Life Cycle Assessment

Of Tabletops
By DFI Geisler

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Ordered by: *DFI Geisler A/S*

DFI-Geisler is Scandinavia's leading manufacturer of kitchen worktops in all materials. We are Danish through and through, and, for decades, we have supplied worktops with personality to more than a million kitchens, mainly in Scandinavia.

DFI Geisler's mission is to "Develop, sell, produce and deliver a wide range of tabletops for kitchen and bath as efficiently as possible".

Issued by: Miljögiraff AB

Miljögiraff is an environmental consultant specialised in Life Cycle Assessment and Ecodesign. We think that it is a combination of analysis and creativity needed to meet today's challenges. Therefore, we provide Life Cycle Analysis for the evaluation of environmental aspects and design methods for the development of sustainable solutions.

We create measurability in environmental work based on a life cycle perspective on environmental aspects. The LCA methodology establishes the basis for modelling complex systems of aspects with a credible assessment of potential environmental effects.

Miljögiraff is part of a global network of experts in sustainability metrics, piloted by PRé Sustainability.

Abbreviations and expressions

Clarification of expressions and abbreviations used in the report

CO2eq – Carbon dioxide equivalents

EPD – Environmental Product Declaration

GWP – Global Warming Potential

ISO – International Organization for Standardization

LCA – Life Cycle Assessment

LCI – Life Cycle Inventory Analysis

LCIA – Life Cycle Impact Assessment

PCR - Product Category Rules

Environmental aspect - An activity that might contribute to an environmental effect, for example, “electricity usage”.

Environmental effect - An outcome that might influence the environment negatively (Environmental impact), for example, “Acidification”, “Eutrophication” or “Climate change”.

Environmental impact - The damage on a safeguarding object (i.e. human health, ecosystems, health and natural resources).

Life Cycle Inventory (LCI) data – Inventory of input and output flows for a product system

1 Introduction

The report presents the total environmental footprint for six tabletops produced by DFI Geisler A/S from a life cycle perspective using the ISO 14040 standard approach.

The purpose is to understand the environmental impact of the six different tabletops to find opportunities to mitigate the adverse effects and increase the potential contribution to sustainable development. The results of the study are also used for external marketing purposes.

1.1 Life Cycle Assessment

The importance of potential environmental impacts associated with the manufacturing and use of products is continuously increasing. A system perspective is required to find the best environmental strategy for product and business development. This has led to development of methods to better understand and address these impacts. One method is Life Cycle Assessment (LCA). It provides the backbone for strategies, management and communication of environmental issues related to products.

LCA can assist in;

- identifying opportunities to improve the environmental performance of products at various points in their life cycle,
- informing decision-makers in industry, government or non-government organizations (e.g. for the purpose of strategic planning, priority setting, product or process design or redesign),
- the selection of relevant indicators of environmental performance, including measurement techniques,
- marketing (e.g. implementing an ecolabelling scheme, making an environmental claim, or producing an environmental product declaration).

Figure 1: The concept of Life Cycle Assessment.

LCA addresses the environmental aspects and potential environmental impacts) (e.g. use of resources and environmental consequences of releases) throughout a product's life cycle from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal (i.e. cradle-to-grave), see Figure 1.

A major part of the environmental impact of a product depends on choices taken during the product development phase, e.g. materials, processes, functionality etc. The basic principles for abatement come from the discipline of cleaner technology, is defined in the concept of Integrated Product Policy (IPP) as:

> "All products cause environmental degradation in some way, whether from their manufacturing, use or disposal. LCA management seeks to minimise these by looking at all phases of a products' life-cycle and taking action where it is most effective.
> The life-cycle of a product is often long and complicated. It covers all the areas from the extraction of natural resources, through their design, manufacture, assembly, marketing, distribution, sale and use to their eventual disposal as waste. At the same time it also involves many different actors such as designers, industry, marketing people, retailers and consumers. LCA management attempts to stimulate each part of these individual phases to improve their environmental performance.
> With so many different products and actors there cannot be one simple policy measure for everything. Instead there are a whole variety of tools - both voluntary and mandatory - that can be used to achieve this objective."

Miljögiraff combines the confidence and objectiveness of the strong and accepted ISO standard, with the scientific and reliable LCI data from ecoinvent and with the world-leading LCA software SimaPro for calculation and modelling (Figure 2).

Figure 2, ISO standard combined with reliable data from Ecoinvent and the LCA software SimaPro.

1.2 ISO 14040

In 1997, the European Committee for Standardization published their first set of international guidelines for the performance of LCA. This ISO 14040 standard series has become widely accepted amongst the practitioners of LCA and is continuously being developed along with progressions within the field of LCA (Rebitzer et al. 2003). The guidelines for LCA are described in two documents; ISO 14040, that contains the main principles and structure for preforming an LCA, and ISO 14044, which includes detailed requirements and recommendations. Furthermore, a document containing the format for data-documentation (ISO/TS 14048), as well as technical reports with guidelines for the different stages of an LCA (ISO/TR 14049 and ISO/TR 14047), are available in this standard series. (Carlsson & Pålsson, 2011)

This LCA follow the “Book-keeping“ LCA approach which is defined as attributional LCA in the ISO 14040 standard.

The environmental management method Life Cycle Assessment (LCA) is used in this study. The LCA has been performed according to the ISO 14040 series standards.
ISO 14040: 2006 - Principles and framework
ISO 14042: 2006 - Life Cycle Impact assessment
ISO 14044: 2006 - Guiding

There are four phases in an LCA study; the goal and scope definition phase, the inventory analysis phase, the impact assessment phase and the interpretation phase. Below is a conceptual picture of this in Figure 3.

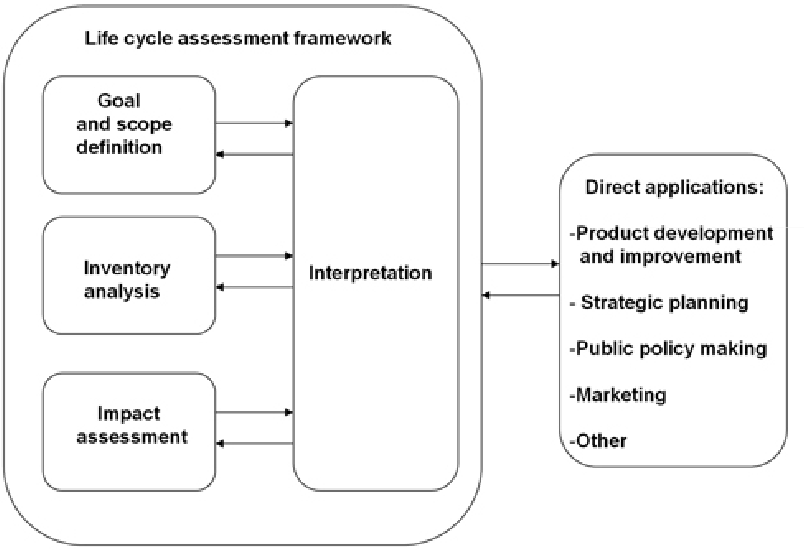

Figure 3. The four phases of the Life Cycle Assessment

1. The first phase is the definition of goal and scope. The goal and scope, including system boundary and level of detail, of an LCA depends on the subject and the intended use of the study. The depth and the breadth of LCA can differ considerably depending on the goal of a particular LCA.

2. The life cycle inventory analysis phase (LCI phase) is the second phase of LCA. It is an inventory of input/output data with regard to the system being studied. It involves the collection of the data necessary to meet the goals of the defined study.

3. The life cycle impact assessment phase (LCIA) is the third phase of the LCA. The purpose of LCIA is to provide additional information to help assess a product system’s LCI results so as to better understand their environmental significance.

4. Life cycle interpretation is the final phase of the LCA procedure, in which the results of an LCI or an LCIA, or both, are summarized and discussed as a basis for conclusions, recommendations and decision-making in accordance with the goal and scope definition.

2 Goal and Scope

2.1 The aim of the study

The goal is to quantify the environmental impact of six different tabletops from a life cycle perspective. The report describes the results in a transparent and reproducible way according to the standard. The results are interpreted a followed by recommendations for mitigating the environmental impact.

The purpose is to understand how the environmental impact differs between the six tabletops and to understand the contribution from different materials used in the tabletops. This in order to improve the environmental performance of the products through product development.

The results are to be used in environmental communication both internally and externally.

The intended audience was external.

2.2 Scope of the Study

2.2.1 Name and Function of the Product/System

The scope of an LCA shall clearly specify the functions (performance characteristics) of the system being studied. The scope was from the cradle to the grave, that is all the way from the extraction of raw materials, production, installation, use and service to the waste disposal.

The six different tabletops that are investigated are:

- Composite
- Solid wood
- Laminate
- Compact laminate
- Ceramic
- Natural stone.

More detailed information about the tabletops can be found in 3 Life cycle inventory (LCI).

2.2.2 The Functional Unit and reference flow

The functional unit shall be consistent with the goal and scope of the study. One of the primary purposes of a functional unit is to provide a reference to which the input and output data are normalized.

In this LCA the functional unit is 1m^2 tabletop during 20 years of usage.

2.2.3 System Boundary

The system boundary determines which processes are included within the LCA. The selection of the system boundary shall be consistent with the goal of the study.

The deletion of life cycle stages, processes, inputs or outputs is only permitted if it does not significantly change the overall conclusions of the study. Any decisions to skip life cycle stages, processes, inputs or outputs are clearly stated, and the reasons and implications for their exclusion are if any explained.

