control cabinet, which is furthermore aligned with the EN15804+A2 (used e.g. for buildings).

As the production and value chains at the current time are very flexible and often stressed by external effects, a representative time range should be discussed to be used to calculate the amounts of material and energy used. Even the mode of transportation might vary within one year.

- The project considers a full year as an appropriate time range to calculate average and being a valid estimation for the carbon footprint.
- In-bound transportation is small contribution to PCF yet could be complex to model. Recommendation is to keep it simple and to propose default value for three inbound logistics routes: Intercontinental (typical X0.000km), Regional (X00 km) and Local (X00 km) with default means and distances (default value from EN50693).
- It is possible to use primary data, i.e., to use industry specific transportation means and distances. The specific data shall be based on a yearly average for every production inputs. Information of the year considered to assess the transportation shall be made available.

3 Discussion of the Results

3.1 Usage of Data and Common Definitions to Harmonize the Calculations

To compare the different assumptions and the results of different calculation methods, the exemplary product has been used to have the same parameter for the calculation. Four calculations have been performed using different assumptions. The four calculations have been performed using the following standards:

- GHG Protocol
- ISO 14044 Life Cycle Assessment Standard
- Product category Rules edition 4 of the PEP Ecopassport association, based on the EN50963 standard (PCR for EEE products)

The results of the different calculations are shown in Diagram 1.

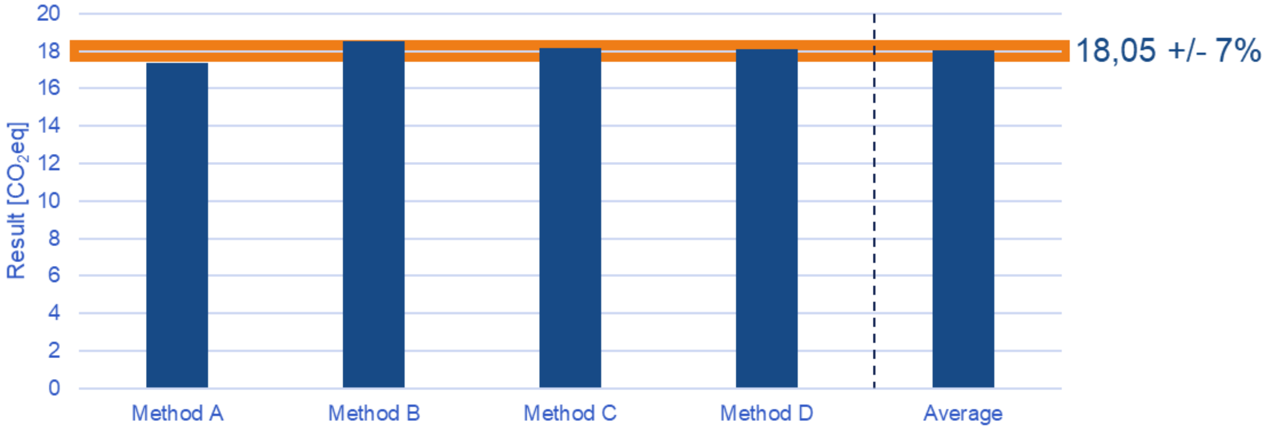

Diagram 1: Results of different calculation methods for the exemplary product

The results show, that when the emissions factors of each material and the boundaries are harmonized, the variation between four individual calculations with different calculation standards is less than 7% regarding the total emissions in CO_2 equivalents.

The remaining differences are due to:

- Mainly individual assumptions within each model (modelling best practices applied by the operator)
- Methodology recommended by the different standards such as different cut-off rules.

At this point, the 7% variation is representative only for the exemplary product selected and highly dependent on the bill of materials agreed upon. A modification in the mass or nature of the components will highly influence the uncertainty range. Therefore, these results should only give an indication but are not transferable to any other system.

3.2 Information on the materials used

By selecting in advance, the bill of materials granulometry and associated emissions factors, the deviations caused by using different calculation standards drastically decrease. To keep the uncertainty as low as possible, product specific rules defining the granulometry of the bills of materials to model may be applied.

Additionally, using a single harmonized database for sourcing emission factors seems paramount to foster both quality of communicated carbon footprint and comparability within.
To leverage environmental performance of materials, many upstream suppliers rely on mass-balance or book and claim approach (for instance for chemical recycling or implementation of biobased content in one compound). The mass-balance approach allows to declare an environmental performance that is decorrelated from a physical flow, often when industrial processes are integrated and don't allow for material traceability. As per now, neither the GHG protocol nor the EPD program operators allow mass-balance approach in accounting practices. The question of acceptance of the mass-balance approach has not been tackled at the workshop.

Even though using data from a database will help in terms of comparability, the use of primary data from suppliers will be key in the future to reduce the carbon footprints of individual products.

3.3 Boundaries and Cut-Offs for the Exemplary Calculations

Infrastructure (construction, installation of the buildings) are out of scope, however infrastructure operations such as energy consumption at manufacturing stage are in scope even though this activity is often de minimis compared to the raw materials footprint.

