



## **The Carbon Handprint approach to assessing and communicating the positive climate impact of products**

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Final Report of the Carbon Handprint  
project

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## Preface

This is the final report of the Carbon Handprint project (2016-2018). The project was carried out in close cooperation between VTT and LUT. Responsibilities of the participating organizations and researchers were as follows: Saija Vatanen acted as the project manager and coordinated the work. In LUT, Kaisa Grönman acted as a project manager and Risto Soukka as the responsible leader. Interviews were conducted in cooperation by researchers from VTT and LUT. Kaisa Grönman, Tiina Pajula, Saija Vatanen, Risto Soukka and Heli Kasurinen were responsible for the development of the carbon handprint approach, and prepared Chapters 1,2,3 and the general conclusions presented in Chapter 6 of this report. Hanna Pihkola was responsible for the review and guidelines related to communication, and writing of Chapter 4. Case studies were conducted by Katri Behm, Saija Vatanen, Catharina Hohenthal, Kaisa Grönman, Maija Leino and Jani Sillman, who contributed in Chapter 5. Heli Kasurinen and Kaisa Grönman were responsible for considering the applicability of the handprint concept in other environmental impacts, and wrote chapter 6.1. together. The report was edited by Saija Vatanen, Kaisa Grönman, Hanna Pihkola and Heli Kasurinen.

The project was funded by Business Finland, the project's industrial partners (AM Finland, AO-allover, Biolan, Gasum, KONE, the Association of Finnish Steel and Metal Producers, Neste, Nokia, Paptic), the Finnish Innovation Fund (Sitra), VTT and LUT. The intention of the project was to create calculation and communication guidelines for quantifying a product's positive climate effects.

This report presents the main findings of the project and the results from the seven case studies in which a handprint was calculated for different products, services and technologies. For a detailed presentation of the carbon handprint approach, see Grönman et al. (2019) in the Journal of Cleaner Production. For practical guidelines on performing a carbon handprint assessment, please refer to the Carbon Handprint Guide (<https://www.vtt.fi/sites/handprint/>).

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**Abstract**  
**Tiivistelmä**

# 1. Introduction

Assessing environmental impacts has traditionally focused on measuring and modelling the negative effects that products, services and companies cause to the environment. In many organizations, it is already common to assess resource use or emissions caused as a result of their activities. These assessment practices are thoroughly guided with standards established for life cycle assessment (LCA) (ISO 14040, 2006; ISO 14044, 2006), carbon footprint (ISO, 14067, 2018) and water footprint (ISO 14046, 2014).

The majority of companies in the developed world recognizes minimizing resource consumption and emissions as a pressing challenge. However, some companies already have a depth environmental know-how and have succeeded in conducting their operations resource efficiently with minimal emissions and waste. Others are going yet further – develop products, services and technologies that reduce the environmental impacts of their customers. However, there is currently no recognized method available to these cleantech and frontrunner companies for calculating and communicating the environmental benefits of their actions.

Environmental claims related to products and services should always be honest, specific and verified. Several international and national guidelines and standards provide guidelines for making these claims (see e.g. ISO 14021 2016; ICC Commission on Marketing and Advertising 2011; Multi-stakeholder Dialogue on Environmental Claims 2016; Finnish Competition and Consumer Authority 2002). From the regulatory point of view, ensuring the truthfulness of green claims is related to consumer protection and preventing unfair commercial practices and competition. Vague or generic claims about sustainability or positive environmental impacts related to products may be considered as greenwashing and should only be presented in cases where clear evidence is available. However, specific methods and approaches for measuring positive impacts and thus providing such evidence has been lacking.

The challenge of communicating the positive impacts of products and services has been recognized in the green marketing literature. To tackle credibility challenges, Ramirez et al. (2014) recommend more consistent communication of a sustainable product's economic benefits and positive environmental impacts. Furthermore, sustainability-oriented customers can be a significant market for some companies (Patala et al. 2016). Access to this market requires rigorous demonstration and communication of the expected sustainability benefits of product and service

offerings. The need for communicating positive environmental impacts has been identified by researchers such as Pihkola et al. (2010) and Tynkkynen and Berninger (2017). Bjørn and Hauschild (2013) emphasize the need to introduce positive product attributes to LCA.

Whereas the 'footprint' concept is universally applied with respect to negative environmental impacts, the lesser known 'handprint' concept can be used to refer to positive impacts. The handprint concept was launched in 2007 by UNESCO as a measure of education for sustainable development action, aiming to decrease the human footprint (Handprint Action Toward Sustainability, n.d.), and Biemer et al. (2013) and Norris (2015) have since further emphasized the environmental approach to handprinting. Whereas the aim of the footprint concept is to reduce negative effects to close to zero, with the handprint concept there is no upper limit on the positive effects that can be achieved (Biemer et al. 2013).

In an ongoing German handprint project (Handabdruck), measurement, evaluation and communication tools for the ecological, economic and social impacts of products are being created (Beckmann 2017) with the ambitious goal of taking into account all three pillars of sustainability. In a similar vein, in Handprint-Based Net-Positive Assessment both the environmental and social impacts of products and actions are addressed (Norris 2013).

The handprint approaches of Biemer et al. (2013) and Norris (2015) highlight the positive reinforcement loop of doing good versus doing harm. They emphasize that positive action promotes other positive actions, e.g. in terms of people educating each other regarding accrued knowledge. Although this is true in many cases, it is hard to prove and even harder to measure and allocate to someone's credit. Biemer et al. (2013) also include the possibility of creating handprints through buying carbon offsets.

Industries and companies have already recognized the need to communicate the environmental benefit of their products over others in the market. The chemical industry (ICCA and WBCSD, 2013) and ICT industry (GeSI, Global e-Sustainability Initiative) have addressed this issue from their own perspectives. The chemical sector has introduced industry-related guidance (ICCA & WBCSD 2013) and guidelines for calculating and reporting avoided emissions are being compiled, while companies such as Outotec (Outotec 2015) have launched their own handprint initiatives.

The handprint concept has emerged as a response to the demand for a method to quantify the positive impacts of a product. However, the handprint concept has been simultaneously developed by multiple researchers and industries. This uncoordinated development work has led to a multitude of definitions and scopes for the handprint concept, which requires consistent clarification. The differences in the existing handprint approaches call for harmonized guidelines in order for handprints to become an established and reliable means of corporate communication.

This report provides a universal definition of handprint that is scientifically grounded and can be used in stakeholder communication. Furthermore, this report specifically defines the concept of carbon handprint. As a second objective, the report provides general guidelines for the LCA-based quantification of a carbon

handprint of an organization's products. Thirdly, as the main input for the methodology development, seven case studies were examined. The case studies and their findings are presented in Chapter 5.

This report is divided into the following parts: a presentation of the theoretical background and calculation guidelines of the proposed carbon handprint approach; an examination of handprint communication; a demonstration of carbon handprint approach with actual case calculations; and, finally, discussion and conclusions in which the applicability of the handprint concept to other environmental categories is also discussed.



## 2. Carbon handprint approach

Our development of the carbon handprint approach is based on multiple lines of investigation: literature review, interviews and case studies. First, we reviewed the existing research on assessing positive environmental impacts (e.g. Biemer, Dixon, and Blackburn, 2013; ICCA and WBCSD, 2013; Norris, 2015). We also closely explored the guidance and standards given for carbon footprint calculation (ISO 14067, 2013; WBCSD and WRI, 2004) and LCA (ISO 14040, 2006; ISO 14044, 2006) as we aim to base the carbon handprint approach as consistently as possible on the LCA guidelines approved by the scientific community. For deeper examination of the existing studies, see Grönman et al. (2019).

Secondly, we interviewed companies and associations about their expectations of and preparedness for carbon handprinting. A total of 20 interviews were conducted with operators in the manufacturing, ICT, chemical, construction, paper, food, recycling, and consulting sectors. The 14 companies interviewed included both SMEs and large international companies. The six associations interviewed represented NGOs and trade associations. The interviews comprehensively covered the range of lifecycle aspects, from raw material processing and manufacturing to end-of-life. The interviewees' experience of environmental impact assessment varied from 'no experience at all' to 'several years of expertise.'

The majority of respondents (ca. 75%) had already used lifecycle thinking, and the main purpose of previous LCA studies had been for communications and marketing purposes. Almost half of the respondents (9) had in some way calculated positive aspects, for example in terms of avoided emissions. The benefits of handprinting were considered to be multifold and ideal for internal education or process management within the company. Handprints were also considered a source of attraction for new customers and so were incorporated into branding and marketing initiatives. Communicating the benefits of handprints was seen as very important and, therefore, companies should strive to make them easy and simple to understand. In order to support this goal we reviewed the available guidelines and standards relevant to environmental communication. We considered this to be important as any positive environmental claims should be presented in a harmonized and transparent way in order to increase trust towards the handprint approach.

In the following section the concept of carbon handprint is defined and presented. This is followed by communication section and a step-by-step guidance on conducting a carbon handprint calculation.

## 2.1 Handprint definition

We define the handprint and carbon handprint as follows (See Figure 1):



Figure 1 Handprint and carbon handprint definitions.

Organization can create a carbon handprint via several contributors. The organization can provide a raw material, a part, a component, a fuel, a technology, a process, a product or a service, here referred to as product that can be shown to reduce the GHG emissions of another product system. Another product system can represent the customer or the actor using the product or further processing or selling it. The product can reduce the carbon footprint of customer by influencing in the following ways:

- 1) **Material use:** Replacing non-renewable / GHG intensive materials / Avoiding material use / Increasing material-use efficiency
- 2) **Energy use:** Replacing non-renewable / GHG intensive energy and fuels / Avoiding energy/fuel use / Increasing energy efficiency
- 3) **Waste:** Reducing waste and losses / Contributing to recycling, reuse, and remanufacture
- 4) **Lifetime and Performance:** Lengthening the lifetime of a product / Enabling the performance improvement of a product
- 5) **Carbon capture and storage:** Contributing to GHG sinks through land-use change / Removal of carbon into biomass / Storing of carbon into products

Whether the studied product will achieve a carbon handprint is revealed by comparing the carbon footprints of the two systems. The carbon handprint is created if the carbon footprint of a customer's product system is smaller when applying handprint product than it is by using baseline product, see the equation and Figure 2:

$$Carbon\ handprint_{Product} = Carbon\ footprint_{Baseline\ solution} - Carbon\ footprint_{Handprint\ solution}$$

Where

$$Carbon\ handprint_{Product} = Carbon\ handprint\ of\ a\ product\ that\ is\ applied\ by\ a\ customer$$

$$Carbon\ footprint_{Baseline\ solution} = Carbon\ footprint\ of\ the\ customer's\ product\ system\ applying\ baseline\ product$$

$$Carbon\ footprint_{Handprint\ solution} = Carbon\ footprint\ of\ the\ customer's\ product\ system\ applying\ handprint\ product$$

The carbon handprint is equal to the reduction of the carbon footprint of a customer, but the term 'handprint' is announced to the product of the organization that provides this solution. Thus, the product that enables the footprint reduction has a handprint.



Handprint = the difference between the carbon footprints of these two systems

Figure 2. Reduced carbon footprint is equal to the created carbon handprint.

A carbon handprint can be created either by offering a product with a lower carbon footprint than the baseline product (Handprint solution A in Figure 3) or by helping the customer to reduce the footprint of his processes (Handprint solution B in Figure 3), or both. The GHG reduction, when compared to the baseline, can already occur in the processes of the carbon handprint solution provider, so long as they provide the solution with less GHG emissions than the baseline solution provider.

Another basic option is that the carbon footprint of the customer's product can be reduced with the help of the carbon handprint solution provider's product. An example could be food packaging that is produced with low carbon emissions and that additionally helps to extend the food's shelf life compared to the baseline packaging, thus preventing food waste.

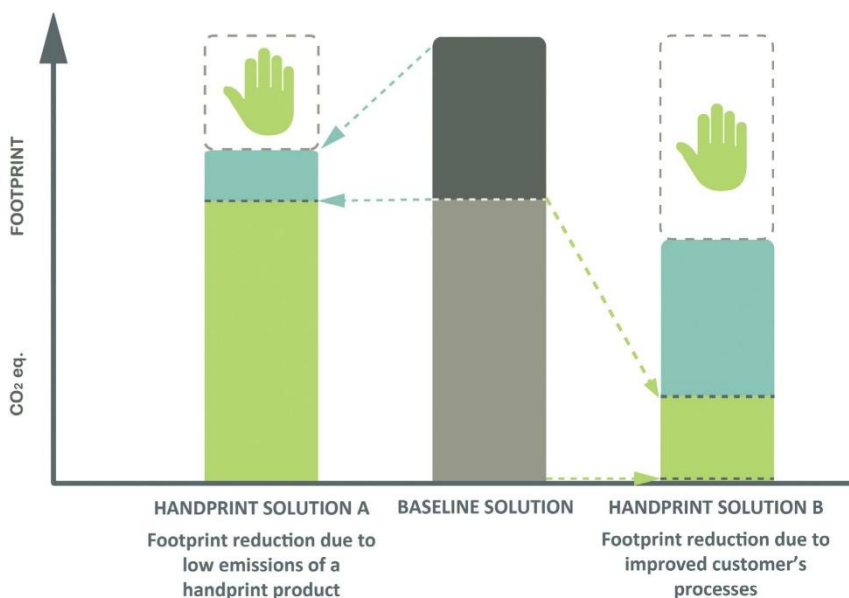


Figure 3. Two basic means for a carbon handprint to be created by the reduction of carbon footprints (CF).

We suggest to clearly differentiate the improvements undertaken within an organization's own production system as reductions of one's footprint. Reducing one's own footprint alone is not creating a handprint. Handprint is an indication of the total footprint of a product when used by a (potential) customer. Companies with a poor environmental performance currently have great potential for achieving reductions in their own footprint. This is still not yet a handprint, but a necessity to be prioritized first in order to deserve a place in the market and have a license to operate. At the same time, forerunner companies have already improved their performance to the top class of resource-efficient and sustainable actors. There is less and less room for improvement in their own functions (reduction of one's own footprint) but plenty of options to help others to reduce their footprints (handprint).

A carbon handprint functions as a marketing and communication tool. For a customer, the possibility of reducing their footprint can prove to be a considerable sales argument. A carbon handprint also offers a means for identifying whether there is a need to further develop one's product in order to create a handprint. A handprint assessment might reveal that the difference in resulting carbon footprints is minimal when compared to a baseline product, or even that the baseline product might have a smaller footprint.

## **2.2 Who can calculate carbon handprints?**

Quantification of the carbon handprint is based on a carbon footprint calculation consisting of a life cycle assessment (LCA) that is limited to GHG emissions. Expertise in LCA and a thorough knowledge of the ISO 14067 standard on the carbon footprint of products is therefore a necessity.

Additionally, to understand the operational environment and to set the baseline, experts acquainted with the product, the considered application, and the examined market must be involved in the study.

### 3. Steps in the carbon handprint calculation

The handprint calculation process consists of four stages and ten steps and is closely based on the LCA method (See Figure 4). In the first stage, which is specific to handprint calculation, the conditions of the examined operational environment are identified in order to set a baseline against which a potential handprint can be created. This stage is followed by typical LCA steps and standard footprint calculations. Finally, the communication part is implemented according to the target audience. As with LCA in general, handprint quantification is essentially an iterative process: the findings of a subsequent step may require the updating of prior steps.