This is a cradle-to-grave study. That means that all processes needed for raw material extraction, manufacturing, transport, usage and end-of-life are included in the study. An illustration of the system boundary for the solid wood tabletop can be seen in Figure 4. The other tabletops have the same system boundary but other raw materials. For the tabletops composite, ceramic and natural stone water is consumed in the manufacturing process.

The data used to represent the different parts are described in detail in 3 Life cycle inventory (LCI).

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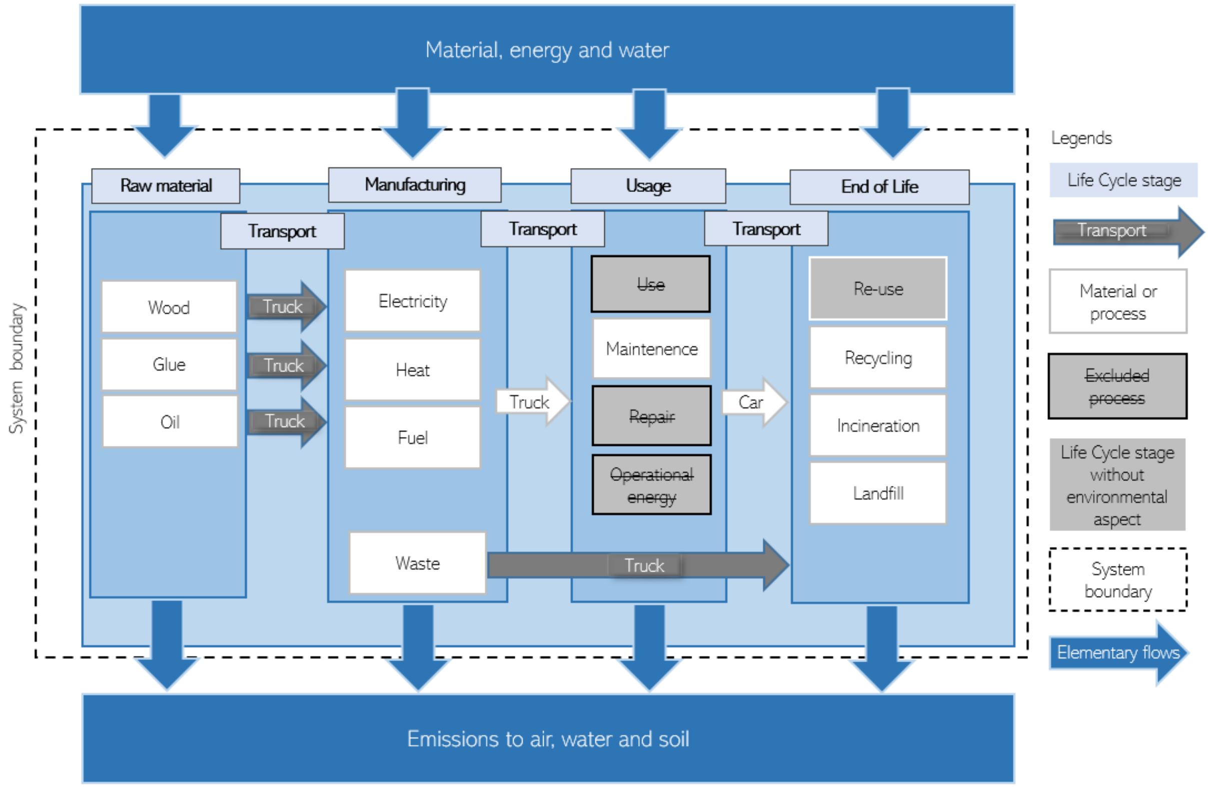

Figure 4. System boundaries for the model of the product system.

In this LCA, boundaries with other systems, and the allocation of environmental burdens between them, are based on the recommendations of the international EPD system[1], which are also in line with the requirements and guidelines of the ISO14040/14044 standards (IEC, 2008). In accordance with these recommendations, the Polluter Pays (PP) allocation method is applied. For allocation of environmental burdens when incinerating waste, this implies that all the processes in the waste treatment phase, including emissions from the incineration are allocated to the life cycle in which the waste is generated. Following procedures for refining of energy or materials used as the input in a following/receiving process, are allocated to the next life cycle.

[1] EPD (Environmental Product Declarations) by the International EPD Cooperation (IEC)

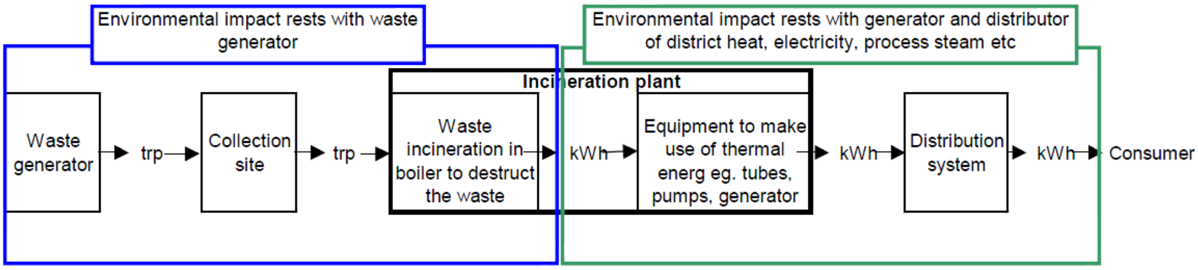

Figure 5: Allocation of environmental impacts between two life cycles according to the PP allocation method. Here in regards to incineration of waste and resulting energy products (Image from IEC, 2008, p14).

In the case of recycling, environmental burdens are accounted for outside of the generating life cycle and have thus been allocated to the subsequent life cycle which uses the recycled materials as input.

Avoided materials due to recycling have therefore not been considered in the main scenario. This in accordance to the ISO recommendations. In other words, only if the generating life cycle do use recycled material as input material will it account for the benefits of recycling.

2.2.4 Excluded parts and “cut-off”

It is common practice to scan for the most important factors (“cut off” at 95% as a minimum) rather than being very thorough. In general, LCA focuses on the most important flows, while the flows that can be considered negligible are excluded. By setting cut-off criteria specific and lower limit for the order of the flows to be included. Flows below the limit can be assumed to have a negligible impact and are thus excluded from the study. For example, cut off criteria can be are determined for inflows with respect to mass or energy or outflows, e.g. Waste.

If data availability is insufficient or if there are large data slots, no more than 1% of total energy usage and 1% of total material usage may be excluded for each unit process according to EN 15804. For the raw material, transport of raw material and manufacturing stage, no more than 5% of materials and energy flows shall be excluded, according to EN 15804. Conservative assumptions, in combination with reasonableness and expert opinion, can be used to demonstrate compliance with these criteria.

To ensure that all relevant environmental impacts were represented in the study, the following cut-off criteria were used.

- Mass — If the flow was less than 1% of the cumulative mass of all the inputs and outputs of the LCI model, it was excluded, provided its environmental relevance was not a concern.
- Energy — If the flow was less than 1% of the cumulative energy of all the inputs and outputs of the LCI model, it was excluded, provided its environmental relevance was not a concern.
- Environmental relevance — If the flow met the above criteria for exclusion yet was thought to have a potentially significant environmental impact. It was evaluated with proxies identified by chemical and material experts within Miljögiraff. If the proxy for an excluded material had a significant contribution to the overall LCIA, more information was collected and evaluated in the system.

The sum of the neglected material flows did not exceed 5% of mass or 1% of energy.

Processes that have been excluded due to cut-off are presented in Table 1.

Table 1 Processes that fall under the cut-off criteria.

Environmental aspect	Cut –off
Sand paper	The sand paper used for the solid wood tabletop has not been included since it has fallen under the cut-off criteria of 1% environmental impact relevance.
Waste treatment	Some waste generated in the manufacturing have fallen under the cut-off criteria of 1% environmental impact relevance.

2.2.5 Allocation

The inputs and outputs shall be allocated to the different products according to clearly stated procedures that shall be documented and explained together with the allocation procedure.

The sum of the allocated inputs and outputs of a unit process shall be equal to the inputs and outputs of the unit process before allocation.

Whenever several alternative allocation procedures seem applicable, a sensitivity analysis shall be conducted to illustrate the consequences of the departure from the selected approach.

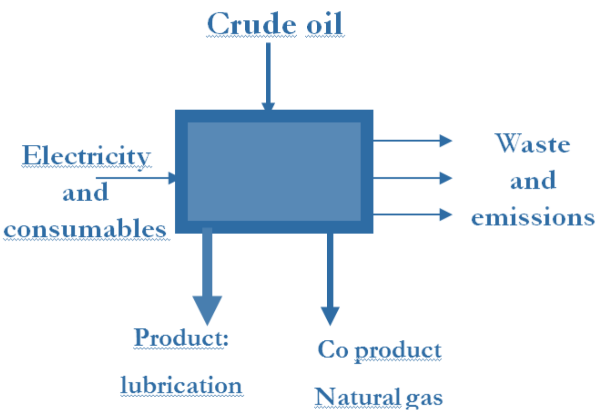

Figure 6: Allocation example

Allocation of environmental aspects may occur when a process produces more than one product. The basis for this allocation is primarily economic value, secondarily physical properties. If the allocation has low importance, it may be “cut-off”, not considered. Instead, all load is on the studied product.
The method chosen for the allocation is the cut-off method. The cut-off method assigns the loads caused by a product to just that product. When the cut-off method is used, environmental aspects or processes which can be assumed to contribute less than 1 %, do not have to be included in the study (Baumann & Tillman, 2004).

2.2.6 Allocation procedure

The study shall identify the processes shared with other product systems and deal with them according to the stepwise procedure presented below:

Step 1: Wherever possible, the allocation should be avoided by dividing the unit process to be allocated into two or more sub-processes and collecting the input and output data related to these sub-processes or expanding the product system to include the additional functions related to the co-products.