Performing carbon footprint calculations on a cradle-to-gate scope only has some limitations, especially that end of life does influence the way cradle-to-gate assessment is performed.
For instance, all biogenic materials generally have no or negative emissions at the manufacturing stage due to the absorption of biogenic carbon during the vegetative growth phase. However, this 'stored' biogenic carbon shall be released at end of life whether the product is recycled, incinerated, or landfilled. It must be discussed if, biogenic materials shall have negative emissions on the calculations or should they be set to zero, to avoid double counting.

Additionally, there are different approaches to model the recycled content and the recycling potential depending on the selected standards. Two methods exist as defined in the ISO14044:

- Cut-off method (or stock method)
- Avoided burden method

With the cut-off method, recycled content has an environmental burden, and no impact is reported at end of life (basically the recycling impact occurs at the manufacturing stage). For the avoided burden method, the recycled content has no environmental burden, and the recycling impacts are reported at the end-of-life stage. Additionally, the avoided burden method allows to declare avoided impacts outside the scope of the system (referred as Module D in the EN15804+A2 – product category rules for building and construction materials, widely spread across the industry). Hence, focusing on a cradle-to-gate scope may not consider this heterogeneity of practices. That suggests that a cradle-to-gate scope is not sufficient for comparison nor transparency, to allow a system carbon footprint on a consistent scope. A cradle-to-gate and end-of-life approach is expected to yield better results. When taking the whole live of a control cabinet into account, the lifetime-emissions play the same role as initial emissions for production as described and calculated in this paper. The use-phase is not part of the scope of this pilot study.

3.4 Cut-Off Criteria

Depending on the standards used, the cut-off criteria, i.e., the number of materials and energy flows that could be excluded from the system, are not set at the same value. For instance, ISO14044 defines the cutoff criteria without providing a threshold, on the other hand the PCRed4 of PEP Ecopassport set a 5% threshold for the cutoff rules. Finally common practices of Life Cycle Assessments generally set the cutoff threshold to 99%.
Additionally, the cutoff thresholds shall apply to the total mass of the system, the total energy consumption and environmental impact
In the current exercise, all materials and processes that have a relevant influence on the level on the PCF have been evaluated. While the mass and energy thresholds are generally correctly set up when an environmental footprint is assessed, the environmental impact is generally harder to handle.
For this exemplary calculation, a 95% threshold was used and including materials and components of Table 3 to ensure the environmental impact threshold is included. This is in accordance with PCRed4 of PEP Ecopassport, however, the list is not complete and relies on the product category.

Materials	Components
Gold	Microprocessors
Silver	Magnesium anode
Silver	Magnesium anode
Copper and alloys	Tantalum capacitor
Antimony trioxide[1]	Arsenic-Gallium capacitor
Insulating gas (e.g.: SF6)	Batteries and storage cells
Coolants	
Rare earths: Indium, Molybdenum, Neodymium	

Table 3: Materials and components for threshold

3.5 Compensations and Offsetting

On the company level many companies started to compensate for the emissions, e.g., by financing sustainable projects or purchasing green electricity or sustainable fuels. The challenge is to bring that information to the level of the product calculations. Therefore, following points should be considered when harmonizing calculation approaches:

- Compensations (Insetting, green electricity, biofuels) can be considered for the PCF (evidence on certificates needs to be provided). A transparency of the used measures (compensation / insetting & offsetting) should be given on company level e.g., in a sustainability report. (Scope 1+2).
- The usage of insetting activities (e.g., green electricity) will be the key for a change of the PCF in the future to reduce CO_2-emissions. Therefore, the benefits on a company level should be useable in a PCF calculation.
- Certificates on product level (compensation scope 3) and offsetting are not in focus.

[1] Additive used in plastics.

4 Recommended Discussion Topics

When working towards the harmonization of calculation methods and to ensure the comparability between values calculated with different methods, especially the following three topics should be considered, as they lead to uncertainties and hard to compare results.

- Data source: The selection of different, non-harmonized data sources of emission factors results in calculations with the different results as the given values in the different sources vary. A harmonized and publicly available data source is therefore seen as paramount to allow industries comparable and transparent calculations. Furthermore, with the use of primary data instead of database values, accuracy of the calculations can be increased.
- Modelling: The assumptions to model the system, including the selection of the right datasets depending on geography, time and represented technology. It can be noted that the selection of data sources would have a great impact on the modelling choices. Modelling discrepancies could therefore be reduced with the above-stated harmonization of databases. Introducing product category rules and product specific rules could help to ensure consistency in modelling assumptions as well. Most of modelling discrepancies come from downstream stages (Usage, End of Life) where endless scenarios can be picked up depending on customer, segment, geographies… reducing the comparability to a cradle-to-gate scope. Moreover, downstream impact should be encompassed using product attributes such as energy efficiency, reparability index or recyclability rate.
- Method: Coming two-fold, either through the selection of the characterization methods to assess the environmental footprint and/or the general methodology selected (e.g., system boundary definition, allocation rules, cut off rules…). Harmonized characterization methods, e.g., climate change categorizations factors to assess the global warming potential of different materials should be discussed.

To foster carbon footprint comparability, uncertainty shall be reduced by strengthening consistency and harmonization of carbon footprint practices across the industry.

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