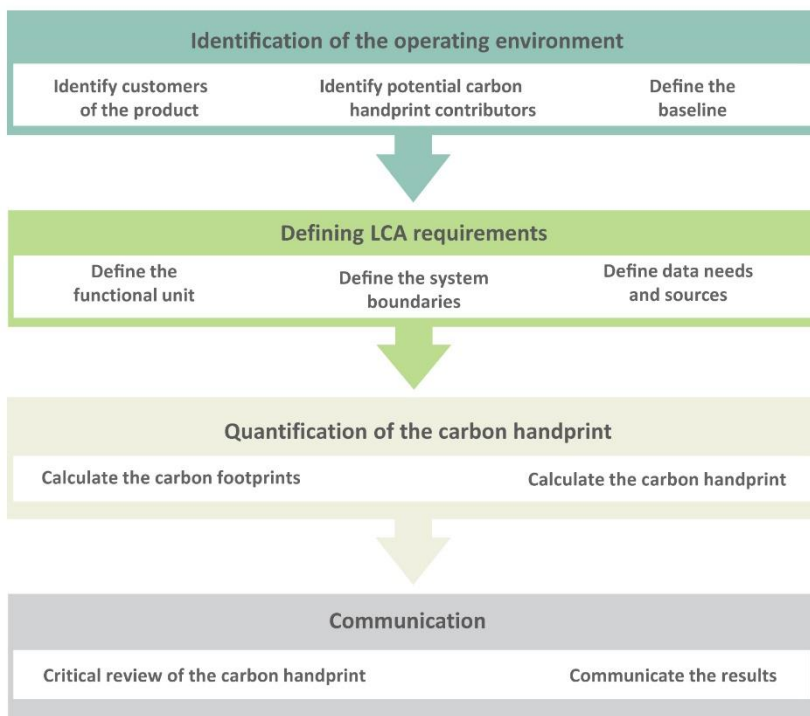


Figure 4. Stages and steps of the carbon handprint approach.

### **3.1 Stage 1: Identification of the operating environment**

#### **Step 1: Identify customers of the product**

Carbon handprint is always quantified for a specific situation and a specific type of user. Without a user applying the examined product, no handprint can be created. Therefore, the first step is to identify potential users of the studied product, here referred to as customers. There may be multiple ways of using the product, and its environmental impact will differ depending on the customer and the geographical market. It is therefore necessary to differentiate between customer types. The example carbon handprint framework in Figure 5 can help to differentiate aspects affecting the handprint calculation. It is useful to identify a number of potential customers even though only one will be selected for the handprint study.

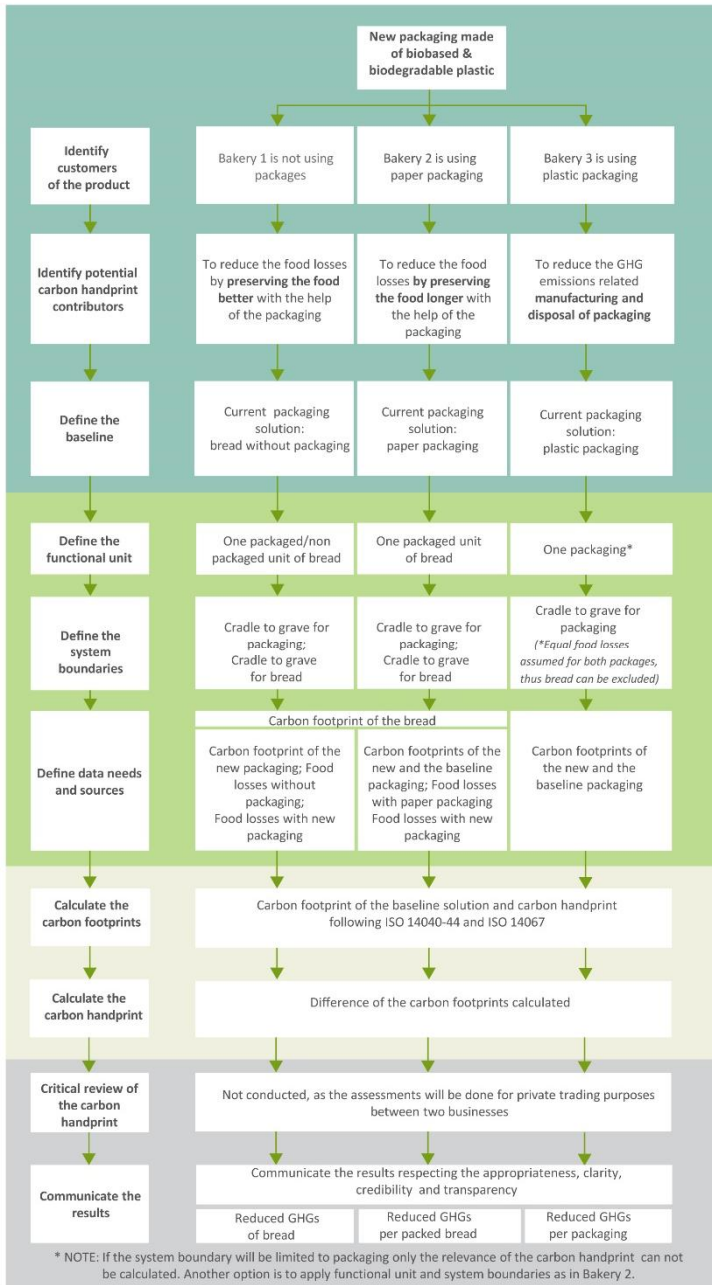


Figure 5. A fictional example of carbon handprint framework for bread packaging used in different bakeries.



## Step 2: Identify potential carbon handprint contributors

Contrary to carbon footprint, which represents the absolute sum of GHG emissions and removals in a product system (expressed as CO<sub>2</sub> equivalents), carbon handprint refers to a change that will result in a beneficial climate impact. The aim of this step is to identify the hypothetical benefits of the product. How will the product contribute to reducing the customer's carbon footprint? Figure 6 introduces various contributors by which a carbon footprint can be reduced and may help to identify the potential pros and cons of the product.

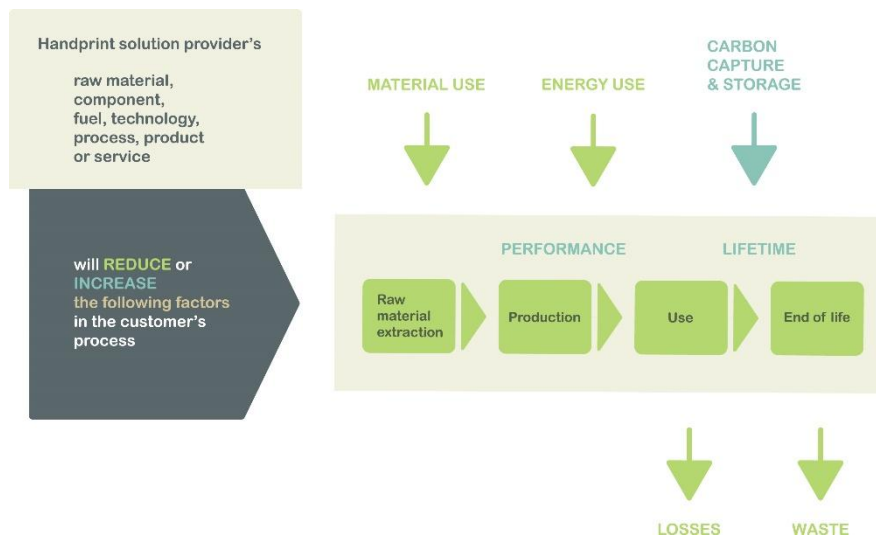


Figure 6. Main carbon handprint contributors.

This process of quantifying the carbon handprint is time and resource intensive. It is recommended to do some screening before starting the full process. Often more than one factor will change, making it difficult to estimate the overall effect at a glance. To gain a better understanding of the potential handprint, a preliminary assessment and screening of possible factors contributing to carbon footprint can be carried out. This can be done using rough data and modelling. Alternatively, an expert panel consisting of industrial and sustainability experts can be called together to discuss and evaluate possible carbon footprint reduction pathways. Only a full handprint quantification will show whether the selected product will have a handprint in reality. The hypothesis is important, however, in order to define a properly grounded baseline and product system boundaries, as described in the steps below.

### Step 3: Define the baseline

To be able to quantify the amount of reduced GHG emissions, a baseline situation must be determined as a point of comparison. The baseline refers to the alternative or current solution in place that delivers the same functions to the customer as the product we are evaluating, that is, the handprint solution.

Unless the product is new on the market, the baseline and the handprint solution should both:

- Deliver the same function
- Be used for the same purpose
- Be available in the market and used in the defined time period and geographic region
- Be assessed in a consistent manner (in terms of data quality, representativeness, system boundaries, assumptions, etc.)

How the baseline is defined will clearly have a major impact on the handprint result: choosing a “worst possible” baseline with a poor environmental performance will increase the handprint significantly. The baseline definition must, therefore, be well grounded and transparently reported.

Two fundamental questions affect the baseline. The first is whether the product that is presumed to create a handprint is replacing another product or is new to the market. If the product is new, a comparison will need to be made between the current situation with and without the new product. If, instead, the product replaces another product, this leads to the second fundamental question: Is the targeted application company-specific?

If the customer using the product is known, the baseline, i.e. the current product to be replaced, can be precisely identified. However, if the product is released to the market with a range of potential customers and uses in mind, a number of different baselines will need to be considered. If a certain product can be clearly identified as the market leader, this should be used as the baseline. For example, shopping bags made of renewable raw material (potentially creating a handprint) offer a clear replacement for the plastic bags currently used in shops and supermarkets (the baseline). However, sometimes it is not possible to single out one type of product from the market as the obvious replaceable product. For example, the environmental performance of currently used traffic fuels varies considerably. If you introduce a new type of fuel it is essentially impossible to identify an exact fuel type that it will replace. In such cases, the average should be taken from all options and used as the baseline. A third option is to use the available product specifications, standards or BREF specifications as baselines. This would be justified in cases where the business-as-usual technologies are plentiful and data on competitors is hard to attain. The baseline situation may also be a combination of multiple baseline products to be replaced if the handprint solution is a multi-functional product.

The baseline determination procedure:

1. Is the product new on the market?
  - a. YES → Use the current situation without the new product as the baseline
  - b. NO → Go to question 2
2. Can the customer be specified?
  - a. YES → Use the customer's current product or another option available on the market as the baseline (not the previous generation product of the handprint provider)
  - b. NO → Choose one of the following as the baseline:
    - i. Market leader or typical product in the identified reference area and time
    - ii. Average product in the identified reference area and time
    - iii. Product specification or BREF that determines the available options

### **3.2 Stage 2: Defining LCA requirements**

This stage is based on the standard LCA procedure and carbon footprinting in accordance with ISO 14040-44 and ISO 14067.

#### **Step 4: Define the functional unit**

The functional unit serves as the basis for quantifying the performance of the studied product system. The primary purpose of a functional unit is to provide a reference on which evaluation of greenhouse gas emissions can be based. This reference is necessary to ensure comparability of the handprint solution to the baseline solution. A system may have a number of possible functions. The one selected for a study depends on the customer and what the customer uses the product for. More information about defining the functional unit can be found in ISO 14040-44.

#### **Step 5: Define the system boundaries**

The system boundary defines the unit processes to be included in the system. Ideally, the product system should be modelled in such a manner that inputs and outputs at its boundary are elementary flows (drawn from the environment and released into the environment). However, the exclusion of life cycle stages, processes, inputs or outputs within the system under study is permitted if they do not significantly change the overall conclusions of the study. The selection of the system boundary has to be consistent with the goal of the study and equal in baseline and handprint solutions.

The criteria used in establishing the system boundary should be explained. In the handprint approach it is a necessity to include the product use stage (intended customer application) in the system. Furthermore, in most cases the end-of-life stage has an influence on the overall conclusions and needs to be included. Setting the system boundaries is elaborated in ISO 14040-44 and ISO 14067.

### **Step 6: Define data needs and sources**

After setting the system boundaries the data needs are identified and data is collected. In carbon handprinting, there are two types of premises: the actual customer is known, or the customer cannot be determined but potential customers or customer groups can be identified. If the customer can be specified, the most recent primary data should be applied. If not, statistical or average data must be relied upon.

Data on the main carbon handprint contributors must reflect an actual existing operating environment in both the baseline and handprint solution. Furthermore, the data for the baseline solution and handprint solution require the same timeframe. Where the GHG emissions and removals associated with specific unit processes vary over time, data must be collected over an appropriate time period to establish the average GHG emissions and removals associated with the life cycle of the product.

The data used should be representative in terms of geographical, time-related, and technological coverage, as well as being precise and complete, as determined in ISO 14040-44 and ISO 14067. However, whereas in carbon footprint calculations the time horizon is typically applied retrospectively, in the handprint approach potential near-future implications are assessed prospectively.

## **3.3 Stage 3: Quantification of the handprint**

### **Step 7: Calculate the footprints**

Using equal functional units, the carbon footprints of the two systems under comparison are calculated following the standardized methodology of ISO 14067 Carbon footprint of products.

### **Step 8: Calculate the handprint**

Finally, the carbon footprints of the two systems are compared. If the carbon footprint of the handprint solution is smaller than the carbon footprint of the practice using the baseline solution, then a carbon handprint has been created. The quantity of the carbon handprint is the difference between these two carbon footprints, as kg CO<sub>2</sub> eq. One should note that the carbon handprint is strongly related to changes in circumstances and will take place only after the handprint solution has been applied by the potential customer. Furthermore, the carbon handprint is bound to a specific

timeframe, whereas the baseline keeps moving over the years as more sophisticated solutions come to occupy the market. The handprint is valid as long as the data used for the calculation is representative of the examined situation.

### **3.4 Stage 4: Communication**

#### **Step 9: Critical review of the carbon handprint**

A handprint communication may be intended for business-to-business or business-to-consumer communication. ISO standard 14040-44 on LCA requires a critical review if the study is intended to be used for a comparative assertion intended to be disclosed to the public. ISO 14026 on Communication of footprint information has requirements on comparative footprints respectively. To be in line with these requirements, a critical review is strongly recommended when the handprint communications are used for business-to-consumer communication and the handprint quantification is based on a comparative footprint relative to another organization's products.

A critical review is a helpful way to verify the calculation process and results and is recommended to be considered in all situations. To keep the procedure leaner, the independent reviewer may also be internal from the organization that conducted the handprint study, for example in the case of business-to-business communications.

#### **Step 10: Communicate the results**

A company has its carbon handprint endorsed once a customer is utilizing their product instead of the baseline solution. Thus, among other purposes, the carbon handprint functions as a marketing and communication tool. For a customer, the possibility of reducing their footprint can prove to be a considerable sales argument.

At this point an appropriate communication unit needs to be selected. The basic measure of a carbon handprint is carbon dioxide equivalents. However, an informative and representative reference unit may be something other than the functional unit used in the calculations. For example, in case of calculating the carbon handprint of a fuel, a reasonable functional unit would be based on the fuel properties (e.g. energy content). However, mileage may be a more informative unit of communication for the customers actually using the fuel.

## 4. Carbon handprint communication

This chapter discusses specific needs related to communication of handprint results. A review of existing guidelines and standards relevant to handprint communication is presented, and recommendations related to communication are proposed. Finally, a checklist for preparing handprint communication that is compatible with the existing guidelines and good practices for environmental communication is presented.

### 4.1 Main needs of handprint communication

The core needs and challenges related to communicating handprint results were discussed in two dedicated workshops. The first workshop was held at the beginning of the project in February 2017 with 35 participants comprising industry representatives and the project researchers. The focus areas of the small group discussions were:

- Potential target groups for handprint communication
- Ideas for communicating and illustrating handprint results to different stakeholder groups
- Potential role of handprint in other sustainability communication

The second workshop held in March 2018 focussed on concrete needs related to communicating handprint results. The starting point for the group discussion was the handprint method and its specific calculation rules. Thus, a major part of the group discussion related to practical aspects and potential formats for communicating the results. In addition, existing standards and guidelines for environmental communication and footprint communication were briefly reviewed, and needs regarding specific guidelines for handprint communication were considered. In total, 11 representatives of research and business organizations participated in the discussion.