Step 2: Where allocation cannot be avoided, the inputs and outputs of the system should be partitioned between its different products or functions in a way that reflects the underlying physical relationships between them; i.e. they should reflect the way in which the inputs and outputs are changed by quantitative changes in the products or functions delivered by the system.

Step 3: Where physical relationship alone cannot be established or used as the basis for allocation, the inputs should be allocated between the products and functions in a way that reflects other relationships between them. For example, input and output data might be allocated between co-products in proportion to the economic value of the products.

In this assessment, an economic allocation is done as far as possible. When other allocations are used, it is expressed if it may be significant to the results. Allocation of waste is described in ISO 14044 section 4.3.4.3.3 (ISO, 2006).

Waste is allocated in accordance with the method Allocation cut-off by classification in accordance with EPD guidelines(The International EPD® System, 2015).

2.2.7 Method of Life Cycle Impact Assessment (LCIA)

The LCIA methods are chosen to give a comprehensive and multifaceted picture of the environmental effects of the different materials life cycle. In total, 7 different environmental effect categories will be used to give a different perspective on the environmental burden, see Table 2. The life cycle impact assessment methods and impact categories are described in more detail in 4.1 Method for impact assessment.

The impact assessment has been harmonized with the available Environmental Product Declarations used for representing raw material in several tabletops. These EPDs harmonises with EN 15 804:2012.

Table 2. Impact categories, indicators and methods used in the study.

Impact category	abbreviation	Category indicator	Method
Acidification potential (fate not included)')	AP	Kg SO_2 equivalents / kg	CML version 4.2
Eutrophication potential	EP	Kg PO_4 equivalents / kg	CML version 4.2
Global Warming Potential 100 years	GWP	Kg CO_2 equivalents	IPCC 2013 GWP 100
Photochemical oxidant creation potential	POC	Kg C2H4 equivalents / kg	CML version 4.2
Ozone-depleting gases	ODP	CFC 11-equivalents, 20 years	CML version 4.2
Abiotic resource depletion, elements	ADe	kg Sb eq / kg	CML version 4.2
Abiotic resource depletion, fossil fuels	ADf	MJ	CED V1.11

2.2.8 LCA Software

The software SimaPro 9.1 was used during the completion of this study.

SimaPro, developed by PRé Sustainability, is the world's leading LCA software chosen by industry, research institutes and consultants in more than 80 countries. SimaPro is a powerful tool for calculations of complex product systems and in-depth comparisons of life cycles with documentation that conform to the ISO 14000 standard.

2.2.9 Interpretation

Interpretation of the results are made by identifying the data elements that contribute significantly to each impact category, evaluating the sensitivity of these significant data elements, assessing the completeness and consistency of the study, and drawing conclusions and recommendations based on a clear understanding of how the LCA was conducted and the results were developed.

2.2.10 Data requirements

The manufacturing stage will be represented with specific data. That means that all data concerning material, energy and waste are modelled for the specific prerequisites of the manufacturing facility and the technology that are used. Data concerning raw material have been represented by EPDs for the composite, compact laminate and ceramic tabletops. For the solid wood and natural stone tabletops general ecoinvent 3.6 data has been used for raw materials and the data has been regionalised concerning energy input and transportation depending on the country or geographical region the supplier comes from. The data regarding the raw materials of the laminate tabletop is a mix of data from EPDs and regionalised ecoinvent 3.6 data.

For the other life cycle stages, general data is used. General data means that material or energy are represented using average LCI data from ecoinvent 3.6.

The following requirements are used (see below) for all the central LCI data.

Time period: 2016 and after
Geography: Europe, Western
Technology: Average technology
Representativeness: Average from a specific process
Multiple output allocation: Physical causality
Infrastructure: Infrastructure processes included
Substitution allocation: Not applicable
Waste treatment allocation: Not applicable
Cut-off rules: Less than 1% environmental relevance
System boundary: Second order (material/energy flows including operations)
Boundary with nature: Agricultural production is part of production system

The level of depth depends on the availability of inventory data. By using general data from well-known organisations that follow the ISO 14048 standard, the transparency and reliability of Life Cycle Inventory (LCI) data increase. It is crucial to understand that the input and output from specific producers may differ significantly from general data provided by certified organisations such as ecoinvent.

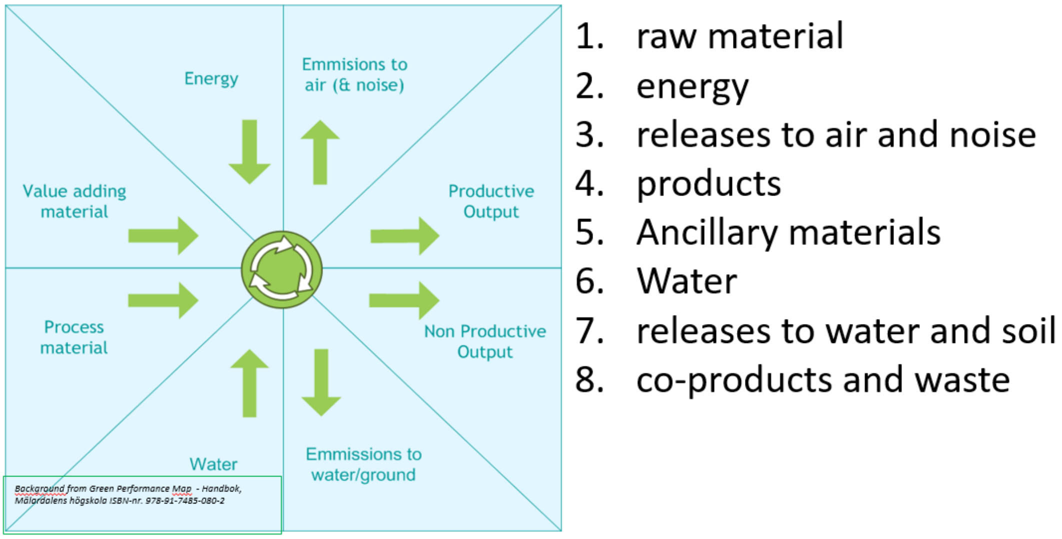

Figure 7 Environmental System Analysis as standard for data to be collected.

2.2.11 Background data

All background data comes from ecoinvent 3.6. ecoinvent is one of the world-leading databases with consistent, open, and updated Life Cycle Inventory Data (LCI).

With several thousand LCI data sets in the fields of agriculture, energy supply, transport, biofuels and biomaterials, bulk and speciality chemicals, construction and packaging materials, basic and precious metals, metals, IT and electronics and waste management, ecoinvent offers the most comprehensive international LCI database.

Ecoinvent's high-quality LCI data sets are based on industrial data and have been compiled by internationally recognised research institutes and LCA consultants.

2.2.12 Assumptions

An assumption is made regarding the soap used in the maintenance phase. It is assumed that it is a soap made mainly from tall oil, which has a lower environmental burden than dishwashing liquid such as "Yes" (also known as "Fairy").

Another assumption is made regarding the transport in the end-of-life phase. Based on a best estimate together with DFI Geisler it is assumed that 50% of the tabletops are sold on a private second-hand market after 20 years and will have a new life cycle of 10 years, see Table 3. The other 50% will be transported 10km to a waste facility where it will be treated according to material type. When the kitchen is uninstalled and transported to the recycling center the transport is allocated according to the weight of a tabletop with the standard size 3.236 m2, divided by the weight of a standard kitchen with the specific type tabletop.

Table 3 End-of life scenarios for the tabletops.

Scenario	Percentage %	Environmental aspects to this life cycle	Comment
Sell the kitchen to a new user	50	None	
Uninstalls and discards at the nearest recycling station	50	Transport 10km to the recycling station. 60% of the time with light truck 40% of the time with personal car and trailer.	It is assumed that 60% of the time the discarding is done by professional builders. 40% of the time it is assumed that the discarding is done by the private person. The private person needs to do the trip twice.

2.2.13 Limitations

The broad scope of analysing a whole life cycle of a product and the holistic approach can only be achieved at the expense of simplifying some aspects. Thus, the following limitations have to be taken into account as summarised by Guinée (Guinée, o.a., 2004):

- LCA does not address localised aspects, and it is not a local risk assessment tool
- LCA is typically a steady state, rather than a dynamic approach
- LCA does not include market mechanisms or secondary effects on technological development
- LCA regards processes as linear, both in the economy and in the environment
- LCA focuses on environmental aspects and says nothing on social, economic and other characteristics
- LCA involves several technical assumptions and value choices that are not purely science-based

3 Life cycle inventory (LCI)

In the inventory analysis, the product system is defined and described. Firstly, the material flows and relevant processes required to the product system are identified. Secondly, environmentally relevant data, (i.e. resource inputs) emissions and product outputs for the system components are collected and interpreted.

All data is gathered by DFI Geisler unless otherwise stated (Nedersee, 2020).

3.1 Composite

The weight of the finished composite tabletop is 75 kg per m2 and has a thickness of 30mm.

Figure 8 Picture of the composite tabletop.

3.1.1 Raw material - Composite

The data for the raw material phase of the composite tabletop is retrieved from an EPD made by Consentino (2019). In- and outflows are stated per 1000kg of composite for the processes in raw material supply, transport to factory and manufacturing of the composite tabletop.

This stage includes the supply of raw material, transport to the production plant in Spain and the production in Spain. The composite tabletop is composed of glass/mirror, cristobalite, quartz/silica sands, resin, pigment, feldspar and catalyser.

3.1.2 Transport of raw material

Table 4 contains information regarding the transport of the raw materials of the composite tabletop.