According to the project discussions and the two dedicated workshops, the potential target groups for handprint communication cover a broad range of both internal and external stakeholders, including customers, employees, investors, consumers, policymakers and the general public. Depending on the context, the customer may be a consumer, a company or a public organization, but often the most important target group is the next actor in the value chain. It was noted that as with all communication, handprint-related communication must be targeted according to stakeholder needs and interests.

In addition to external communication, the importance of internal communication was highlighted during the workshops. Employees were mentioned as one of the most important target groups for handprint communication because employees are the ones communicating the message to external stakeholders. Handprinting was generally considered particularly beneficial for communication purposes. The need for specific guidelines for making environmental claims based on handprint results

was one of the main needs identified. Common guidelines were considered important for avoiding potential misuse and for creating confidence among stakeholders. Moreover, as sustainability aspects and related communication already cover a wide range of topics, and companies need to implement many different methods and means of communication, it was considered practical for handprinting to be compatible with methods and tools already in use.

In order to prepare guidelines that would be compatible with existing methods and tools, existing guidelines and standards for environmental marketing and communication were first reviewed. The aim of the review was to determine whether existing guidelines would be directly applicable for the purposes of handprint communication, or whether additional guidance specific to the handprint concept would be needed. The key findings of the review are reflected on briefly in the following chapter and discussed in relation to the key aspects of the handprint concept.

## **4.2 Existing guidelines for environmental communication and marketing**

Several guidelines, standards and recommendations for environmental communication and marketing are available. These include guidelines prepared by national authorities, such as those prepared by the Finnish Consumer Ombudsman (Finnish Competition and Consumer Authority 2002), supporting documents related to the European Directive on Unfair Commercial Practices (Multi-stakeholder Dialogue on Environmental Claims 2016), international guidelines (ICC Commission on Marketing and Advertising 2011) and international standards dedicated to environmental communication (ISO 14063 2010), life cycle assessment (ISO 2006a), footprint communication (ISO 14026 2017) and eco-labels (ISO 14021 2016).

### **4.2.1 Principles for environmental communication**

The overall aim of the guidelines and standards is to present good practices, prevent misleading statements and unfair competition and protect consumers. The guidelines are relevant to all environmental marketing and claims but are especially relevant to handprint communication, since the aim of the handprint is to communicate positive environmental impacts. It is extremely important therefore to avoid misleading statements that could be interpreted as greenwashing.

According to the European Commission's definition of environmental claims:

*The expressions "environmental claims" or "green claims" refer to the practice of suggesting or otherwise creating the impression (in the context of a commercial communication, marketing or advertising) that a product or a service, is environmentally friendly (i.e. it has a positive impact on the environment) or is less damaging to the environment than competing goods or services. This may be due to, for example, its composition, the way it has been manufactured or produced, the way it can be disposed of and the reduction in energy or pollution which can be expected*

*from its use. When such claims are not true or cannot be verified this practice can be described as "green washing".* (European Commission 2009)

It is clear from this definition that the use of handprint results as part of any commercial communication is considered an environmental claim. As a consequence, national and European compliance criteria for environmental claims need to be considered in the context of handprint communication. Another important point is the need for verification, which is highlighted in all available guidelines and standards. On the other hand, life cycle assessment is commonly mentioned as a scientific method that can or should be used for verification purposes, especially if it is verified by a third party. However, care must be taken in presenting the results and especially when making a comparative claim or a generic claim about positive environmental impacts. Additionally, an important criterion shared by the reviewed communication guidelines is the need to make the evidence for the claim fully or at least partially available to the public.

It is important to remember that most of the guidelines focus on product-based claims that are directed towards consumers. The ICC Framework for Responsible Environmental Marketing Communications notes that product-based claims should be differentiated from announcements made by companies regarding their commitment or achievement of sustainability goals or future sustainability targets (ICC Commission on Marketing and Advertising 2011). Nonetheless, while more freedom can be used in such statements, the main principles of environmental communication should be applied in all contexts. According to the ICC Framework, 'all marketing communication should be legal, decent, honest, and truthful', and 'prepared with a due sense of social and professional responsibility' (ICC Commission on Marketing and Advertising 2011).

When considering the available standards, the European Standard EN ISO 14063 Environmental Communication - Guidelines and Examples (ISO 14063 2010) provides guidance for all organizations regarding general principles, policy, strategy and activities that may relate to both internal and external environmental communication, and to an organization or its products. According to the standard, the following principles should be applied in all environmental communication:

- Transparency – Processes, data and assumptions related to environmental communication should be made available to all interested parties (but taking into account confidentiality requirements).
- Appropriateness – Information should be relevant and understandable to the stakeholders
- Credibility – Communication should be conducted in an honest and fair manner and the information should be produced using recognized and reproducible methods and indicators
- Responsiveness – All communication should be open and responsive to the needs of interested parties
- Clarity – Communication and language used should be understandable to the interested parties (ISO 14063 2010).



The generic principles presented in ISO14063 can be considered as comprehensive, overall guidelines for preparing environmental communication and thus also a valid guideline for handprint communication. Similar principles are repeated in reviewed guidelines and recommendations related to making product-specific claims. While the standards and frameworks are voluntary methods and tools that companies can use for supporting responsible activity, similar principles are central in both Finnish and European legislation concerning consumer protection and fair competition.

#### **4.2.2 Consumer protection and fair competition**

From a legal point of view, national and European authorities monitor the credibility and clarity of environmental claims based on notifications made by consumers, companies and other public and private organizations. In Finland, monitoring of environmental claims falls under the responsibility of the Consumer Ombudsman. The responsibility of the Consumer Ombudsman is to supervise that the Consumer Protection Act and other laws passed to protect consumers are observed. The Consumer Ombudsman has published dedicated guidelines for environmental marketing (Finnish Competition and Consumer Authority 2002). The guidelines are compatible with the principles of consumer protection legislation and are intended to provide guidance for planning a marketing campaign or advertisement in which an environmental claim is presented. The principles provide generic but clear guidelines similar to the principles of environmental communication presented in the existing international standards. The guidelines cover five main principles:

1. Importance of environmental impact should first be assessed – an environmental claim can be made if there is clear evidence of its relevance and benefit to the consumer.
2. Environmental impact should be made clear – All claims must be presented in an unambiguous manner – they must be precise and understandable to the consumer. The impact of a product should not be exaggerated. If a claim can be interpreted in a misleading way, it should not be used.
3. Overall impression should be assessed – The overall impression given by marketing must be consistent with the available facts.
4. Generalizations are permissible only when the entire life cycle of the product is known.
5. Only compare similar products – Comparisons can only be made between products that serve a similar purpose. (Finnish Competition and Consumer Authority 2002)

In addition to Finland, public authorities have published similar guidelines concerning all types of environmental claims in the Czech Republic, Denmark, France, Iceland, Norway and the UK. In addition, a variety of general and sector-specific guidelines prepared by private organizations have been identified (Multi-stakeholder Dialogue on Environmental Claims 2013).

The European Commission has published its own guidance document concerning compliance criteria for environmental claims<sup>1</sup>. The document has been developed by the Multistakeholder Dialogue on Environmental Claims (2016). The aim of the guidance is to support the application of the Unfair Commercial Practices Directive (UCPD) (2005/29/EC) in the area of greenwashing and misleading environmental claims. The document provides advice on defining the contents of a green claim and presenting the results in a clear and accurate manner, as well as recommendations regarding claim substantiation and documentation. The document also provides guidance regarding transparency towards consumers. The document is not legally binding, and in case of a suspected misuse, national courts and authorities would perform a case-by-case assessment on whether a claim is misleading. The compliance criteria presented within the guidance document are very similar with the criteria provided by the Finnish Consumer Ombudsman. Many national guidelines are mentioned as references to the guidance document.

The guidelines of specific relevance to the handprint point of view relate to ensuring clarity regarding the scope and boundaries of claims. According to the Multistakeholder Dialogue on Environmental Claims (2016):

*'The scope and boundaries should be clear from the way it is presented. It should be evident whether a claim is referring to the whole product or organization, or just specific aspects. The particular environmental impact or process it addresses should also be clear.'*

From the handprint point of view, a critical aspect with respect to communication is the mechanism or contributor that creates the handprint: where it originates from and in which part of the life cycle the emission reduction takes place. Based on the case studies and discussions held during the project, this might also be the point that might be most difficult to communicate in a simplified manner. This is most likely at least partly due to the differing logic behind the creation of a handprint and a footprint.

Another main principle common to the different guidance documents is the need to avoid making generalized statements about positive environmental impacts (e.g. claiming that a product is sustainable or environmentally friendly without credible specification). This principle is especially relevant from the handprint point of view. If only carbon handprint is calculated, it should be made clear in all communication that the positive impact refers to greenhouse gas emissions, and not all environmental aspects.

However, even generic claims may be acceptable if there is sufficient proof of the claimed environmental benefits of the product, in relation to other similar products (see e.g. Multi-stakeholder Dialogue on Environmental Claims 2016; Finnish Competition and Consumer Authority 2002). Required proof could be a third-party verified environmental label (such as the Nordic Swan or the EU-label), or a life cycle assessment study verified by a third party (critical review). For example, a LCA study applying the principles of the EU Product Environmental Footprint (PEF) could

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<sup>1</sup> Compliance criteria on Environmental Claims. Multi-stakeholder advice to support the implementation/application of the Unfair Commercial Practices Directive (2005/29/EC) (2016).

be considered as valid evidence of environmental performance if the results are in line with the claim. However, if others have presented considerable evidence of conflicting results, the claim might be questioned even if an appropriate background study is available. Thus, any generic claim about a product being sustainable or having a positive impact on the environment should always be first comprehensively studied and considered in order to avoid potential misunderstandings and to provide sufficient background evidence to support it.

Another key principle common to all available guidance documents is transparency. According to the EC's guidance (2016), traders should consider providing the public with reasonably detailed explanations of the presented environmental claims. In practice, this could mean providing a summary of the findings of scientific studies, including descriptions of the nature of those studies and the organizations and experts involved. Additionally, traders should consider making documentation supporting their environmental claims publicly available. This can be done in a way that safeguards confidentiality, but if the supporting evidence is confidential, the guidance document advises traders to consider whether the claim should be made at all (Multi-stakeholder Dialogue on Environmental Claims 2016). Similar requirements regarding verification of a self-declared claim are included within the ISO14021 standard concerning self-declared environmental claims, which has also been used as one of the source documents for the abovementioned ICC Framework.

For the purposes of transparency and trust, independent verification and assurance of environmental claims is recommended as the default option (Multi-stakeholder Dialogue on Environmental Claims 2016). In that sense, the guidelines are clear regarding public disclosure of supporting studies or other evidence. Thus, the guidance concurs with the ISO 14040-44 standard for LCA, which requires a critical review when making a comparative statement for marketing purposes (ISO 2006a).

### **4.3 Potential challenges in communication**

Specific guidance regarding communication of the LCA-based footprint related information is provided in ISO14026 (ISO 14026 2017), which lists both generic principles and examples that are also useful in the case of handprint communication. According to the standard, the main principles that should be followed when communicating footprint results are:

- Credibility and reliability – information should be relevant and reliable in terms of addressing areas of concern
- Life cycle perspective – relevant life cycle stages should be considered
- Comparability – comparison is possible only between products in the same product category and having the same functional unit
- Transparency – access to information on where the footprint communication originated should be provided
- Regionality – local or regional context relevant to the area where the impacts occur should be considered (ISO 14026 2017).

Since a handprint is always case or value chain (or customer) specific, regionality is an additional aspect that needs to be included in the communication. This means that the impacts that are communicated should be relevant also concerning the market area in question.

In the case of handprint communication, needs related to both: business-to-business and business-to-consumer communication are important. While similar principles related to communication should apply in both cases, differences may occur in the amount of details delivered, as it may be expected that in the case of a business-to-business customer more technical information about the product or the processes can and should be delivered. Or, if the same life cycle based assessment methods are applied by the value chain actors, more detailed information regarding the assessment details and assumptions applied would be of interest and useful to the receiver.

Overall, it can be concluded that the available guidance documents and frameworks, together with the LCA standards (ISO14040-44), the standard on footprint communication (ISO14026) and eco-labels (ISO14021) are quite clear and strict in their demands regarding comparative claims. The existing documents should therefore in principle provide sufficient guidance on making claims that are not misleading and have enough background evidence. One potential difficulty from the communication point of view is that LCA results have been considered difficult to understand by consumers and other stakeholders (Dahlbo et al. 2013; Nissinen et al. 2007).

In general, LCA studies include a great deal of information and assumptions that would need to be made clear to the receiver in order for them to properly understand the result and its meaning (Dahlbo et al. 2013). It is therefore reasonable to assume that similar challenges would apply to handprinting, which is based on the LCA methodology. In addition, a common challenge related to environmental communication is that even though many consumers are interested in environmental information, general awareness and knowledge related to environmental impacts and the mechanisms behind them might be low (European Commission 2014). Consequently, this often leads to challenges in interpreting the meaning of environmental claims ascribed to products. The environmental awareness of the receivers and their ability to interpret the meaning of the claim must be taken into account in all environmental communication, and especially when making statements about potential positive impacts.

Since the concept of handprint is new, and the logic of creating a handprint differs from that of a footprint, the concept might at first be difficult to communicate and understand even for experts familiar with LCA and footprint vocabulary and methodology. Communication related to handprinting must therefore be carefully considered not only with respect to consumers and other stakeholders that might not be experts in the methodology, but also other companies and stakeholders that might have previous experience of LCA.

#### **4.4 Conclusions and recommendations related to communication**

The reviewed standards and guidelines for environmental communication (ISO 14063 2010; ISO 14021 2016; ISO 14026 2017) and environmental marketing (Finnish Competition and Consumer Authority 2002; ICC Commission on Marketing and Advertising 2011; Multi-stakeholder Dialogue on Environmental Claims 2016) provide clear principles that can be also used for planning and preparing handprint communication. LCA standards (ISO14040-44) and their instructions for preparing comparative claims are also valid and need to be applied in this context.

As handprint is a new concept, the scientific grounding of the approach needs to be emphasized (e.g. by highlighting its compliance with the same standards that are applied to footprint calculations) to avoid any association with greenwashing. Transparency and clarity are needed, especially regarding the baseline scenario and the origin of the handprint. Transparency is important, since the result of the assessment is usually heavily affected by the assumptions made during the study. When only carbon handprint is considered, it should be made clear that the claim relates to climate impacts. In all cases, the message must be targeted according to the audience (own employees, consumers, other companies, policy makers, other stakeholders) taking into account their knowledge of the value chain and product in question, together with their general environmental awareness.

In addition, interested parties should be informed how and where they can get further information. This information does not have to be included in the product itself, but it should be easily accessible and in an understandable format – the latter being perhaps the biggest challenge. In addition, anyone presenting a handprint result should be prepared to provide additional information and share original calculations, reports or relevant parts of them, and use critical reviews as a necessary third party verification.

Due to the novelty of the concept, it is recommended to distinguish between information on the handprint concept and information on case study results (actual handprint results). Targeted communication of both the handprint concept and specific case results will be needed during the introductory phase of the concept.

## **4.5 Checklist for planning and preparing handprint communication**

To support the planning phase of handprint communication, we have compiled the following checklist. The checklist follows the general principles of ISO14063 for environmental communication and the specific questions correspond to the principles laid out in the standard on footprint communication (ISO14026). The list is not exhaustive and cannot be used as the sole guidelines for communication planning, but it provides a useful summary of basic principles and expands the scope of handprint guidance from calculation to communication. The aim of the checklist is to help in preparing environmental claims that are specific and that provide sufficient background information, thus avoiding generalized statements that could be easily viewed as greenwashing.

## Checklist for planning and preparing handprint communication

- \* Necessary information

### Appropriateness

- Is the intended audience familiar with the product and the life cycle in question?
- Is the intended audience familiar with the life cycle assessment method or the carbon footprint concept?
- Is the intended audience familiar with the carbon handprint concept?

### Clarity

- \* **What is the quantity and reference unit of the calculated handprint?**
- \* **What is the baseline scenario?**
- \* **Who is the customer using the product?**
- \* **What are the main contributors to the handprint (or mechanisms behind emission reduction)?**
- \* **What year does the data and/or most important assumptions apply to?**
- In which parts of the life cycle does the handprint (emission reduction) take place?
- What geographical area does the result directly or potentially apply to?
- How significant is the handprint in comparison to the baseline footprint?
- How significant is the quantity of the baseline footprint?

### Credibility

- Which methods, guidelines and standards were used for the calculations?
- Who was responsible for conducting the assessment?
- Has the study been critically reviewed?

### Transparency

- Is the original study available to the public?
- Do you have a result report that can be made publicly available or shared with interested stakeholders upon request?
- \* **How can/will additional information be provided to interested parties?**
- \* **Is a contact point for any further inquiries included?**

## 5. Case studies

The case studies were selected to cover a range of products, services and processes in order for the methodology development to be applicable to different kinds of value chains and sectors. Examples of carbon handprints not only for products but also for services and technologies are presented.

The chosen case studies were: 1) base station cooling technology from a wireless network service provider, 2) elevator technology from an elevator manufacturer, 3) renewable diesel from a fuel manufacturer, 4) material for shopping bags from a material manufacturer, 5) a carpet service from an interior design company, 6) an additive manufacturing service from a 3D printing company, and 7) a bio-waste treatment solution from a composter manufacturer.

Each of the products was examined from the point of view of various customers. Both business-to-consumer products and business-to-business products were examined. In order to ensure the applicability of the carbon handprint approach, potential customers included consumers, other companies and public organizations, and the products chosen covered many different industrial sectors. In addition, the studied products represented both mass-produced products and tailor-made products. The studied cases were also based on situations where several actors in the value chain were found to influence the carbon handprint creation.

The principal aim of the case studies was to test and develop the handprint concept and the assessment approach presented in this report. The case studies presented here thus serve as examples of the applicability of the handprint concept to different contexts. The cases, as reported here, cannot therefore be used as examples of full-scale handprint reports or benchmarks.

### 5.1 Base station cooling technology from a wireless network service provider

Radio base station sites are responsible for the majority of energy consumption and carbon footprint of the wireless telecommunications infrastructure. This case study considers Nokia's liquid-cooled base station, which reduces energy consumption by 15% compared to air-cooled base stations. Additionally, the liquid-cooled base station provides a source of excess heat for waste heat recovery. The heat is provided in liquid form from the cooling system, has a volume flow of approximately 2 litres per minute and a temperature between 50–60 °C. The product is shown in Figure 7.

Liquid cooling of radio base stations brings several benefits. Firstly, liquid is a superior heat transfer medium than air, which further enables radical device miniaturization and use of the most energy efficient technologies. Secondly, heat is easily stored and moved to other locations in liquid, enabling efficient waste heat reuse. Additionally, liquid cooling increases reliability and decreases maintenance demand, which also contribute to the handprint. Liquid cooling is a new technology for



base stations and forms part of Nokia's zero-emission base station concept. The carbon handprint will be used in customer communication.



Figure 7. Nokia's liquid-cooled base station.

### **Defining the customers and handprint contributors**

Nokia has identified several applications for waste heat reuse, such as space heating and cooling and hot water heating as well as industrial applications such as clean water production and electricity generating technologies. Five possible customers for the liquid-cooled base station handprint were identified:

- Customer 1: Telecom operator: handprint derives from reducing the energy consumption of the operator.
- Customer 2: Telecom operator: handprint derives from reducing the energy consumption of the operator and from avoiding concrete construction. Typically, concrete constructions are needed to prevent heat dissipation to the building and, e.g., roof structures.
- Customer 3: Telecom operator and heat utilizer: handprint derives from reducing the energy consumption of the operator and from recovering waste heat as space heating, replacing district heating.
- Customer 4: Telecom operator and heat utilizer: handprint comes from reducing the energy consumption of the operator and by recovering waste heat for hot water heating, replacing electricity.
- Customer 5: Clean water user: handprint derives from reusing waste heat from the base station. The water distilling liquid-cooled base station provides clean water where it is needed.

The framework for defining the handprint for the abovementioned customers is presented in Figure 8. Handprints were calculated for customer cases 1, 3 and 4 as these are considered the most important handprint applications.

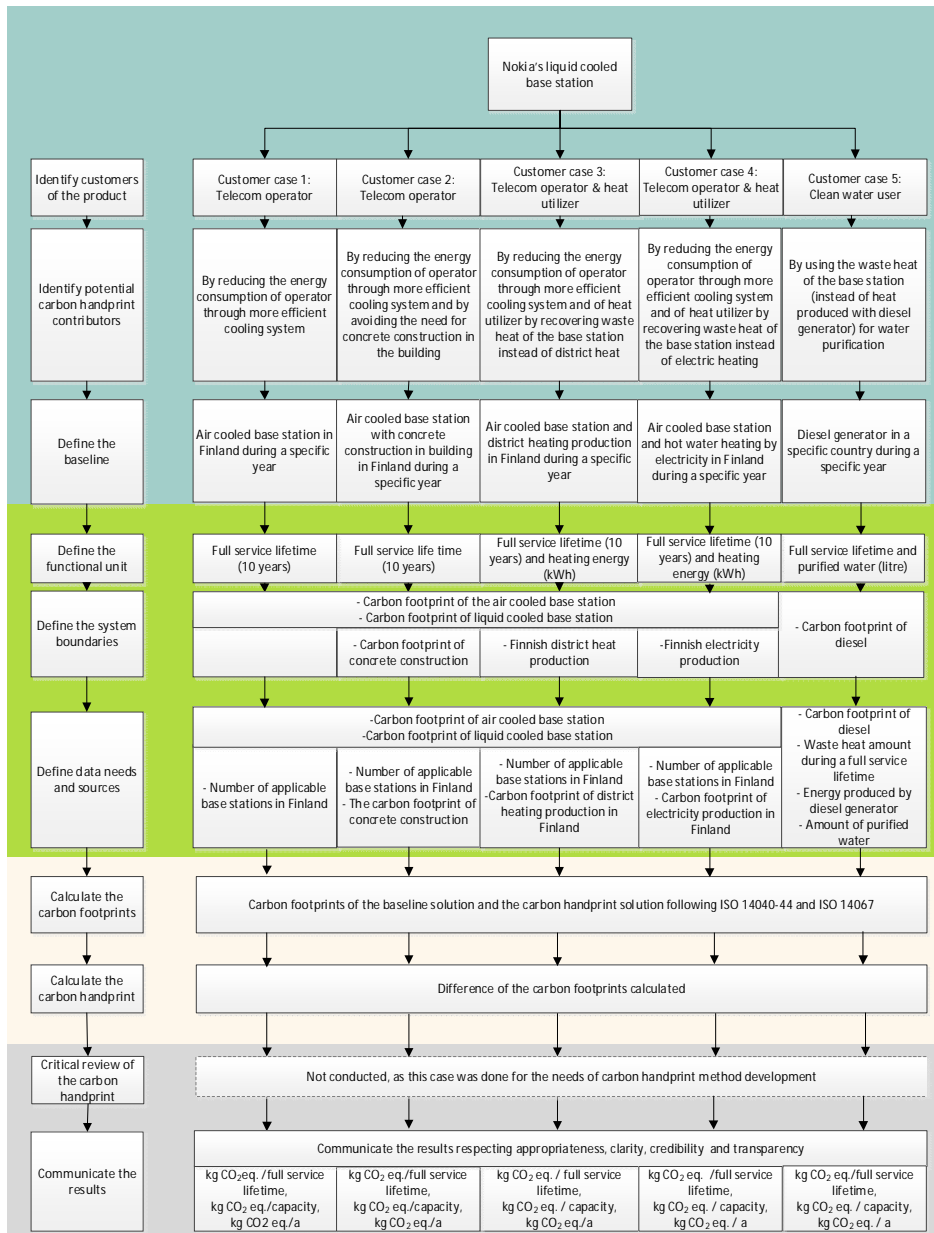


Figure 8. Carbon handprint framework for Nokia's liquid-cooled base station.

## **Defining the baseline**

The baseline case consists of an air-cooled base station without energy reuse. In the case of waste heat reuse, the baselines are electricity production and direct heating production in Finland. In the water purification case, the baseline is the electricity produced by diesel generator.

## **Defining the functional unit**

The functional unit for handprint calculations of liquid cooling is the full service life cycle of the base station, in this case 10 years. Carbon handprints are also calculated per year. In cases where waste heat is reused, the additional functional unit is heating energy (kWh) per full service life cycle of the base station. In the case of water purification, the functional unit for handprint calculations is the amount of waste heat per year.

## **Defining system boundaries**

The system boundaries of the base station liquid system handprint calculations cover cradle-to-grave life cycle inventory, i.e. manufacturing, transportation, use and end-of-life treatment. The system boundaries are the same for the baseline and handprint solution.

## **Results**

Customer cases 1, 3 and 4 are presented as examples of handprint calculation in this study. The baseline case consists of the air-cooled base station without energy reuse. Carbon footprints of the base stations cover the whole service life cycle from manufacturing to end-of-life treatment.

The liquid cooling handprint is derived firstly by reducing the energy consumption of the telecom operator and secondly by reusing waste heat of the base station. Handprints are calculated per base station, although radio base station sites typically include several base stations. The handprint of customer case 1 (energy consumption decreased by 15%) is 170 kg CO<sub>2</sub> eq./y (Figure 9). The handprint of customer case 3 (energy consumption decreased by 15%, and waste heat reused as space heating replacing district heating) is 970 kg CO<sub>2</sub> eq./y (Figure 10). The handprint of customer case 4 (energy consumption decreased by 15%, and waste heat reused as space heating replacing electricity) is 930 kg CO<sub>2</sub> eq./y.

**CUSTOMER 1: TELECOM OPERATOR**

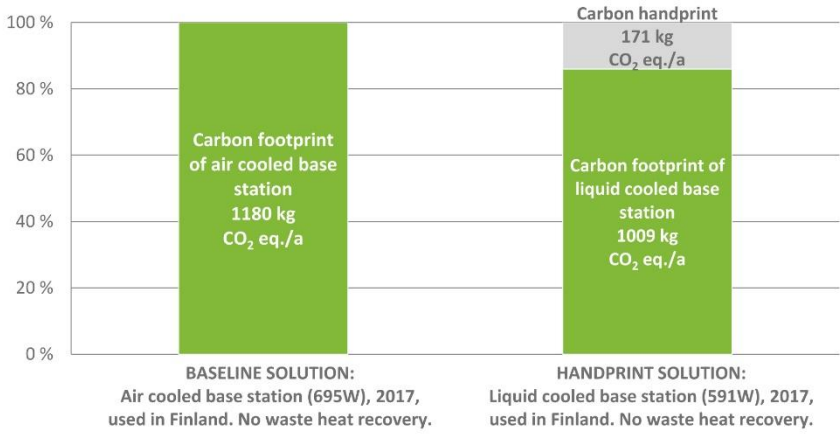


Figure 9. Handprint of liquid-cooled base station due to operator energy consumption being reduced.

**CUSTOMER 3: TELECOM OPERATOR AND HEAT UTILIZER**

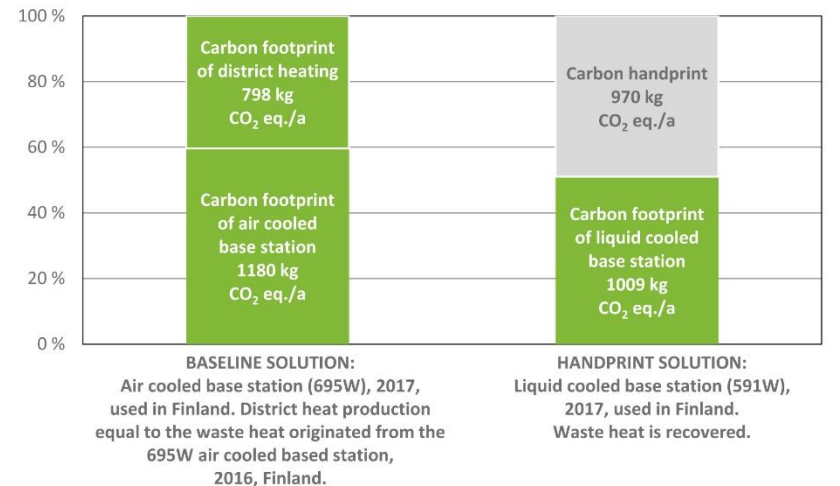


Figure 10. Handprint of liquid-cooled base station due to energy consumption of operator being reduced and waste heat recovered.

## Conclusions

The growing demand for mobile data is a strong driver for developing energy efficiency improvements for the telecommunication sector. Radio base station sites are responsible for the majority of energy consumption of the wireless telecommunication infrastructure. Most of the energy input to base stations is dissipated as heat, with approximately 75% of all energy consumed by the station being converted into waste heat. The recently developed liquid cooling system in the base station enables more energy efficient heat transfer in the cooling system while also providing a hot utility output from the station in the form of hot water. The resulting 15% energy saving compared to conventional cooling systems is a major handprint contributor, but even more significant environmental benefit is achieved when waste energy is reused. In this handprint calculation no GHG emissions were allocated to waste heat. The conversion of 200 building sites (with three base stations per site) from air-cooled to liquid-cooled and with waste heat reused to replace electricity or district heat, the handprint would be more than 550,000 kg CO<sub>2</sub> eq./y. As a result of this project, handprinting has been incorporated as part of Nokia's responsibility communication.

### 5.2 Elevator technology from an elevator manufacturer

The KONE MonoSpace® 500 elevator is designed for primarily passenger transport in residential and office buildings and for installation in both new and existing buildings with modernization needs. The MonoSpace 500 uses innovative and energy efficient technologies for lifting, lighting and stand-by operations and thus has a potential handprint. It is an electric elevator, with a gearless traction drive system. It has a rated load of 320–1150 kg, a speed of 0.63–1.75m/s, and a travel height of up to 24 floors (75 m). The expected life time of the KONE MonoSpace 500 is 25 years. In this project, the elevator was assumed to have a load of 630 kg, a traveling speed of 1.0 m/s, and a travel height of 12 m (5 floors). The product is illustrated in Figure 11.



Figure 11. KONE MonoSpace 500. Copyright: KONE 2018.

### **Defining the customers and handprint contributors**

KONE MonoSpace500 can be used in a wide range of building types from residential to public, such as offices, hotels or shopping centres. The potential customers therefore also range widely from, for example, building owners to global real estate investors. The elevator can be installed in a new building or used to replace an old elevator in an existing building. The following customers were identified as potential users of a handprint product:

- Customer 1: Residential building owner who decides to install a KONE MonoSpace 500 elevator as a new installation or a modernization. The baseline is the reference elevator.
- Customer 2: Residential building owner who decides to install a KONE MonoSpace 500 elevator as a new installation or a modernization. The baseline is the energy efficiency class of the reference elevator.
- Customer 3: Office building owner who decides to install several (5–10) KONE MonoSpace 500 elevators as new installations. The baseline is either an LCA study or the energy efficiency class of the reference elevator.

The framework for defining the handprint for the abovementioned customers is presented in Figure 12. The calculation for Customer 2 was demonstrated and reported.