Table 4 Supplier, distance and type of transport for the composite tabletop.

Raw material	From	Distance	Description of LCI data in ecoinvent
Composite tabletop	Consentino, Cantoria, Almería, Spain	2900 km	Transport, freight, lorry 16-32 metric ton, EURO5 {RER}| transport, freight, lorry 16-32 metric ton, EURO5 | Cut-off, U

3.1.3 Manufacturing at DFI Geisler - Composite

At DFI Geisler the tabletops are custom-made. They are cut in specified dimensions and the surface and edges of the tabletop are polished with water.

In the manufacturing process 7.92 kWh of electricity are used per 1m2 of tabletop. The electricity comes from 100% renewable energy by wind power in Denmark, certificate can be seen in Appendix 2. The electricity is represented by the dataset *Electricity, high voltage {DK}| electricity production, wind, >3MW turbine, onshore | Cut-off, U* in ecoinvent.

The manufacturing process also uses 6.853 MJ heat per 1m2 of tabletop, where 6.217 MJ heat comes from a wood chip boiler on site where production waste is incinerated and 0.636 MJ of heat is bought natural gas. The heat from the inhouse production is represented by the dataset *Heat, central or small-scale, other than natural gas {DK}| heat production, softwood chips from forest, at furnace 50kW | Cut-off, U* in ecoinvent. The heat bought from the local grid is represented by the dataset *Heat, central or small-scale, natural gas {Europe without Switzerland}| heat production, natural gas, at boiler atm. low-NOx condensing non-modulating <100kW | Cut-off, U* in ecoinvent.

Additionally, 0.627 m3 of water is used per 1m2 of tabletop which is represented by the dataset *Water, well, DK* in ecoinvent. The amount of fuel used for trucks on site corresponds to 0.02 kg of gas per m2 of tabletop.

47.95 kg of composite waste is generated per m2 of tabletop in the manufacturing process. The waste is transported 5 km to a waste facility where it is crushed and used as landfill. The waste management process is represented by *Rock crushing {DK}| processing | Cut-off, U* in ecoinvent.

3.1.4 Packaging

The finished tabletops are packaged with corner protectors in corrugated paper and then the tabletops are put on wooden pallets/constructions. The packaging material is specified in Table 5.

Table 5 Packaging material for the composite tabletop

Packaging material	Kg/m2	Description of LCI data in ecoinvent
Corrugated paper	0.584	Linerboard {RER}| production, kraftliner | Cut-off, U
Wood	11.86	EUR-flat pallet {RER}| production | Cut-off, U

3.1.5 Transport of finished goods

The finished tabletop is transported 400 km by truck to a customer in Copenhagen. This is a representation of the most common customer and transport distance since most of the DFI Geisler's sales go to Copenhagen.

3.1.6 Usage

For the user phase it is assumed that there is only an impact from the maintenance of wiping off the tabletop. The tabletop is cleaned with green soap and the assumed yearly consumption is 0.2 kg of soap per m^2.

3.1.7 End-of-Life

The end of life stage is a life cycle stage that in general includes the waste of the product. The end of life stage shall include the dismantling of the product, and the transport to an end of life treatment plant. If recycled to new product, the environmental aspects of processing the secondary material, are allocated to the new products lifecycle.

Based on a best estimate together with DFI Geisler it is assumed that 50% of the tabletops are sold on a private second-hand market after 20 years and will have a new life cycle of 10 years, see Table 6. The other 50% will be transported 10km to a waste facility where it will be crushed and used as roadfill/landfill material.

When the kitchen is uninstalled and transported to the recycling center the transport is allocated according to the weight of a standard tabletop (3.236 m2) divided by the weight of a standard kitchen.

Table 6 End-of life scenarios for the tabletop.

Scenario	Percentage %	Environmental aspects to this life cycle	Comment
Sell the kitchen to a new user	50	None	
Uninstalls and discards at the nearest recycling station	50	Transport 10km to the recycling station. 60% of the time with light truck 40% of the time with personal car and trailer.	It is assumed that 60% of the time the discarding is done by professional builders. 40% of the time it is assumed that the discarding is done by the private person. The private person needs to do the trip twice.

3.2 Solid wood

The weight of the finished solid wood tabletop is 21.3 kg per m2 and the tabletop has a thickness of 30 mm.

Figure 9 Picture of the solid wood tabletop.

3.2.1 Raw material - Solid Wood

The raw materials for the solid wood tabletop and the amounts are stated in Table 7.

Table 7 Raw materials in the solid wood tabletop.

Raw material	Kg/m2	LCI data name
Wood	21,3	See details in 3.2.1.1
Glue	0,144	See details in 3.2.1.2

3.2.1.1 Wood

The wood used in the solid wood tabletop is oak from Croatia represented by the dataset *Sawnwood, hardwood, raw {Croatia}| sawing, hardwood | Cut-off, U* in ecoinvent. The wood is transported 1657 km by truck from Croatia to Herning Massivtræ A/S in Herning, Denmark.

At Herning Massivtræ A/S, the wood is glued into the wooden tabletops that are sent to DFI Geisler, for information about the glue see 3.2.1.2. In the manufacturing process at Herning Massivtræ A/S 9.088 kWh of electricity from the Danish grid is used per m2 tabletop, represented by the dataset *Electricity, medium voltage {DK}| market for | Cut-off, U* in ecoinvent.

The manufacturing process at Herning Massivtræ A/S generates 48.6% wooden waste per m2 tabletop, where 36.1% is generated in the process and 12.5% is due to quality issues. This is represented with the dataset *Waste wood, untreated {CH}| treatment of, municipal incineration with fly ash extraction | Cut-off, U* in ecoinvent.

3.2.1.2 Glue

The glue, Multibond EZ-1, used in the manufacturing at Herning Massivtræ A/S is modelled based on information from a safety data sheet by Franklin International. The data sheet presents the percentages of the toxic substances formaldehyde, methanol and aluminium chloride. It is assumed that the glue is based on vinyl acetate since it is an industrial wood glue. The details are presented in Table 8.

Table 8 Raw materials for 1 kg of the glue used in the solid wood tabletop.

Raw material	Amount	Description of LCI data in ecoinvent
Ethylene vinyl acetate copolymer	0.9 kg	Ethylene vinyl acetate copolymer {RER}| production | Cut-off, U
Formaldehyde	0.001 kg	Formaldehyde {RER}| market for formaldehyde | Cut-off, U
Methanol	0.003 kg	Methanol {GLO}| market for | Cut-off, U
Aluminium chloride, anhydrous	0.03 kg	Aluminium chloride {GLO}| market for aluminium chloride | Cut-off, U
Chemical factory, organics	1p	Chemical factory, organics {RER}| construction | Cut-off, U

3.2.2 Transport of raw materials

Information regarding the transport of different raw material from the suppliers is stated in Table 9.

Table 9 Supplier, distance and type of transport for the raw material of the solid wood tabletop.

Component	From	Distance	Description of LCI data in ecoinvent
Solid wood tabletop	Herning Massivtræ, Herning, Denmark	100 km	Transport, freight, lorry 16-32 metric ton, EURO5 {RER}| transport, freight, lorry 16-32 metric ton, EURO5 | Cut-off, U
Oil for solid wood tabletop	Aalborg Farve og Lak A/S, Aalborg, Denmark	116 km	Transport, freight, lorry 16-32 metric ton, EURO5 {RER}| transport, freight, lorry 16-32 metric ton, EURO5 | Cut-off, U
Packaging	Styropak, Denmark	160 km	Transport, freight, lorry 16-32 metric ton, EURO5 {RER}| transport, freight, lorry 16-32 metric ton, EURO5 | Cut-off, U

3.2.3 Manufacturing at DFI Geisler - Solid wood

At the factory the tabletops are custom-made. They are cut in specified dimensions, the surface and edges of the tabletop are polished and then the tabletop is oiled.

In the manufacturing process 9.75 kWh of electricity are used per 1m2 of tabletop. The electricity comes from 100% renewable energy by wind power in Denmark, certificate can be seen in Appendix 2. The electricity is represented by the dataset *Electricity, high voltage {DK}| electricity production, wind, >3MW turbine, onshore | Cut-off, U* in ecoinvent.

20% of solid wood waste is generated per m2 of tabletop in the manufacturing process. The manufacturing process uses 6.853 MJ heat per 1m2 of tabletop, where 6.217 MJ heat comes from a wood chip boiler on site where production waste is incinerated and 0.636 MJ of heat is bought natural gas. The heat from the inhouse production is represented by the dataset *Heat, central or small-scale, other than natural gas {DK}| heat production, softwood chips from forest, at furnace 50kW | Cut-off, U* in ecoinvent. The heat bought from the local grid is represented by the dataset *Heat, central or small-*

scale, natural gas {Europe without Switzerland}| heat production, natural gas, at boiler atm. low-NOx condensing non-modulating <100kW | Cut-off, U in ecoinvent.

Additionally, 0.0429 kg of oil is used per 1m2 of tabletop which is represented by the dataset *Light fuel oil {RER}| market group for | Cut-off, U* in ecoinvent. The amount of fuel used for trucks on site corresponds to 0.02 kg of gas per m2 of tabletop. The process also uses 0.107 m2 sandpaper per m2 tabletop, but this has been assumed irrelevant and is therefore excluded.

The manufacturing process also generates 0.0871 kg of oil waste which transported 29 km to a waste facility. The waste management process for the oil is represented by the dataset *Bilge oil {CH}| treatment of, hazardous waste incineration | Cut-off, U* in ecoinvent.

3.2.4 Packaging

The finished tabletop is packaged with plastic corner protectors, EPS packaging and stretch wrap. The packaging material is specified in Table 10.