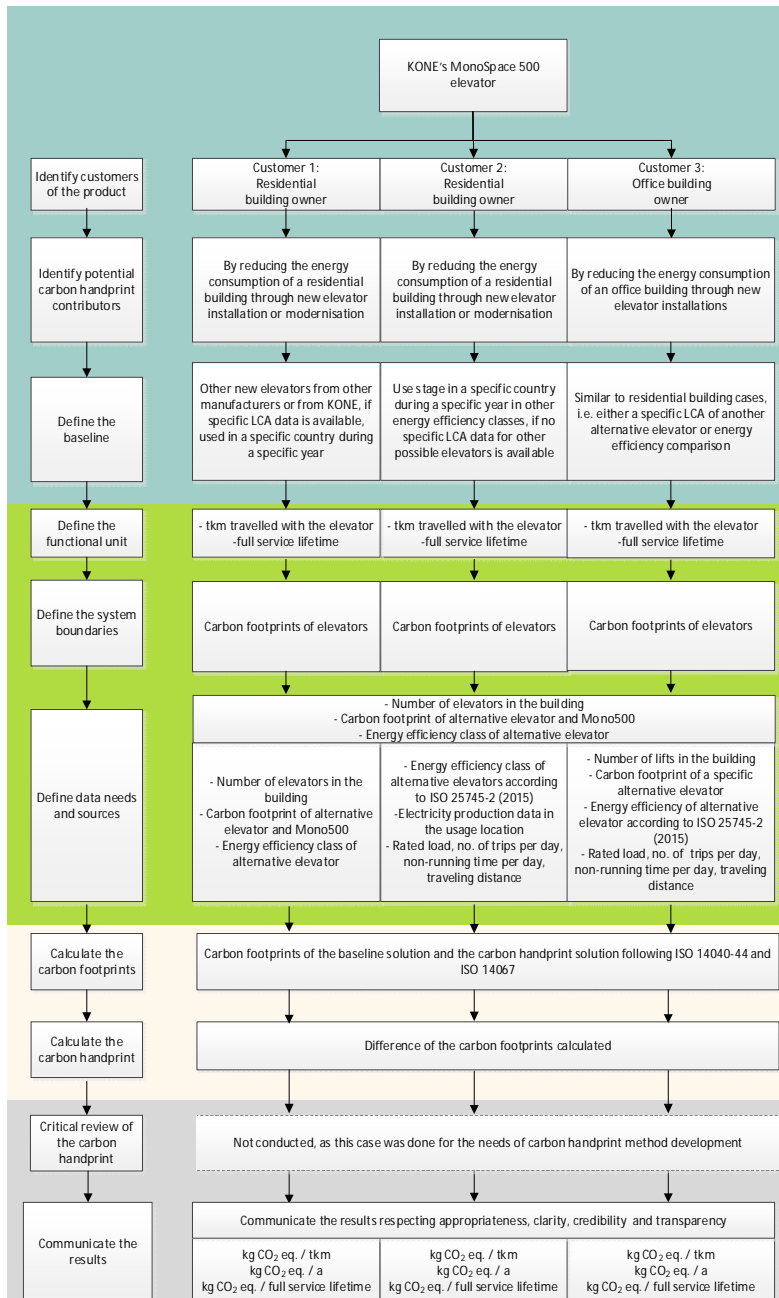


Figure 12. Carbon handprint framework for KONE MonoSpace 500.

## **Defining the baseline**

The challenge in this case study is to define the baseline solution, i.e. alternative reference elevator against which the KONE MonoSpace 500 could be compared. Elevator types range hugely, from hydraulic to gearless and geared traction with different speeds and travel heights and loads, and manufactured from different materials in many locations by several manufacturers – it is therefore very difficult or impossible to define an ‘average elevator’ to be used as a baseline product. Nevertheless, the full life cycle from material acquisition, component manufacturing and assembly to installation, use, maintenance and finally end-of-life solutions needs to be considered in the handprint calculations.

As elevators are products with a long life cycle and energy is used for their operation, their use stage is often the most important life cycle stage when carbon footprint is considered. The ISO 25745-2 standard ‘Energy performance of lifts, escalators and moving walks. Part 2: energy calculation and classification for lifts (elevators)’ (ISO 25745-2:2015) defines energy efficiency classes for elevators, from A-G, depending on the energy consumption level per day. The energy efficiency classes depend on the specific running energy for the average running cycle. If the rated load, number of trips per day, average running distance and the non-running time per day are kept constant, the energy efficiency of different elevators can be compared based on these specific running energy consumptions. The rest of the life cycle can be considered to remain the same as that of the KONE MonoSpace 500. Thus, the energy consumption of the KONE MonoSpace 500 can be compared to these other energy efficiency classes and the handprint of the KONE MonoSpace 500 can be estimated, keeping in mind that the other life cycle stages could also play an important role in the results, either increasing or decreasing the handprint, if actual data was available.

## **Defining the functional unit**

The functional unit for handprint calculations of the KONE MonoSpace 500 can be tonnes per kilometre travelled, or per year, or per full service lifetime of the elevator, in this case 25 years.

## **Defining system boundaries**

The system boundaries of an elevator handprint include the life cycle of the elevator from cradle to grave, with special focus on electricity consumption in the use stage. The manufacturing of the elevator remains the same, but the electricity produced for the use stage is country-specific depending on the use location, as this has a major impact on the carbon footprints and handprint. The system boundaries are the same for the baseline elevator and the handprint elevator.



## Results

Customer 2 is used as an example case for handprint calculation in this study. The actual use stage data of the KONE MonoSpace 500 was used in the energy consumption calculations and the results were compared to the values of energy efficiency class boundaries A–F. Four different electricity production profiles were used, namely Sweden, France, European average and global average. The handprint of the KONE MonoSpace 500 varied from 10 kg CO<sub>2</sub> eq./year (compared to energy efficiency class A elevator with Swedish electricity) to 12 650 kg CO<sub>2</sub> eq./year (compared to energy efficiency class F elevator with global average electricity). Below are example figures of the handprint results when the elevator is used in Europe (baseline solution: energy class B (Figure 13) and D (Figure 14) and in Sweden (baseline solution: energy class B (Figure 15)).

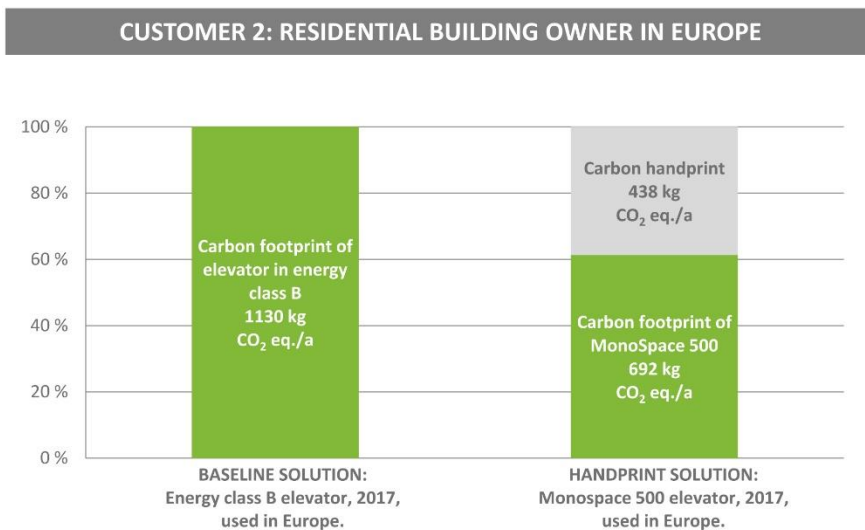


Figure 13. Handprint of the elevator when used in Europe by Customer 2 and compared to elevator in energy class B (calculation based on ISO 25745 methodology with 630 kg load, 1.0 m/s speed, and 12 m height).

## CUSTOMER 2: RESIDENTIAL BUILDING OWNER IN EUROPE

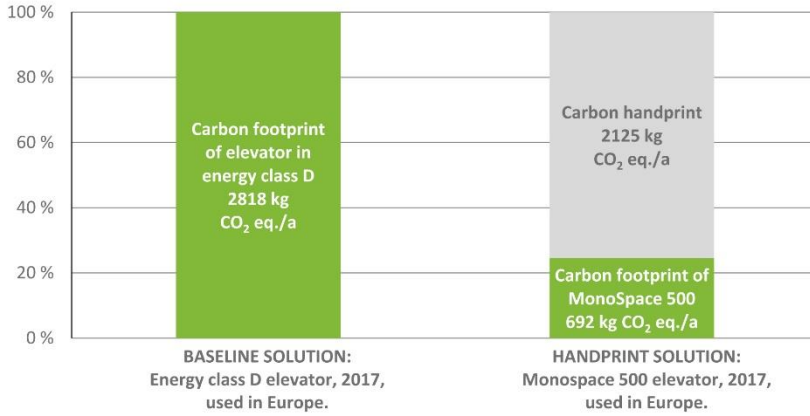


Figure 14. Handprint of the elevator when used in Europe by Customer 2 and compared to elevator in energy class D (calculation based on ISO 25745 methodology with 630 kg load, 1.0 m/s speed, and 12 m height).

## CUSTOMER 2: RESIDENTIAL BUILDING OWNER IN SWEDEN

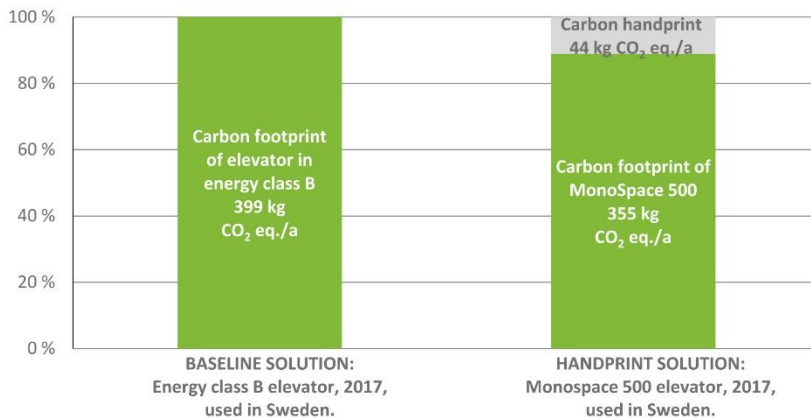


Figure 15. Handprint of the elevator when used in Sweden by Customer 2 and compared to elevator in energy class B (calculation is based on ISO 25745 methodology with 630 kg load, 1.0 m/s speed, and 12 m height).

## Conclusions

Elevators tend to be essential products that are not replaceable with alternative solutions, particularly if the travel height is considerable or stair use is otherwise not viable. Therefore, the choice between different elevator options for a given building can create a handprint. In this example, the handprint is created by minimizing the electricity consumption of the elevator in the use stage. The handprint of an elevator is greatly dependent on the system boundaries and assumptions used in the study, such as the use location and fuel profile of electricity used during the use stage. Since there are no 'average elevators' that could be used as a baseline, the handprint should be based on actual LCA studies of alternative elevators or, if this is not available, on the energy consumption in the use stage, since the energy efficiency can vary greatly between different elevators.

As a test case for the handprint methodology, this case study shows the huge impact that the baseline and the usage location can have on a handprint of a product. KONE plans to use handprint calculations in its product development for low carbon solutions.

### 5.3 Renewable diesel from a fuel manufacturer

In this case study, a hydrotreated vegetable oil (HVO) fuel (see case brand in Figure 16) is examined. The fuel is produced from used cooking oil. By using the renewable fuel in their vehicles, customers have the potential to reduce their greenhouse gas (GHG) emissions.



Figure 16. Neste's renewable diesel. Copyright: Neste 2018.

## **Defining the customers**

Three different customer types are identified for the diesel fuel:

- Customer 1: consumers using the fuel (private car owners)
- Customer 2: logistics operators
- Customer 3: cities, companies and other organizations with vehicle fleets

The customers are identified based on the function and purpose of use of the product. The function of the renewable diesel is to act as a motive power for diesel-operated vehicles. Consumers consist of all customers using fuel for their own purposes to move from one place to another. For logistics operators, the purpose is to move objects from place to place. For cities, companies and other organizations, the purpose is to provide their employees with travel mobility. Cities, companies and other organizations can therefore be classed together as a customer type.

The framework for defining the handprint for the abovementioned customers is presented in Figure 17. The carbon handprint calculation is conducted for customer 2, a logistics operator with one vehicle.

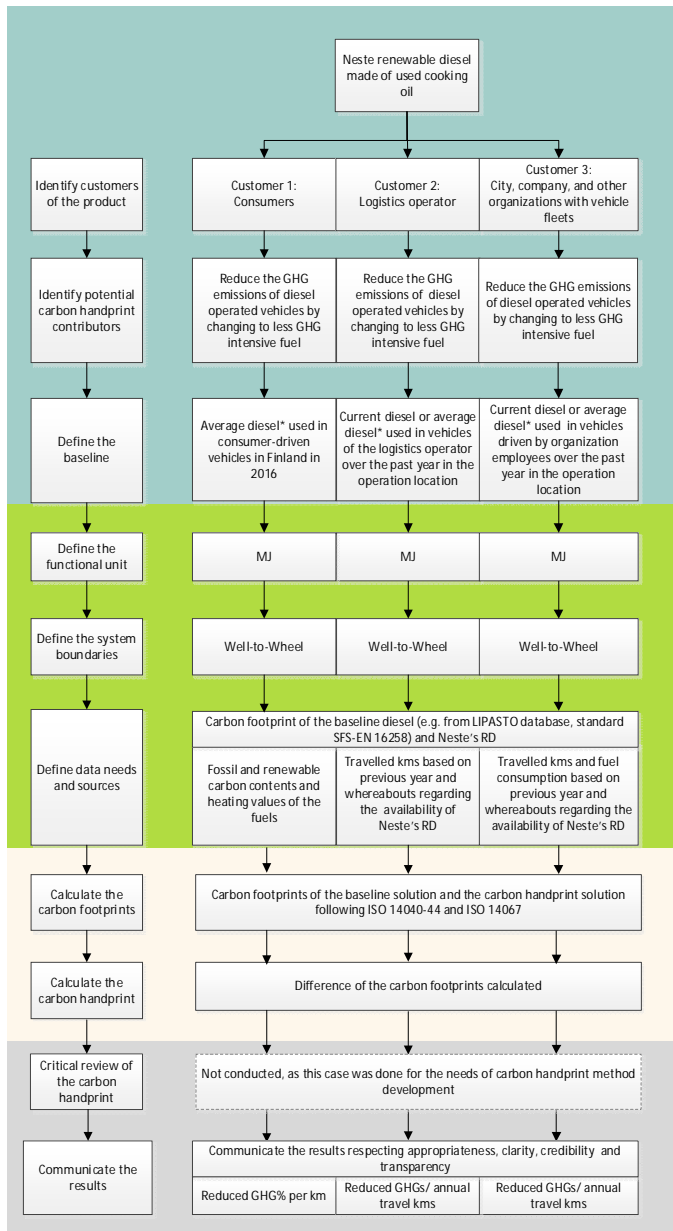


Figure 17. Carbon handprint framework for Neste's renewable diesel.

## **Defining the handprint contributors**

Neste's customers have the potential to reduce their traffic-related GHG emissions by using the diesel produced from renewable and waste-based raw materials. According to directive 2009/28/EC, waste and residue-based raw materials have zero lifecycle greenhouse gas emissions up to the process of collection of those materials. In this case, the biogenic carbon intake equals the number of released biogenic carbon emissions, resulting in zero net biogenic CO<sub>2</sub> emissions.