Table 10 Packaging material for the solid wood tabletop

Packaging material	Kg/m2	Description of LCI data in ecoinvent
Plastic corner protectors	0.0295	Polyethylene, high density, granulate, recycled {CH}| polyethylene production, high density, granulate, recycled | Cut-off, U Injection moulding {RER}| processing | Cut-off, U
EPS edges/packaging	0.2	Polystyrene, expandable {RER}| production | Cut-off, U
Stretch wrap	0.105	Polyethylene, low density, granulate {RER}| production | Cut-off, U Extrusion, plastic film {RER}| extrusion, plastic film | Cut-off, U

3.2.5 Transport of finished goods

The finished tabletop is transported 400 km by truck to a customer in Copenhagen. This is a representation of the most common customer and transport distance since most of the DFI Geisler's sales go to Copenhagen.

3.2.6 Usage

For the user phase it is assumed that there is only an impact from the maintenance of wiping off the tabletop. The tabletop is cleaned with green soap and the assumed yearly consumption is 0.2 kg of soap per m^2. The solid wood tabletop is also to be oiled 4 times per year and the amount of oil used is 5ml per m^2 each time, which gives a yearly consumption of 20 ml oil per year per m^2.

3.2.7 End-of-Life

Based on a best estimate together with DFI Geisler it is assumed that 50% of the tabletops are sold on a private second-hand market after 20 years and will have a new life cycle of 10 years, see details in Table 6. The other 50% will be transported 10km to a waste facility where it will be incinerated.

3.3 Laminate

The weight of the finished laminate tabletop is 22 kg per m2 and the tabletop has a thickness of 29 mm.

Figure 10 Picture of the laminate tabletop.

Raw material – Laminate

The raw materials and the amount used in the laminate tabletop are presented in Table 11.

Table 11 The raw materials in the laminate tabletop.

Raw material	Kg/m2	Description of LCI data in ecoinvent
Laminate	1.1	See details in 3.3.1.1
Particle board	20.4	See details in 3.3.1.2
Balancing foil	0.14	See details in 3.3.1.3
PVAC glue	0.22	See details in 3.3.1.4
ABS edge	0.12	See details in 3.3.1.5
ABS glue	0.0132	See details in 3.3.1.6

3.3.1.1 Laminate (layer)

The laminate is produced by Riisfort in Århus, Denmark. The data for the raw material phase of the laminate is retrieved from an EPD made by Eggers (Fritz EGGER GmbH & Co. OG Holzwerkstoffe, 2014). The EPD is used to provide data for the extraction/production of raw material, transport to production site and production of laminate. The production site is modified to Århus, Denmark and a Danish electricity mix is used.

3.3.1.2 Particle board

The particle board is produced by Kronospan in Århus, Denmark. The data for the raw material phase of the particle board is retrieved from an EPD made by Verband der Deutschen Holzwerkstoffindustrie e.V. (VHI) (2013). The EPD provides data for the extraction/production of raw material, transport to production site and production of particle board. The production site is modified to Århus, Denmark. Additional data is retrieved from Kronospan regarding the energy used in the production (0.9 kWh/kg corresponding to 16kWh/m2 from mixed energy sources (biomass, oil and electricity)). All waste that occurs in the manufacturing of the particle board is incinerated.

3.3.1.3 Balancing foil

Riisfort is the supplier of balancing foil, but the balancing foil is not produced at Riisfort and therefore an extra transport between sub-supplier and Riisfort is included in this phase of the life cycle.

The electricity used at the sub-supplier corresponds to 1.013 kWh/kg of balancing foil. The purchased electricity is generated 50% from renewable sources (water and wind power). The production site also has an in-house production where 95% originates from renewable resources.

3.3.1.4 PVAC glue

In the calculations the glue used in the solid wood tabletop, see 3.2.1.2, is used as PVAC glue. The PVAC glue is produced by PKI Industrial Adhesives in Frederica, Denmark and it a polyvinyl acetate-based glue.

3.3.1.5 ABS edge

The ABS edge is produced in Germany by REHAU. It consists of 0,155 kg of ABS, which is represented by the dataset *Acrylonitrile-butadiene-styrene copolymer {RER}| production | Cut-off, U* in ecoinvent.

3.3.1.6 ABS glue

The ABS glue is modelled based on information in the datasheet for the glue Technomelt KS 300. The raw materials are stated in Table 12.

Table 12 Raw materials for 1 kg of the ABS glue used in the laminate tabletop.

Raw material	Amount	Description of LCI data in ecoinvent
Calcium carbonate	0.40 kg	Calcium carbonate, precipitated {GLO}| market for calcium carbonate, precipitated | Cut-off, U
Distillates, petroleum, steam-cracked, polymd.	0.10 kg	C3 hydrocarbon mixture {RoW}| C3 hydrocarbon production, mixture, petroleum refinery operation | Cut-off, U
Vinyl acetate	0.01 kg	Vinyl acetate {GLO}| market for | Cut-off, U
Water	0,49 kg	Tap water {Europe without Switzerland}| market for | Cut-off, U
Chemical factory, organics	1p	Chemical factory, organics {RER}| construction | Cut-off, U

3.3.2 Transport of raw material

Information regarding the transport of different raw materials for the laminate tabletop is stated in Table 13.

Table 13 Transport of raw materials for the laminate tabletop.

Which product	From	Distance	Description of LCI data in ecoinvent
Laminate	Riisfort, Århus, Denmark	126 km	Transport, freight, lorry 16-32 metric ton, EURO5 {RER}| transport, freight, lorry 16-32 metric ton, EURO5 | Cut-off, U
Particle board	Kronospan, Århus, Denmark	140 km	Transport, freight, lorry 16-32 metric ton, EURO5 {RER}| transport, freight, lorry 16-32 metric ton, EURO5 | Cut-off, U

Balancing foil	Riisfort, Århus, Denmark	126 km	Transport, freight, lorry 16-32 metric ton, EURO5 {RER}| transport, freight, lorry 16-32 metric ton, EURO5 | Cut-off, U
Laminate glue PVAC	PKI Industrial Adhesives, Frederica, Denmark	173 km	Transport, freight, lorry 16-32 metric ton, EURO5 {RER}| transport, freight, lorry 16-32 metric ton, EURO5 | Cut-off, U
ABS glue	PKI Industrial Adhesives, Frederica, Denmark	173 km	Transport, freight, lorry 16-32 metric ton, EURO5 {RER}| transport, freight, lorry 16-32 metric ton, EURO5 | Cut-off, U
ABS edge	REHAU, Germany	420 km	Transport, freight, lorry 16-32 metric ton, EURO5 {RER}| transport, freight, lorry 16-32 metric ton, EURO5 | Cut-off, U

3.3.3 Manufacturing at DFI Geisler - Laminate

At DFI Geisler the particle board is glued together with laminate on top of it and a balancing foil underneath the particle board in standard dimensions. Then they are cut in custom-made dimensions and an ABS edge is attached with glue.

In the manufacturing process 9.75 kWh of electricity are used per 1m2 of tabletop. The electricity comes from 100% renewable energy by wind power in Denmark, certificate can be seen in Appendix 2. The electricity is represented by the dataset *Electricity, high voltage {DK}| electricity production, wind, >3MW turbine, onshore | Cut-off, U* in ecoinvent.

The manufacturing process also uses 6.853 MJ heat per 1m2 of tabletop, where 6.217 MJ heat comes from a wood chip boiler on site where production waste is incinerated and 0.636 MJ of heat is bought natural gas. The heat from the inhouse production is represented by the dataset *Heat, central or small-scale, other than natural gas {DK}| heat production, softwood chips from forest, at furnace 50kW | Cut-off, U* in ecoinvent. The heat bought from the local grid is represented by the dataset *Heat, central or small-scale, natural gas {Europe without Switzerland}| heat production, natural gas, at boiler atm. low-NOx condensing non-modulating <100kW | Cut-off, U* in ecoinvent.

The amount of fuel used for trucks on site corresponds to 0.02 kg of gas per m2 of tabletop.

33% of waste is generated in the manufacturing process. The waste is transported 140 km for recycling to Kronospan, the supplier for particle board. The transport is allocated to the life cycle of the laminate tabletop, but the benefit from the recycled material is allocated to the life cycle of the new product.

3.3.4 Packaging

The finished tabletop is packaged with EPS packaging and plastic corner protectors. Finally, the tabletop is wrapped with stretch wrap. The packaging material is specified in Table 14.

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Table 14 Packaging material for the laminate tabletop.

Packaging material	Kg/m2	Description of LCI data in ecoinvent
Plastic corner protectors	0.0547	Polyethylene, high density, granulate, recycled {CH}| polyethylene production, high density, granulate, recycled | Cut-off, U Injection moulding {RER}| processing | Cut-off, U
EPS edges/packaging	0.2	Polystyrene, expandable {RER}| production | Cut-off, U
Stretch wrap	0.105	Polyethylene, low density, granulate {RER}| production | Cut-off, U Extrusion, plastic film {RER}| extrusion, plastic film | Cut-off, U

3.3.5 Transport of finished goods

The finished tabletop is transported 400 km by truck to a customer in Copenhagen. This is a representation of the most common customer and transport distance since most of the DFI Geisler's sales go to Copenhagen.

3.3.6 Usage

For the user phase it is assumed that there is only an impact from the maintenance of wiping off the tabletop. The tabletop is cleaned with green soap and the assumed yearly consumption is 0.2 kg of soap per m^2.

3.3.7 End-of-Life

Based on a best estimate together with DFI Geisler it is assumed that 50% of the tabletops are sold on a private second-hand market after 20 years and will have a new life cycle of 10 years, see details in Table 6. The other 50% will be transported 10km to a waste facility where it will be incinerated.