## **Defining the baseline**

The renewable diesel needs to be compared to fuel(s) that similarly provide motive power for diesel engines. When considering consumers as the customers, they have a vast number of possible fuels to choose from so no single, specific baseline product for comparison can be specified. Therefore, the average diesel fuel sold and used in Finland during the previous full year (2016) was selected as the baseline fuel, consisting of a mix of fossil diesel and 12% bio-based diesel (LIPASTO 2017). Annual statistics of market area specific fuel consumption are likewise well-suited to be used as a baseline.

If the logistics operators, cities, companies and other organizations can be specified, the baseline fuel can be defined more accurately and the currently used diesel can be chosen as the baseline fuel.

## **Defining the functional unit**

The functional unit of the study could be annual distance (km) driven per vehicle if the annual total figure for the vehicle is known. If the total kilometres driven cannot be determined, the lower heating value of the fuel in megajoules can be used as a functional unit. Using megajoules can be useful in the case of consumers where driving distances are not known or not available, e.g., from bookkeeping records. Companies usually keep records of annual mileage data, which can be used to calculate the GHG reduction based on actual annual kilometres driven.

## **Defining system boundaries**

In this case, the fuel is burned in the motor of a vehicle and, thus, the product systems of fuels and vehicles are considered as part of the system boundary. It was assumed that different fuels do not differ in how they decrease or reduce the lifetime or efficiency of a motor. Thus, the analysis focused on the use phase while other lifecycle phases were excluded from the analysis. The system boundary fits the definition of the Well-to-Wheel (W-to-W) approach. The system boundaries are the same for both the baseline and handprint solutions.

## Results

The carbon handprint calculations were carried out for a logistics operator that owns one vehicle. The examined vehicle operates in the Helsinki region of Finland, consumes 6 litres of diesel per 100 km, and had an annual mileage in 2016 of 130,000 km. The logistics operator had no information on the GHG emissions of the fuel used in 2016. The GHG emissions of average diesel was therefore used as a baseline. When the density (0.824 kg/m<sup>3</sup>), lower heating value (43 MJ/kg), and emissions per litre of the baseline diesel (SFS-EN16258, 2012; LIPASTO, 2017) are known, the consumed energy and total emissions per year can be estimated. Based on the values, 6 litres of baseline diesel per 100 km accounts for 2.1 MJ per km.

The availability of the fuel must also be taken into account when calculating the carbon handprint. As the fuel was available only at a limited number of fuel stations, it was estimated that the distance to the nearest station selling the examined renewable diesel was approximately 10 km longer than the closest station. Considering the tank size of the examined vehicle (50 l), the annual distance travelled, and the roundtrip to the nearest station selling renewable diesel, the logistics operator had to refill the tank more frequently compared to the situation in 2016. Annually, based on the increased number of fillings and the distance to the selected station, the travelled distance increased by approximately 3,200 km.

The logistics operator saved 21 tonnes of CO<sub>2</sub> equivalent per year after switching from average diesel to renewable diesel (Figure 18). The impact would be multiplied if the logistics operator had a fleet in the same region and all vehicles switched to renewable fuel.

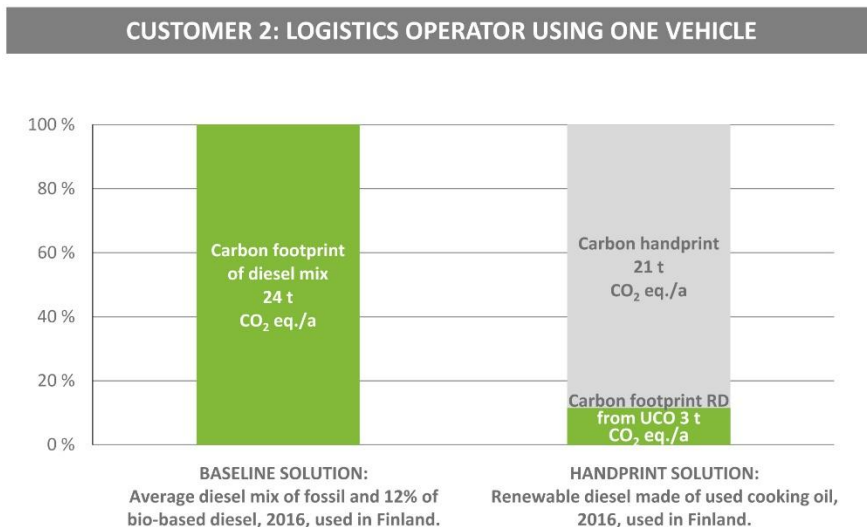


Figure 18. Handprint of the renewable diesel made from used cooking oil when used by a logistics operator using one vehicle.

## Conclusions

Results of the renewable diesel handprint calculation indicate that switching the baseline diesel to renewable diesel provides the user with clear potential to reduce greenhouse gas emissions. Based on this, the renewable diesel made of used cooking oil has a certain handprint. It must be remembered, however, that this handprint is linked to a specific customer (logistics operator with certain annual driven kilometres) using the renewable diesel instead of the baseline fuel (average diesel fuel mix sold in Finland in 2016). This handprint can thus be used in communicating the carbon footprint reduction potential that the renewable diesel can provide for this specific customer.

Setting the baseline for this case study was relatively straightforward because the fuel sector in Europe has detailed regulations and reliable statistics in place and the data for the average baseline fuel could therefore be easily acquired.

### 5.4 Biodegradable shopping bags from a material manufacturer

The Paptic bag is a shopping bag made almost entirely of wood fibre. The bag is recyclable and combines the beneficial qualities of both paper and plastic. The Paptic material can be used to replace both plastic and paper bags and packaging materials. The idea of the bag is to offer a biodegradable packaging material that, if littered or landfilled, will break down safely in the environment and not accumulate in marine organisms, thus providing an environmentally responsible alternative to conventional plastic packaging. The product is shown in Figure 19.



Figure 19. Paptic bag.



## Defining the customers and the handprint contributors

Paptic bag is assumed to replace either plastic or paper bags. As consumers behave in many different ways and waste management options differ regionally, the number of uses may vary and there are different possibilities for the end-of-life stage of potential baseline solutions. Some examples of possible customers for Paptic bags and the baseline solutions are identified as follows:

- Consumer 1: uses plastic bag with end-of-life recycling, would use Paptic bag 1 time like plastic bag
- Consumer 2: uses plastic bag with end-of-life recycling, would use Paptic bag 5 times
- Consumer 3: uses plastic bag with end-of-life incineration, would use Paptic bag 1 time like plastic bag
- Consumer 4: uses plastic bag with end-of-life incineration, would use paptic bag 5 times
- Consumer 5: uses paper bag with end-of-life recycling
- Consumer 6: uses paper bag with end-of-life incineration
- Retail/Brand Owner (RBO): Plastic bags. Assumed annual consumption 5 million bags

Based on earlier studies, it can be assumed that the new material has potentially a lower carbon footprint compared to plastic bags of the same size and corresponding grammage. Furthermore, the motivation of using Paptic bag multiple times may be higher than when using typical plastic or paper bags thus lowering the overall environmental impact of the Paptic bag user. The assumption that the Paptic bag could be used several times is based on the design of the bag and the usability and durability of the Paptic material compared to the plastic bag. Therefore also customers using Paptic bags five times versus the one-time use of plastic bags are identified.

Another positive environmental benefit for the Paptic bag could be the reduction in marine plastic pollution achieved by using Paptic bags instead of plastic bags. This benefit applies especially to developing countries in which waste management systems are often ineffective or non-existent. This impact category, however, is outside the scope of the carbon handprint.

The framework for defining the carbon handprint for the abovementioned customers is presented in Figure 20. The calculation for Consumer 3 was selected to be demonstrated and reported as an example. Incineration is still currently the most common way of getting rid of plastic waste. However, due to increasing demands related to recycling of plastic packaging, other Customer profiles may become more relevant in the future.



Figure 20. Carbon handprint framework for Paptic bag.

### **Defining the baseline**

The baseline against which the Paptic bag is compared in the selected case of Customer 3 is a plastic bag made from polyethylene including 10% of recycled plastic representing a typical plastic bag in the market.

### **Defining the functional unit**

The functional unit for handprint calculations of the Paptic bag is a bag, and total amount of bags / year.

### **Defining the system boundaries**

The system boundaries in the calculated case include the bag production from cradle to end-of-life incineration. The main raw material used in the Paptic bag is wood pulp, so raw material acquisition starts with forestry, whereas the PE bag cradle traces back to oil pumping. The collection and transport of the bags to incineration are left outside the boundaries, as they are the same for both options.

### **Results**

For the Consumer 3 (baseline: plastic bag with end-of-life incineration) the Paptic bag gets a carbon handprint of 56 g CO<sub>2</sub> eq./bag when the bags are incinerated at end-of-life (Figure 21). The biggest share of the handprint comes from the end-of-life stage where incineration of plastic accounts for ~70% of the handprint compared to the Paptic bag, which is assumed to have zero impact on climate change at end-of-life. Also the production from cradle to gate of a Paptic bag has a lower carbon footprint than plastic bags.

### CUSTOMER 3: CONSUMER

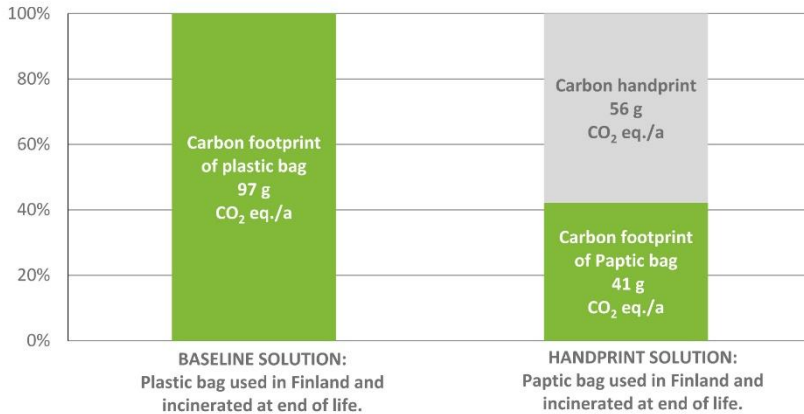


Figure 21. Handprint of the Paptic bag, Consumer 3.

## Conclusions

A carbon handprint is created when Paptic bags are used to replace plastic bags that end up in incineration. It is foreseen, however, that the size of the handprint varies considerably depending on the Customer. The results are sensitive for applied assumptions related to the assumed baseline materials, the number of times the bags are used and the end-of-life options. Increasing the number of use times would furthermore increase the carbon handprint of the Paptic bag. In this case study the handprint was calculated for a fictitious customer in order to test the methodology. In reality, it is likely that the bags would end up in many different end-of-life options and several scenarios would be needed to ensure comparability and transparency of the results if applied for consumer or customer communication.

### 5.5 Carpet with optional cleaning service from an interior design company

AO-allover's INNOcarpet products (example shown in Figure 22) are used in public buildings such as schools, conference rooms and entrance halls. They are made from wear-resistant, non-slip materials (e.g. polypropylene or nylon PA6-6 with nitrile butadiene rubber) and can be custom made in various shapes, sizes and colours. In addition to manufacturing carpets, AO-allover offers a 3–5 year on-site INNOcarpet cleaning service. The INNOcarpet case was chosen in order to test the applicability of the handprint approach to services.



Figure 22. INNOcarpet. Copyright: AO-allover 2018.

### **Defining the customers**

INNOcarpets are designed primarily for use in public buildings such as schools, offices and hotels. Private consumers are not the main target customers. The carpets can be customized according to the customer's wishes and delivered with or without the optional cleaning service. The following two potential customer types were identified:

- Customer 1: Public building owner using INNOcarpets without the cleaning service
- Customer 2: Public building owner using INNOcarpets with the cleaning service

The framework for defining the handprint for the above customers is presented in Figure 23. The case was assessed qualitatively and no actual handprint calculations were made.

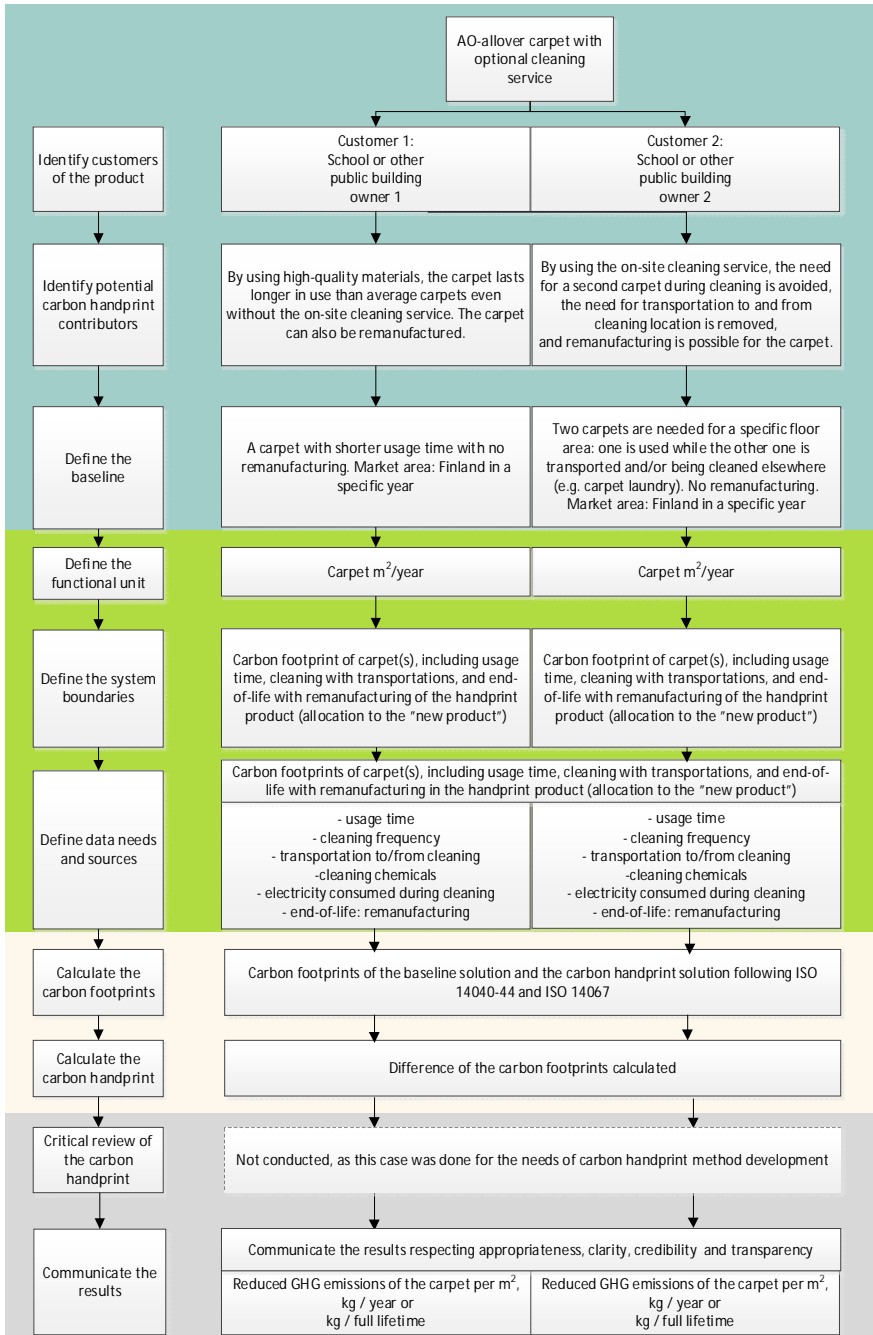


Figure 23. Carbon handprint framework of the INNOcarpet.

## **Defining the handprint contributors and the baseline**

The difference between INNOCarpet and the baseline service is that cleaning can be done on-site instead of transporting the carpet to and from an external laundry. This also eliminates the need for a replacement carpet to be provided during cleaning.

## **Defining the functional unit**

The functional unit for handprint calculations of INNOCarpet with a possible cleaning service can be carpet m<sup>2</sup>, or per year, life cycle of the carpet, e.g. 5 years.

## **Defining system boundaries**

The system boundaries of a carpet handprint include the cradle-to-grave life cycle assessment of the carpet, including cleaning alternatives. INNOCarpet products can also be remanufactured at the end-of-life stage, which can be considered in the assessment by allocating a proportion of the manufacturing impacts to the next life cycle. If actual handprint calculations were made, the system boundaries for the baseline and handprint solutions should be the same.

## **Results**

Customer 2, using INNOCarpets with the cleaning service, was considered a qualitative example case in this project. The potential handprint of the product is created via reduced transportation emissions due to the on-site cleaning service and the eliminated need to manufacture and deliver a replacement carpet. In addition, the possibility of remanufacturing the carpet at its end-of-life stage increases the handprint of the product. However, the cleaning stage can decrease the handprint if the chemicals used in INNOCarpet cleaning are more GHG intensive than those used in the conventional cleaning of the reference solutions. In addition, the usage time of the INNOCarpet and reference carpets needs to be defined carefully to ensure comparable results.

## **Conclusions**

INNOCarpet products with a cleaning service can achieve a carbon handprint. Additionally, the customer-specific shape, material and colour options can serve more than only decorative purposes. If, for example, the carpet material could be proven to bind dust more efficiently than the reference carpets, other handprints could also be attained, such as improvements to human health. From the climate change perspective though, the main improvement is the on-site cleaning service that can be purchased with the carpet.

As a test case for the handprint methodology, this case study showed that the methodology works also for services and not only products. In addition, the benefits of remanufacturing can also be considered through allocation.

## **5.6 Additive manufacturing technology**

AM Finland specializes in 3D printing of metals using additive manufacturing technology. The company uses laser melting to manufacture products according to the customer's designs. There are various routes by which an additive manufacturing service provider could derive a carbon handprint: For example by improving the performance of a product with an additively manufactured component, by reducing the mass of a product, by creating a novel design leading to improved energy efficiency, or by having the ability to quickly provide spare parts in situ. These possibilities are further discussed in the conference paper by Leino et al. (2018).

### **Defining the customers**

In this case no specific customer is identified in order to safeguard producer and client confidentiality. Instead, an imaginary, though realistic microturbine manufacturing case for AM Finland's additive manufacturing service is presented. The framework for defining the potential handprint for additive manufacturing is presented in Figure 24. The case was assessed qualitatively and no actual handprint calculations were made.



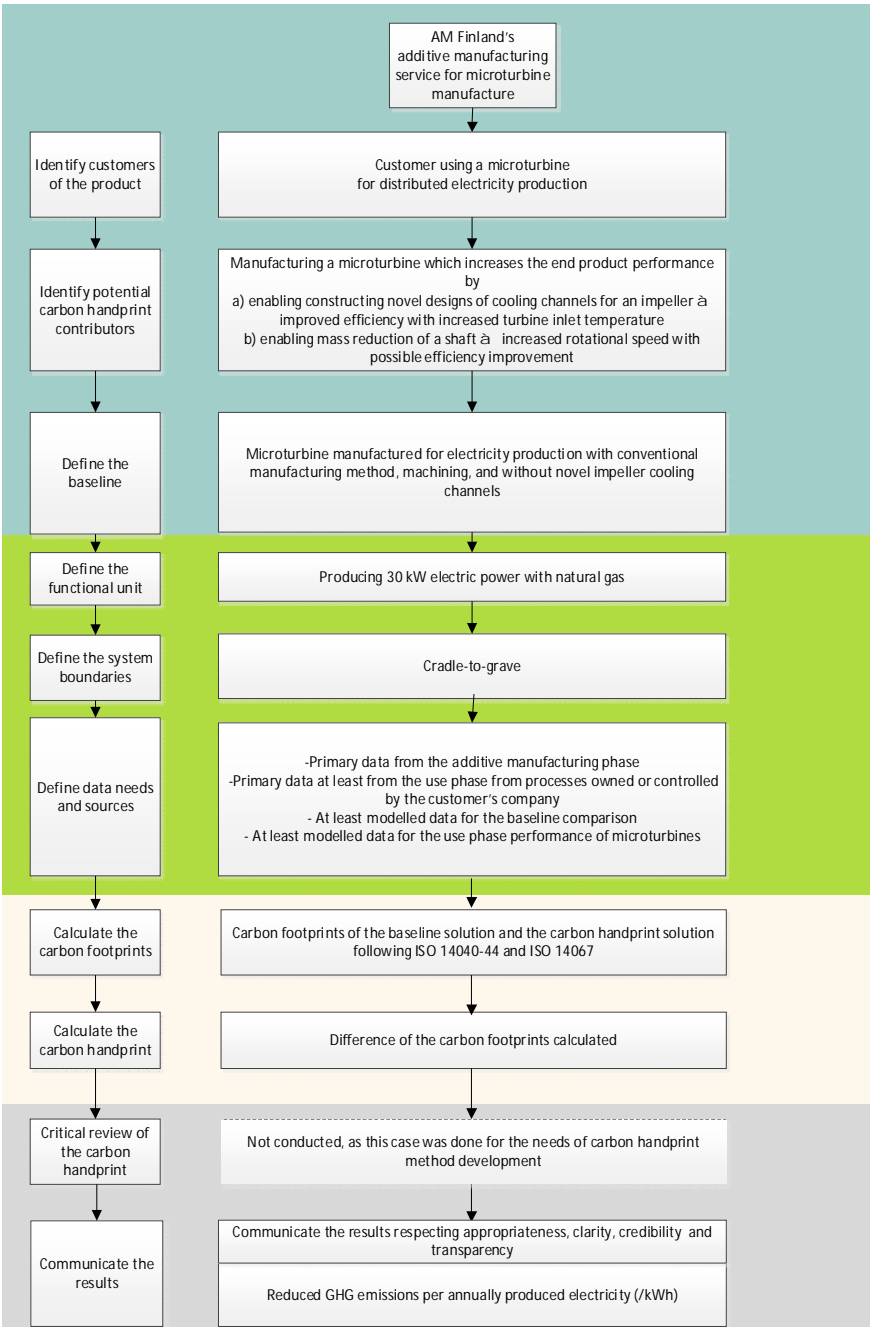


Figure 24. Carbon handprint framework for the additive manufacturing technology.

## **Defining the handprint contributors**

The customer is using a microturbine for distributed electricity production. With additive manufacturing a novel design of microturbine can be produced. This novel structure increases the end-product performance by two means. First, novel cooling channels for the impeller can be constructed. This can improve energy efficiency by enabling a higher turbine inlet temperature. Secondly, mass reduction of the shaft can be achieved with additive manufacturing. This can lead to increased rotational speed with possible energy efficiency improvement.

## **Defining the baseline**

The baseline product is a microturbine for the same purpose but manufactured with conventional manufacturing technology, i.e. machining. Machining does not allow novel impeller cooling channels.

## **Defining the functional unit**

The functional unit for the handprint assessment can be specific, such as the output power produced by the microturbine using a specific fuel, e.g. 30 kW electric power with natural gas.

## **Defining system boundaries**

System boundaries of the study would need to reach from cradle to grave. As the studied microturbines are produced using different technologies and raw materials, the difference between the baseline and handprint microturbine will become evident in the use phase. Because the end-of-life processes of the two microturbines might differ, the full life cycle of the products are recommended to be included in the study. The system boundaries include the same life cycle phases for both the handprint solution and the baseline solution.

## **Conclusions**

Carbon handprint potential can be uncertain if it is not clear who is the initiator of the carbon handprint solution and who is needed in the value chain as enablers. In the present case, it could be contemplated whether the handprint benefit should be forwarded to the AM technology developer or to the user of the technology. In addition, because the product design originates from the customer, the novel structures of the product are initiated by the product designer rather than the AM service provider. Therefore, the situation needs to be assessed case-by-case with a real customer in order to assess whether a handprint is created.

## 5.7 Biowaste treatment solution from a composter manufacturer

The product studied in this case is the Biolan composter shown in Figure 25. It represents a typical composter used by Finnish households. The composter enables consumers to process and utilize household biowaste independently instead of relying on centralized waste collection. The thermally insulated composter works all year round, even in harsh Nordic winter conditions. The frost-resistant UV-protected polyethylene composter can process the volume of biowaste generated by up to 6 persons per year (Biolan 2018).



Figure 25. Biolan composter. Copyright: Biolan 2018.

### Defining the customers and the baselines

As the product users are general consumers with a wide range of behaviour patterns and living habits, there are numerous possibilities for how the composter is used. In addition, the baseline scenario of using no composter will differ depending, for example, on the communal waste treatment services available. The composter is principally used for disposing of household biowaste. For a proportion of households compost production is also valued as gardening compost would otherwise need to be purchased. The potential handprint of the composter is therefore specific to different households. Eight examples of potential customer types for composters are identified below:

- Household 1: Biowaste is disposed of along with mixed waste and sent to landfill. No compost is purchased by the household.
- Household 2: Biowaste is disposed of along with mixed waste and incinerated. No compost is purchased by the household.

- Household 3: Biowaste is disposed of along with general waste and incinerated. Some compost is purchased by the household.
- Household 4: Biowaste is disposed of along with mixed waste and incinerated during the cold season (6 months) and composted on site during the warm season (6 months). Some compost is purchased by the household.
- Household 5: Biowaste is collected separately and processed in an anaerobic digestion plant. No compost is purchased by the household.
- Household 6: Biowaste is collected separately and composted in a centralized composting plant. No compost is purchased by the household.
- Household 7: Biowaste is processed according to the average Finnish household: 1% landfilled, 6% incinerated, 19% treated in an anaerobic digestion plant and 74% composted. No compost is purchased by the household. (Grönman et al. 2016)

Many more potential customer scenarios are possible in addition to the above; for example, the number of persons in a household can also vary affecting the handprint. The framework for defining the handprint for the abovementioned customers is presented in Figure 26. The calculation for household 3 was demonstrated and reported.



Figure 26. Carbon handprint framework for the Biolan composter.

## Defining the functional unit

The functional unit for handprint calculations in households 1–7 for a composter is the annual amount of biowaste generated by a 4-person household. The handprint results in this case are reported on a yearly basis as decreased CO<sub>2</sub> equivalent emissions per household or per person.

## Defining system boundaries

The system boundaries of the baseline solution and the composter handprint include the life cycle of the biowaste, from generation in the household to the end of waste treatment, including possible transportations. The manufacture of the composter would be included in the calculations by dividing the emissions from manufacturing by the expected lifetime of the composter, i.e. 30 years. Use of the composter also includes use of bulking material made from bark and peat, which is added to improve and stabilize the moisture balance of the composting material. The bulking material makes up approximately 1/3 of the volume of biowaste. The possible emissions of fossil CO<sub>2</sub> released from peat in the composter are considered in the handprint calculation. The CO<sub>2</sub> emissions from the biomass, though, are considered biogenic and thus climate neutral. No methane emissions are expected if the composter is used and functioning properly.

If the treatment of biowaste creates outputs (such as soil or collected methane gas in the baseline options), the system boundaries should be expanded to also consider the production and use of replaced (possibly fossil) materials. For example, methane produced at the anaerobic digestion plant would be converted to bio-fuels replacing fossil fuels, so also the production and use of those fossil fuels of similar volume should be included in the baseline solution.

## Results

Household 3 is used as an example case for handprint calculation in this project. The baseline solution consists of the carbon footprints of the collection, transportation and incineration of the biowaste (together with mixed waste) and the production of purchased compost. Since biowaste is typically very moist, the incineration plant uses additional energy to incinerate it, thus creating a footprint instead of producing energy from the biowaste, and thus system expansion is not needed. The carbon footprint of biowaste (from a 4-person household) treated within mixed waste incineration equals 10.4 kg CO<sub>2</sub> eq./y.

The handprint of the composter is created by decreasing the amount of waste collected, transported and treated at the incineration plant by composting the household biowaste on site. At the same time, the frequency of waste collection can be reduced, saving transportation of mixed waste, and compost that was purchased in the baseline is now produced on-site. On the other hand, the manufacture of the composter and the bulking material create a carbon footprint, which needs to be

considered in the calculation. Additionally, the bulking material includes peat, which decomposes in the compost, releasing some fossil CO<sub>2</sub>. When all of these aspects are included in the calculation, the carbon footprint of biowaste composting in a four-person household equals 9.1 kg CO<sub>2</sub> eq./y. The handprint of the composter in household 3 is thus 1.3 kg CO<sub>2</sub> eq./y (Figure 27).

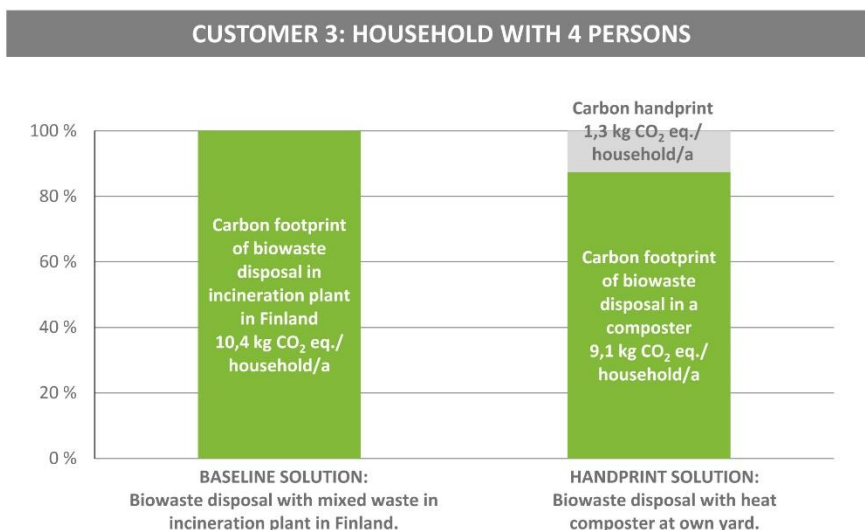


Figure 27. Handprint of the composter for the Household 3 scenario: biowaste is composted on site and produced compost replaces purchased compost.

## Conclusions

The potential handprint of a composter derives from reduced emissions from biowaste collection, transportation and treatment. In addition, the composter produces garden compost, which would otherwise be produced and purchased elsewhere by some customers. Thus, the composter handprint relates to two units: biowaste treatment and compost production, although compost is seen as an unwanted by-product by some customers. For these customers, who would not otherwise purchase compost, the system boundaries are different from those who would buy in compost. The calculation boundaries may also need system expansion in baseline solutions that produce, for example, heat or electricity in biowaste treatment plants. The definition of the baseline solution(s) is also challenging because the options for centralized waste treatment vary in different communities and household biowaste generation depends on the eating and behaviour habits of the customers. These factors need to be considered in a manner that describes the customer in the most accurate way possible. Consequently, the potential handprint of a composter is not constant, but always customer-specific.

On the other hand, the production of the composter and the bulking material from bark and peat decrease the handprint, as also does the composting of the peat in the bulking material, which releases fossil CO<sub>2</sub>. Use of peat for bulking may be the single most important factor hindering a handprint result for a composter, depending on the assumed composting reaction of the bulking material taking place in the composter.

As a test case for the handprint methodology, the composter revealed the importance of careful baseline definition and system boundary expansion in the case of multiple output products or services.



## 6. Conclusions and discussion

The handprint approach proposed is targeted at companies and organizations that are willing to quantify and communicate the environmental benefits of the products, services, or technologies that they offer to their customers.