3.4 Compact Laminate

The weight of the finished compact laminate tabletop is 15 kg per m2 and has a thickness of 12 mm.

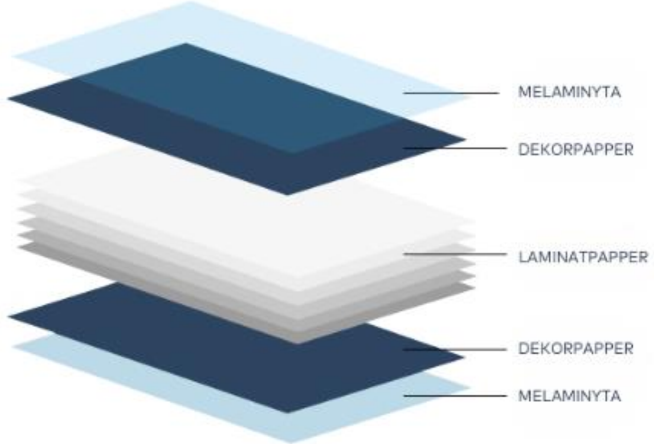

Figure 11 Picture of the compact laminate tabletop.

3.4.1 Raw material - Compact Laminate

The data for the raw material phase of the compact laminate is retrieved from an EPD made by FunderMax GmbH (2019). The EPD is used to provide data for the extraction/production of raw material, transport to production site and production of compact laminate.

3.4.2 Transport of raw material

Information regarding the transport of the raw material from the supplier can be seen in Table 15.

Table 15 Supplier, distance and means of transport for the compact laminate tabletop.

Component	From	Distance	Description of LCI data in ecoinvent
Compact laminate	Fundermax, Neudörfl, Austria	1400 km	Transport, freight, lorry 16-32 metric ton, EURO5 {RER}| transport, freight, lorry 16-32 metric ton, EURO5 | Cut-off, U

3.4.3 Manufacturing at DFI Geisler

At DFI Geisler the tabletops are custom-made. They are cut in specified dimensions and the edges polished.

In the manufacturing process 9.75 kWh of electricity are used per 1m2 of tabletop. The electricity comes from 100% renewable energy by wind power in Denmark, certificate can be seen in Appendix 2. The electricity is represented by the dataset *Electricity, high voltage {DK}| electricity production, wind, >3MW turbine, onshore | Cut-off, U* in ecoinvent.

The manufacturing process also uses 6.853 MJ heat per 1m2 of tabletop, where 6.217 MJ heat comes from a wood chip boiler on site where production waste is incinerated and 0.636 MJ of heat is bought natural gas. The heat from the inhouse production is represented by the dataset *Heat, central or small-scale, other than natural gas {DK}| heat production, softwood chips from forest, at furnace 50kW | Cut-off, U* in ecoinvent. The heat bought from the local grid is represented by the dataset *Heat, central or*

small-scale, natural gas {Europe without Switzerland}| heat production, natural gas, at boiler atm. low-NOx condensing non-modulating <100kW | Cut-off, U in ecoinvent.

The amount of fuel used for trucks on site corresponds to 0.02 kg of gas per m2 of tabletop.

6.74 kg of compact laminate waste is generated per m2 of tabletop in the manufacturing process. The waste is transported 50 km to a waste facility and put in a landfill.

3.4.4 Packaging

The finished tabletop is packaged with EPS packaging and is wrapped with stretch wrap. The packaging material is specified in Table 16.

Table 16 Packaging material for the compact laminate tabletop

Packaging material	Kg/m2	Description of LCI data in ecoinvent
EPS edges/packaging	0.2	Polystyrene, expandable {RER}| production | Cut-off, U
Stretch wrap	0.105	Polyethylene, low density, granulate {RER}| production | Cut-off, U Extrusion, plastic film {RER}| extrusion, plastic film | Cut-off, U

3.4.5 Transport of finished goods

The finished tabletop is transported 400 km by truck to a customer in Copenhagen. This is a representation of the most common customer and transport distance since most of the DFI Geisler's sales go to Copenhagen.

3.4.6 Usage

For the user phase it is assumed that there is only an impact from the maintenance of wiping off the tabletop. The tabletop is cleaned with green soap and the assumed yearly consumption is 0.2 kg of soap per m^2.

3.4.7 End-of-Life

Based on a best estimate together with DFI Geisler it is assumed that 50% of the tabletops are sold on a private second-hand market after 20 years and will have a new life cycle of 10 years, see details in Table 6. The other 50% will be transported 10km to a waste facility where it will be put in a landfill.

3.5 Ceramic

The weight of the finished ceramic tabletop is 35 kg per m2 and has a thickness of 12 mm.

Figure 12 Picture of the ceramic tabletop.

3.5.1 Raw material - Ceramic

The data for the raw material phase of the ceramic tabletop is retrieved from an EPD of the material Dekton made by Consentino (2016). In- and outflows are stated per 1000kg of material for the processes in raw material supply, transport to factory and manufacturing of the tabletop.

3.5.2 Transport of raw material

Information regarding the transport of the raw material from the supplier can be seen in Table 17.

Table 17 Supplier, distance and means of transport for the ceramic tabletop.

Which product	From	Distance	Description of LCI data in ecoinvent
Ceramic tabletop	Neolith, Almassora, Spain	2500 km	Transport, freight, lorry 16-32 metric ton, EURO5 {RER}| transport, freight, lorry 16-32 metric ton, EURO5 | Cut-off, U

3.5.3 Manufacturing at DFI Geisler

At DFI Geisler the tabletops are custom-made. They are cut in specified dimensions and the surface and edges of the tabletop are polished with water.

In the manufacturing process 7.92 kWh of electricity are used per 1m2 of tabletop. The electricity comes from 100% renewable energy by wind power in Denmark, certificate can be seen in Appendix 2. The electricity is represented by the dataset *Electricity, high voltage {DK}| electricity production, wind, >3MW turbine, onshore | Cut-off, U* in ecoinvent.

The manufacturing process also uses 6.853 MJ heat per 1m2 of tabletop, where 6.217 MJ heat comes from a wood chip boiler on site where production waste is incinerated and 0.636 MJ of heat is bought natural gas. The heat from the inhouse production is represented by the dataset *Heat, central or small-scale, other than natural gas {DK}| heat production, softwood chips from forest, at furnace 50kW | Cut-off, U* in ecoinvent. The heat bought from the local grid is represented by the dataset *Heat, central or*

small-scale, natural gas {Europe without Switzerland}| heat production, natural gas, at boiler atm. low-NOx condensing non-modulating <100kW | Cut-off, U in ecoinvent.

Additionally, 0.627 m3 of water is used per 1m2 of tabletop which is represented by the dataset *Water, well, DK* in ecoinvent. The amount of fuel used for trucks on site corresponds to 0.02 kg of gas per m2 of tabletop.

27.5 kg of ceramic waste is generated per m2 of tabletop in the manufacturing process. The waste is transported 10 km to a waste facility where it is crushed and used as roadfill material. The waste management process is represented by *Rock crushing {DK}| processing | Cut-off, U* in ecoinvent.

3.5.4 Packaging

The finished tabletops are packaged with corner protectors in corrugated paper and then the tabletops are put on wooden pallets/constructions. The packaging material is specified in Table 18.

Table 18 Packaging material for the ceramic tabletop.

Packaging material	Kg/m2	Description of LCI data in ecoinvent
Corrugated paper	0.584	Linerboard {RER}| production, kraftliner	Cut-off, U
Wood	11.86	EUR-flat pallet {RER}| production	Cut-off, U

3.5.5 Transport of finished goods

The finished tabletop is transported 400 km by truck to a customer in Copenhagen. This is a representation of the most common customer and transport distance since most of the DFI Geisler's sales go to Copenhagen.

3.5.6 Usage

For the user phase it is assumed that there is only an impact from the maintenance of wiping off the tabletop. The tabletop is cleaned with green soap and the assumed yearly consumption is 0.2 kg of soap per m^2.

3.5.7 End-of-Life

Based on a best estimate together with DFI Geisler it is assumed that 50% of the tabletops are sold on a private second-hand market after 20 years and will have a new life cycle of 10 years, see details in Table 6. The other 50% will be transported 10km to a waste facility where it will be crushed and used as roadfill/landfill material.

3.6 Natural Stone

The weight of the finished natural stone tabletop is 90 kg per m2 and has a thickness of 30 mm.

Figure 13 Picture of the natural stone tabletop

3.6.1 Raw material - Natural stone

The raw material for the natural stone tabletop will be represented with the dataset *Natural stone plate, polished {CH}| production | Cut-off*, U where the electricity has been modified to represent production at Consentino in Spain with 64% wind power, 25% hydro power and 11% solar power.

3.6.2 Transport of raw material

Information regarding the transport of the raw material from the supplier can be seen in Table 19.

Table 19 Supplier, distance and means of transport for the natural stone tabletop.

Which product	From	Distance	Description of LCI data in ecoinvent
Natural stone/Marble tabletop	Consentino, Cantoria, Almería, Spain	2900 km	Transport, freight, lorry 16-32 metric ton, EURO5 {RER}| transport, freight, lorry 16-32 metric ton, EURO5 | Cut-off, U

3.6.3 Manufacturing at DFI Geisler

At DFI Geisler the tabletops are custom-made. They are cut in specified dimensions and the the surface and edges of the tabletop are polished with water.

In the manufacturing process 7.92 kWh of electricity are used per 1m2 of tabletop. The electricity comes from 100% renewable energy by wind power in Denmark, certificate can be seen in Appendix 2. The electricity is represented by the dataset *Electricity, high voltage {DK}| electricity production, wind, >3MW turbine, onshore | Cut-off, U* in ecoinvent.