As an additional advantage over carbon footprinting, carbon handprinting offers the company two major benefits. The handprint approach forces companies to extend their environmental responsibility beyond their gates. It urges them to customize their product to fit the needs and preferences of each customer and to optimize the product to the real-world operating environment in terms of GHG emissions and increases cooperation along the value chain. Simultaneously, the handprint approach gives companies the means to quantify the environmental benefits that their product offers to their customers. Previously, these kinds of calculation guidelines have been missing.

Secondly, carbon handprinting offers companies a tool for managing their climate impacts. This approach has its roots in the measuring of footprints, but instead of stopping there it requires the conductor to place the product being assessed in the surrounding environment, in the actual use of their customers, in a consistent way. This improved calculation might not only reveal the climate benefits but also the possibility that no handprint is created, which can be determined when compared to the baseline product in the same market. If so, this will provide a clear indication to the company to rethink their product and to optimize its carbon footprint throughout its lifecycle. Handprint thinking is shifting the decision-making process from conventional towards a strategic decision-making process, where the long-term objective is to produce and use climate friendly solutions. The positive mindset of the approach emphasizes that actors involved are solving the challenge instead of just causing more greenhouse gas emissions.

As with any method, carbon handprinting also has its limitations. Calculating a carbon handprint can be laborious, as two footprints need to be calculated, both the modified practice and the baseline practice, also beyond the factory gates. The same difficulties as with carbon footprinting are therefore also encountered, such as acquiring reliable data for comparison. However, the process creates a great deal of valuable information that can be used for product development and maximising the environmental benefits created.

Due to the novelty of the handprint concept, specific emphasis should be put on planning and preparing communication related to both the handprint concept and the results of handprint assessments. Whenever making claims about positive environmental impacts based on handprint assessment, it is important to specify the claim, make it understandable to the target audience and present it together with the relevant information needed to correctly interpret the result. Within communication, transparency and clarity is needed especially regarding the baseline scenario and the origin of the handprint. Transparency is important, since the result of the assessment is usually heavily affected by the assumptions made during the study. When only carbon handprint is considered, it should be clear that the claim is related

to climate impacts. According to the existing guidelines for environmental marketing and green claims, evidence for the claim should be made available (e.g. by publishing the original study or parts of it). Furthermore, in order to increase the credibility of the handprint concept, a critical review by a third party is recommended.

## **6.1 Handprint concept's applicability to other environmental impacts**

At this stage, the handprint methodology is applicable to assessing greenhouse gas emissions reduction. In the future, the carbon handprint methodology could be applied to other environmental impacts related to, for example, water use, raw material consumption, energy consumption, waste production, circular economy, and land use. However, adjustments to the current methodology are first needed, for example due to the varying spatial scale of environmental impacts.

This extension would be beneficial in advancing environmental sustainability more holistically. The need to extend the handprint methodology is evident as numerous companies and organizations are already considering the potential environmental impacts or benefits of their products or services also from other viewpoints beyond greenhouse gas emissions, and stakeholders are increasingly demanding information on environmental sustainability. In general, adoption of the handprint concept more widely would help change the mindset from focusing on the negative to focusing on the positive – the many (business) opportunities to do the right thing to solve the pressing sustainability challenges, taking local and users' needs as the starting point for product and business planning. The handprint concept could thereby significantly contribute to global sustainable development targets, such as Agenda 2030.

Water handprint could be the next handprint methodology to follow carbon handprint. The most important reason for this is that an established calculation methodology for water footprint exists as an ISO standardized methodology (ISO 14046 and guidance document ISO/TR 14073) along with carbon footprint (ISO 14067). Respectively, one of the main challenges in defining raw material, energy, waste, circular economy or land use handprint is the lack of scientific consensus in the definition of the respective footprints and the lack of established footprint methodologies.

We recommend that the starting point for water handprint is water scarcity handprint, which only considers the impacts of water consumption to water scarcity quantitatively. It is further recommended that water scarcity handprint is calculated in accordance with the guidelines of ISO 14046, the examples of ISO/TR 14073, and by applying the newest scientific consensus methodology AWaRe (Available Water Remaining) (Boulay et al. 2018). Qualitative impacts on water availability could be included in water handprinting in the future along with the development of qualitative water footprint methodologies. The handprint methodology requires adjustments in order to consider the locality of water use, for example with regard to defining the baseline.

Reduced consumption of raw materials could be easily included in a raw material handprint, including aspects related to material efficiency, avoiding losses, and replacing products with immaterial services. However, positive environmental impacts and a possible handprint could also be derived if raw materials with environmentally more beneficial qualities are preferred over poorer alternatives. For example, renewable materials are selected over non-renewable materials, abundant materials over scarce materials, recycled materials over virgin materials and materials with less environmentally or health hazardous qualities (e.g. toxicity) or less polluting materials over poorer materials in that regard. A challenge in qualitative raw material handprinting is to determine objectively and case-by-case the preference criteria unless, for example, applicable local legislation exists. Material selection could lead to adverse effects, such as shortened product lifetime.

Similar aspects apply to energy handprint. Quantitative energy handprint calculations could take into account measures related to energy consumption, efficiency, savings, losses and avoided energy use. A qualitative energy handprint would require qualitative criteria for better energy sources with regard to, for example, renewable vs. non-renewable energy, CO<sub>2</sub> intensity and air pollution. Determining best possible local energy sources is often a complex and controversial issue with no absolute answers. Moreover, qualitative aspects of energy handprinting could depend on local sensitivity to pollution and even social aspects of energy supply chains.

A waste handprint could simply indicate the quantity of reduced, avoided waste. If the quality of produced waste is considered in the waste handprint, then the waste hierarchy is firstly reusable waste, then recyclable waste, and then otherwise recoverable waste (2008/98/EC). Discussion about a possible waste handprint quickly leads to a discussion about choices in the product planning phase, such as raw material selection, recyclability, the circularity of product chains, versatile products, the abandonment of throwaway culture, and the principles of circular economy. It is important, therefore, that raw material, waste and circular economy handprints are developed together in line with each other.

A handprint for land use could quantitatively consider avoided land area use and land use efficiency aspects. Land use includes qualitative issues that are often associated with other environmental or social impacts. The impacts of land use change could also be considered. Qualitatively, the use of less vulnerable land areas with regard to, for example, ecosystems and biodiversity (Bruckner et al. 2015; Mattila et al. 2011; O'Brien et al. 2015), carbon stock, water quality and availability (Bruckner et al. 2015), soil quality and productivity (Bruckner et al. 2015; Mattila et al. 2011), topsoil degradation (O'Brien et al. 2015), cultural or recreational values and violation of land-use rights could be included in the land use handprint of a product chain.

The abovementioned suggestions are summarized in Table 1. In conclusion, application of the handprint methodology to other environmental impacts requires further research. Because handprinting currently exists as a method of quantifying environmental impacts, the starting point for methodology development could be quantitative environmental impacts and quantifiable qualitative aspects. Handprint

research could be further extended to developing a multi-criteria product environmental handprint or even a sustainability handprint, to pinpoint and avoid possible trade-offs and compromises between environmental handprints.

Table 1. Summary of the applicability of handprint concepts in other environmental impacts.

<b>Env. impact</b>	<b>Footprint starting point</b>	<b>Challenges</b>	<b>Recommendation</b>
<b>Water use</b>	ISO standardized methodology for water footprint (14046 & 14073)	Inclusion of water quality issues. Locality.	1. Quantitative aspects: <ul style="list-style-type: none"> <li>• water scarcity</li> </ul> 2. Qualitative aspects <ul style="list-style-type: none"> <li>• water quality</li> </ul>
<b>Energy consumption</b>	Possible applicable local legislation; Publications e.g. (Kaltenegger et al. 2017; Jeon et al. 2015; Chen & Lin 2008; Ferng 2002; De Benedetto & Klemeš 2009; Pagani et al. 2016; Chakraborty & Roy 2013)	Locality, in terms of available sources and acceptance	1. Quantitative aspects: <ul style="list-style-type: none"> <li>• energy efficiency</li> <li>• avoidance of energy use</li> </ul> 2. Qualitative aspects: <ul style="list-style-type: none"> <li>• renewability</li> <li>• (local) availability</li> <li>• pollution intensity</li> </ul>
<b>Land use</b>	Possible applicable local legislation; Publications e.g. (WRI and WBCSD 2006; Steen-Olsen et al. 2012; O'Brien et al. 2015; Mattila et al. 2011; Bruckner et al. 2015; Perminova et al. 2016; de Ruiter et al. 2017)	Inclusion of land use quality issues.	1. Quantitative aspects: <ul style="list-style-type: none"> <li>• land use efficiency</li> <li>• avoidance of land use</li> </ul> 2. Qualitative aspects: <ul style="list-style-type: none"> <li>• vulnerability</li> <li>• carbon stock</li> <li>• water quality and availability</li> <li>• soil quality and productivity</li> <li>• topsoil degradation</li> <li>• cultural or recreational values</li> </ul>
<b>Raw material consumption</b>	Possible applicable local legislation; Publications e.g. (Shigetomi et al. 2015; Lutter et al. 2016; Wiedmann et al. 2015;	Trade-offs in single product life cycle: What to prioritize?	1. Quantitative aspects: <ul style="list-style-type: none"> <li>• material efficiency</li> <li>• immateriality</li> </ul> 2. Qualitative aspects: <ul style="list-style-type: none"> <li>• renewability</li> <li>• availability</li> </ul>

	Bruckner et al. 2012; Giljum et al. 2016; Weinzettel & Kovanda 2011; Muñoz et al. 2009; Wang et al. 2014)		<ul style="list-style-type: none"> <li>• circularity</li> <li>• pollution intensity</li> <li>• environmental or health hazards, such as toxicity</li> </ul>
<b>Waste production</b>	Possible applicable local legislation; Publications e.g. (Entreprises pour L'Environnement Working Group 2013; Beylot et al. 2017; Tisserant et al. 2017; Fry et al. 2015; Jiao et al. 2013; Jensen et al. 2013; Tsukui et al. 2015)		<ol style="list-style-type: none"> <li>1. Quantitative aspects: <ul style="list-style-type: none"> <li>• reduced &amp; avoided waste</li> </ul> </li> <li>2. Qualitative aspects: <ul style="list-style-type: none"> <li>• reusability</li> <li>• recyclability</li> <li>• recoverability</li> </ul> </li> </ol>
<b>Circular economy</b>	Publications e.g. (Tisserant et al. 2017; Kirchherr et al. 2017)	Inclusion of all principles of CE (raw material selection, design for recycling and structural design, circularity of product chains, versatile products, abandonment of throwaway culture, societal impacts...)	To be developed together and in line with raw material and waste handprints

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Title	<p><b>The Carbon Handprint approach to assessing and communicating the positive climate impact of products</b></p> <p>Final Report of the Carbon Handprint project</p>
Author(s)	<p>Saija Vatanen, Kaisa Grönman, Tiina Pajula, Hanna Pihkola, Risto Soukka, Heli Kasurinen, Katri Behm, Catharina Hohenthal, Jani Sillman &amp; Maija Leino</p>
Abstract	<p>Currently, there is a lack of methods for calculating and communicating the beneficial environmental impacts of products and services. To fill this gap, this report presents a new approach for calculating the positive climate impact of a product or service – the carbon handprint. The purpose of the carbon handprint approach is to assess and communicate the positive climate impact of products and services, thereby incentivizing environmentally responsible practices and enabling informed choices.</p> <p>The core of the suggested approach involves comparing the carbon footprint of an improved product with the carbon footprint of the baseline product, and subsequently calculating the reduction in greenhouse gas emissions that can be achieved by using the improved product. The carbon handprint approach is founded on the standardized life cycle assessment methodology for footprints and provides a framework for identifying climate impacts in the actual operational environment.</p> <p>Methodological development is based on seven industrial case studies, in which carbon handprints of different products, services, and technologies are assessed. These case studies, carried out with AM Finland, AO-allover, Biolan, KONE, Neste, Nokia, and Paptic, are presented in this report.</p> <p>Organizations can use carbon handprints to quantify the greenhouse gas reductions that their customers can achieve by using certain products. The carbon handprint can thus serve as a powerful tool in communications and marketing. By conducting carbon handprint assessments, a company can also find out how their product qualifies in comparison to baseline products. Carbon handprints can therefore also support decision-making and lifelong product design.</p> <p>Through further research, the carbon handprint methodology can be adjusted to also cover other environmental impacts. Aspects to consider include different spatial scales of impacts and quantitative and qualitative aspects of material and energy flows. Quantitative and quantifiable qualitative environmental impacts could be the starting point for extension of the methodology to other environmental impacts. A more extensive view of environmental handprints could help avoid trade-offs between beneficial impacts.</p>
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Nimeke	<b>Hiilikädenjälki positiivisten ilmastovaikutusten arviointiin ja viestintään</b> Hiilikädenjälki-projektin loppuraportti
Tekijä(t)	Saija Vatanen, Kaisa Grönman, Tiina Pajula, Hanna Pihkola, Risto Soukka, Heli Kasurinen, Katri Behm, Catharina Hohenthal, Jani Sillman & Maija Leino
Tiivistelmä	<p>Tämä raportti esittelee hiilikädenjäljen, uuden lähestymistavan tuotteen tai palvelun positiivisen ilmastovaikutuksen arviointiin. Aikaisemmat menetelmät ovat perustuneet lähinnä negatiivisten ympäristövaikutusten kuvaamiseen, ja keinot tuotteiden tai palveluiden positiivisten ilmastovaikutusten esittämiseen ovat puuttuneet. Tuotteiden hiilikädenjälki kannustaa yrityksiä ympäristövastuullisiin käytäntöihin ja mahdollistaa valintojen tekemisen tieteelliseen tietoon perustuen.</p> <p>Hiilikädenjälki perustuu tuotteen ja vertailutuotteen hiilijalanjälkien vertailuun. Hiilikädenjälki tarkoittaa kasvihuonekaasupäästövähennyistä, jonka asiakas voi saavuttaa parannetun tuotteen avulla. Tämän määritelmän mukaisesti oman hiilijalanjäljen pienennys ei muodosta kädenjälkeä. Tässä raportissa esitetty hiilikädenjälkimenetelmä pohjautuu standardoituihin elinkaariarvioinnin ja hiilijalanjäljen menetelmiin ja tarjoaa puitteet ilmastovaikutusten tunnistamiseksi asiakkaan toimintaympäristössä.</p> <p>Menetelmäkehitykseen kuului seitsemän tapaustutkimusta, joissa arviointiin eri tuotteiden, palveluiden ja teknologioiden mahdollisesti aikaansaamia kasvihuonekaasupäästöjen vähennyksiä. Nämä AM Finlandin, AO-alloverin, Biolanin, KONEen, Nesteen, Nokian ja Papticin tapaustutkimukset on lyhyesti esitelty tässä raportissa.</p> <p>Yritykset ja muut organisaatiot voivat käyttää hiilikädenjälkeä määrittääkseen kasvihuonekaasupäästövähennyksen, jonka heidän asiakkaansa voivat saavuttaa parannettujen tuotteiden avulla. Hiilikädenjälki voi siten toimia tehokkaana välineenä viestinnässä ja markkinoinnissa. Hiilikädenjälkilaskennan avulla yritys voi myös tunnistaa keinoja, jotka mahdollistavat ilmastohyötyjen maksimoinnin arvoketjussa. Näin ollen hiilikädenjälki voi tukea yrityksen päätöksentekoa ja tuotesuunnittelua.</p> <p>Tulevaisuudessa kädenjälkikonseptia voidaan soveltaa myös muihin ympäristövaikutuksiin. Laajempi näkemys eri ympäristövaikutuksista on tarpeen, jotta eri ympäristönäkökulmat voidaan huomioida päätöksenteossa, eikä vaikutuksia siirretä paikasta toiseen.</p>
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