The manufacturing process also uses 6.853 MJ heat per 1m2 of tabletop, where 6.217 MJ heat comes from a wood chip boiler on site where production waste is incinerated and 0.636 MJ of heat is bought natural gas. The heat from the inhouse production is represented by the dataset *Heat, central or small-scale, other than natural gas {DK}| heat production, softwood chips from forest, at furnace 50kW | Cut-off, U* in ecoinvent. The heat bought from the local grid is represented by the dataset *Heat, central or*

small-scale, natural gas {Europe without Switzerland}| heat production, natural gas, at boiler atm. low-NOx condensing non-modulating <100kW | Cut-off, U in ecoinvent.

Additionally, 0.627 m3 of water is used per 1m2 of tabletop which is represented by the dataset *Water, well, DK* in ecoinvent. The amount of fuel used for trucks on site corresponds to 0.02 kg of gas per m2 of tabletop.

57.54 kg of natural stone waste is generated per m2 of tabletop in the manufacturing process. The waste is transported 10 km to a waste facility where it is crushed and used as roadfill material. The waste management process is represented by *Rock crushing {DK}| processing | Cut-off, U* in ecoinvent.

3.6.4 Packaging

The finished tabletops are packaged with corner protectors in corrugated paper and then the tabletops are put on wooden pallets/constructions. The packaging material is specified in Table 20.

Table 20 Packaging material for the natural stone tabletop

Packaging material	Kg/m2	Description of LCI data in ecoinvent
Corrugated paper	0.584	Linerboard {RER}| production, kraftliner | Cut-off, U
Wood	11.86	EUR-flat pallet {RER}| production | Cut-off, U

3.6.5 Transport of finished goods

The finished tabletop is transported 400 km by truck to a customer in Copenhagen. This is a representation of the most common customer and transport distance since most of the DFI Geisler's sales go to Copenhagen.

3.6.6 Usage

For the user phase it is assumed that there is only an impact from the maintenance of wiping off the tabletop. The tabletop is cleaned with green soap and the assumed yearly consumption is 0.2 kg of soap per m^2.

3.6.7 End-of-Life

Based on a best estimate together with DFI Geisler it is assumed that 50% of the tabletops are sold on a private second-hand market after 20 years and will have a new life cycle of 10 years, see details in Table 6. The other 50% will be transported 10km to a waste facility where it will be crushed and used as roadfill/landfill material.

4 Life cycle impact assessment (LCIA)

4.1 Method for impact assessment

The methods chosen for assessing the life cycle impact is called **IPCC 2013 GWP 100** and **EPD (2018).**

For the single issue climate change the method **IPCC 2013 GWP 100 years** was chosen because it is the method that best describes climate change potential for gases contributing to the greenhouse effect.

The **EPD (2018)** method was chosen to ensure the compatibility between the EPDs used for the raw materials and the calculations in this LCA. The EPD (2018) method assesses the impact in 7 different impact categories and is harmonised with EPD:s done according to EN 15 804:2012.

All of these are well recognised scientific methods.

Some terms are used below that require clarification:

- Environmental aspect: An activity that might contribute to an environmental effect, for example “electricity usage”.
- Environmental effect: An effect that might influence the environment negatively (Environmental impact), for example, “Acidification”, “Eutrophication” or “Climate change”.
- Environmental impact: The generated damage on a value we want to protect, for example damage on human health, biological diversity etc.

A simple example which incorporates all of the above could be a scenario, where a person drives 1km in a car. This scenario is a direct depiction of an environmental aspect with several different environmental impacts.

> An **environmental aspect** can be carbon dioxide emission. This can contribute to the **environmental effect** Global warming which might lead to the **environmental impact** of flooding, draught and landslide.
> Another environmental aspect could be the consumption of oil that contributes to the environmental effect of resource depletion.

4.1.1 Classification and characterization

Determining what an environmental aspect may contribute to is called *classification*, i.e. use of water contributes to water depletion. How much an aspect contributes to it is called *characterisation*, i.e. usage of 1 ton river water contributes by the factor 1 to water depletion.

Adjusting to how critical that is in a specific area depends on the current environmental load, pressure from resource consumption and the eco system´s carrying capacity. This is done through *normalisation*.

4.1.2 Weighting

To compare between different environmental effects and identifying “hot spots”, a term called *weighting* is applied. The calculated environmental effect is weighted together to form an index called "*single score*” which describes the total environmental impact.

Because weighting involves subjective weighting (by an expert panel) it is recommended for internal communication only. The risk is mistrust if the choice of weighting method used leads to results which benefit the upsides and hide the “downsides for the analysed product. For external communication only *Single issues* should be communicated.

The Environmental Footprint method involves two stages of mechanism. The first stage is called classification and characterization and calculates how much an 'environmental aspect' contributes to a specific 'environmental effect'. Stage two mechanism is called weighting and calculates together all the results from stage one to create a summary result where each 'environmental effect' category is given a score, see Figure 15.

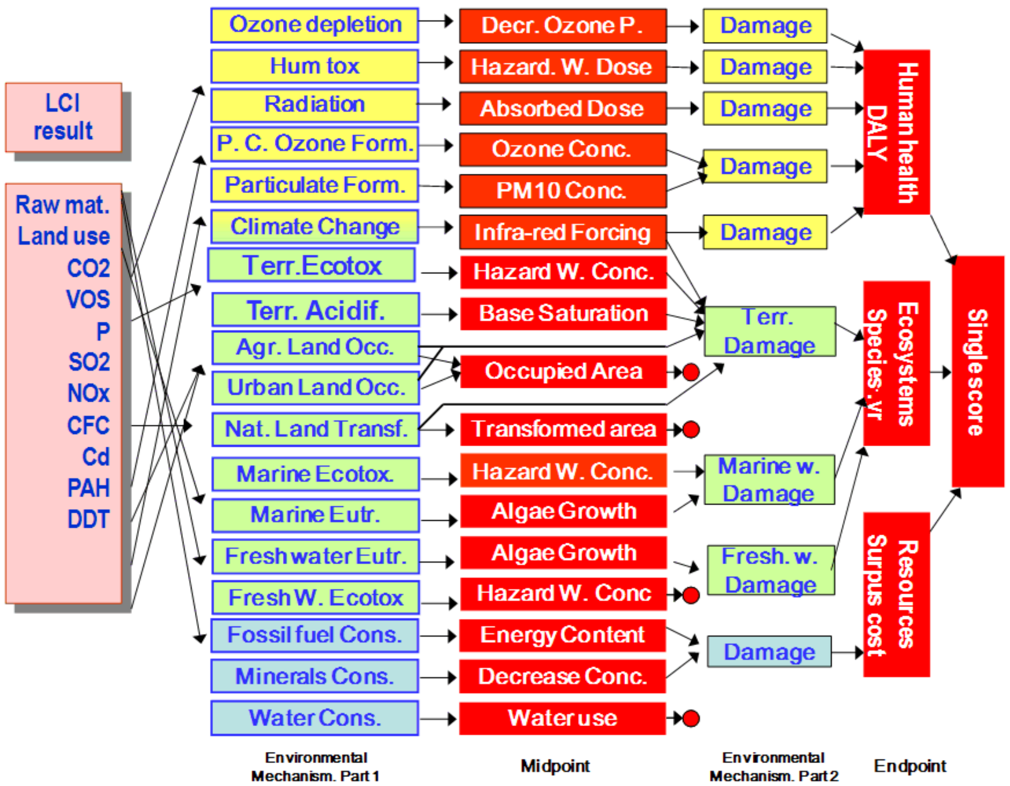

Figure 14, example of a harmonised midpoint-endpoint model for 18 environmental effects, linking to human health, ecosystem damage and resource depletion.

For example, in assessing the environmental impact of the activity 'driving a car', the aspects 'dust from road and tyres' (PM10 emissions) and 'combustion of gasoline' (CO2 emissions) were assessed. Dust for the contribution to the environmental effect category “damage on respiratory organs” and combustion for the contribution to “climate change”. The results are two Midpoint scores. The two scores were then combined by calculating how much they contribute to damage the safeguard objects; Human health, Ecosystem and Resources, to arrive at the final endpoint, a single score.

For a more detailed description see Appendix 2.

4.1.3 Single issues

In contrast to weighted results which are the combined results from many different environmental effect categories, single issue focuses on just one issue. It is important to break out some single issues that are relevant for the analysed product both considering the environment and marketing. All the different environmental effect categories will still be accounted for in the weighted result.

IPCC 2013 is the successor of the IPCC 2007 method, which was developed by the Intergovernmental Panel on Climate Change. It contains the climate change factors of IPCC with a timeframe of 100 years and calculates the single issue climate change potential.

4.2 Impact categories

Environmental Footprint 3.0 divides the whole environmental impact of the life cycle in 19 different impact categories, see Table 21. All these different categories represent different environmental aspects. Every aspect is then assigned points that represent how serious the environmental aspect is, the higher the score the more serious the environmental aspect. In the end all the different categories are added together to weigh the whole life cycle. The different categories with the connecting impact category unit can be seen in Table 21.

Table 21 impact category name and unit in environmental footprint 3.0.

Impact category name	Unit
Climate change	kg CO2 eq
Ozone depletion	kg CFC11 eq
Ionising radiation, HH	kBq U-235 eq
Photochemical ozone formation, HH	kg NMVOC eq
Respiratory inorganics	disease inc.
Non-cancer human health effects	CTUh
Cancer human health effects	CTUh
Acidification terrestrial and freshwater	mol H+ eq
Eutrophication freshwater	kg P eq
Eutrophication marine	kg N eq
Eutrophication terrestrial	mol N eq
Ecotoxicity freshwater	CTUe
Land use	Pt
Water scarcity	m3 depriv.
Resource use, energy carriers	MJ
Resource use, mineral and metals	kg Sb eq
Climate change - fossil	kg CO2 eq
Climate change - biogenic	kg CO2 eq
Climate change - land use and transform.	kg CO2 eq

Climate change: Climate change causes a number of environmental mechanisms that affect both the endpoint human health and ecosystem health. Climate change models are in general developed to assess the future environmental impact of different policy scenarios. Baseline model of the IPCC 2013 + some factors Calculated from JRC.

Impact indicator: Global Warming Potential 100 years

Ozone layer: The characterisation factor for ozone layer depletion accounts for the destruction of the stratospheric ozone layer by anthropogenic emissions of ozone depleting substances (ODS). These are recalcitrant chemicals that contain chlorine or bromine atoms. Because of their long atmospheric lifetime they are the source of chlorine and bromine reaching the stratosphere. Chlorine atoms in chlorofluorocarbons (CFC) and bromine atoms in halons are effective in degrading ozone due to heterogeneous catalysis, which leads to a slow depletion of stratospheric ozone around the globe.

Impact indicator: Ozone Depletion Potential (ODP) calculating the destructive effects on the stratospheric ozone layer over a time horizon of 100 years.

Ionizing radiation: This describes the damage to Human Health related to the routine releases of radioactive material to the environment.

Impact indicator: Ionizing Radiation Potentials: Quantification of the impact of ionizing radiation on the population, in comparison to Uranium 235.

Photochemical ozone formation: Impact indicator: Photochemical ozone creation potential (POCP): Expression of the potential contribution to photochemical ozone formation.

Impact indicator: Photochemical ozone creation potential (POCP): Expression of the potential contribution to photochemical ozone formation.

Respiratory inorganics: Fine Particulate Matter with a diameter of less than 2,5 μm (PM2,5) represents a complex mixture of organic and inorganic substances. PM2,5 causes health problems as it reaches the upper part of the airways and lungs when inhaled. Secondary PM2,5 aerosols are formed in air from emissions of sulphur dioxide (SO2), ammonia (NH3), and nitrogen oxides (NOx) among others (World Health Organisation, 2003). Inhalation of different particulate sizes can cause different health problems.

Impact indicator: Disease incidence due to kg of PM2.5 emitted

Cancer human health effects: Impact indicator: Comparative Toxic Unit for human (CTUh) expressing the estimated increase in morbidity in the total human population per unit mass of a chemical emitted (cases per kilogramme).
USEtox consensus model (multimedia model). No spatial differentiation beyond continent and world compartments. Specific groups of chemicals require further works (cf. details in other sections).

Impact indicator: Comparative Toxic Unit for human (CTUh) expressing the estimated increase in morbidity in the total human population per unit mass of a chemical emitted (cases per kilogramme).

Acidification: Atmospheric deposition of inorganic substances, such as sulphates, nitrates, and phosphates, cause a change in acidity in the soil. For almost all plant species there is a clearly defined optimum of acidity. A serious deviation from this optimum is harmful for that specific kind of species and is referred to as acidification. As a result, changes in levels of acidity will cause shifts in species occurrence (Goldcorp and Spriensma, 1999, Hayashi et al. 2004). Major acidifying emissions are NOx, NH3, and SO2

Impact indicator: Accumulated Exceedance (AE) characterizing the change in critical load exceedance of the sensitive area in terrestrial and main freshwater ecosystems, to which acidifying substances deposit.

Eutrophication: Aquatic eutrophication can be defined as nutrient enrichment of the aquatic environment. Eutrophication in inland waters as a result of human activities is one of the major factors that determine its ecological quality. On the European continent it generally ranks higher in severity of water pollution than the emission of toxic substances. Aquatic eutrophication can be caused by emissions to air, water and soil. In practice the relevant substances include phosphorus and nitrogen compounds emitted to water and soil as well as ammonia (NH3) and nitrogen oxide (NOx) emitted to air.

Impact indicator freshwater: Phosphorus equivalents: Expression of the degree to which the emitted nutrients reaches the freshwater end compartment (phosphorus considered as limiting factor in freshwater).

Impact indicator: Nitrogen equivalents: Expression of the degree to which the emitted nutrients reaches the marine end compartment (nitrogen considered as limiting factor in marine water).

Impact indicator: Accumulated Exceedance (AE) characterizing the change in critical load exceedance of the sensitive area, to which eutrophying substances deposit.

<u>Ecotoxicity freshwater</u> Impact indicator: Comparative Toxic Unit for ecosystems (CTUe) expressing an estimate of the potentially affected fraction of species (PAF) integrated over time and volume per unit mass of a chemical emitted (PAF m3 year/kg).

<u>Land occupation:</u> The land use impact category reflects the damage to ecosystems due to the effects of occupation and transformation of land. Although there are many links between the way land is used and the loss of biodiversity, this category concentrates on the following mechanisms:
1. Occupation of a certain area of land during a certain time;
2. Transformation of a certain area of land.
Both mechanisms can be combined, often occupation follows a transformation, but often also occupation occurs in an area that has already been converted (transformed). In such cases the transformation impact is not allocated to the production system that occupies an area.

Impact indicator: Soil quality index

<u>Water scarcity:</u> Water is a scarce resource in many parts of the world, but also an abundant resource in other parts of the world. Unlike other resources there is no global market that ensures a global distribution. The market does not really work over big distances as transport costs are too high. Extracting water in a dry area can cause very significant damages to ecosystems and human health.

Impact indicator: m3 water eq. deprived.

<u>Resource use:</u> ADP for energy carriers, based on van Oers et al. 2002 as implemented in CML, v. 4.8 (2016). Depletion model based on use-to-availability ratio. Full substitution among fossil energy carriers is assumed.

ADP for mineral and metal resources, based on van Oers et al. 2002 as implemented in CML, v. 4.8 (2016). Depletion model based on use-to-availability ratio. Full substitution among fossil energy carriers is assumed.

Impact indicator: Abiotic resource depletion fossil fuels (ADP-fossil); based on lower heating value
Impact indicator: Abiotic resource depletion (ADP ultimate reserve)

4.3 Life Cycle Assessment results

In this part the result from the different environmental impact assessment methods will be presented.

First, the results from the method IPCC GWP 2013 100 will be presented.
Secondly, the results from the method EPD (2018) will be presented.

4.3.1 Results IPCC 2013 GWP 100a

The results from IPCC 2013 GWP 100a are presented first for all tabletops and then for each tabletop separately.

4.3.1.1 Comparison total and per life cycle stage

The results of the total impact on climate change for each tabletop are illustrated below in Figure 15. The tabletop with the highest impact is the natural stone tabletop with 204 kg CO_2eq, followed by the composite tabletop (196 kg CO_2eq) and then the ceramic tabletop (112 kg CO_2eq). The tabletop with the least impact on climate change is the laminate tabletop with 22 kg CO_2eq.

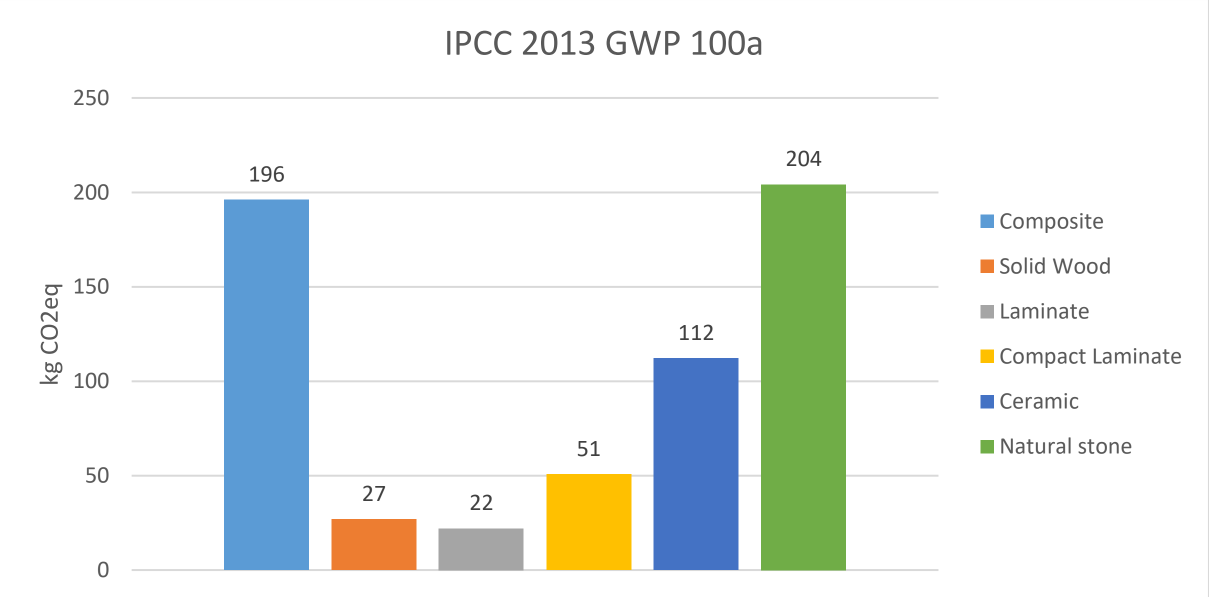

Figure 15 The total impact on climate change for the six tabletops.

The impact for each stage in the life cycle (raw material, transport raw material, manufacturing at DFI Geisler, packaging, transport finished tabletop, usage phase and disposal scenario) is seen in Figure 16 and Table 22 below.

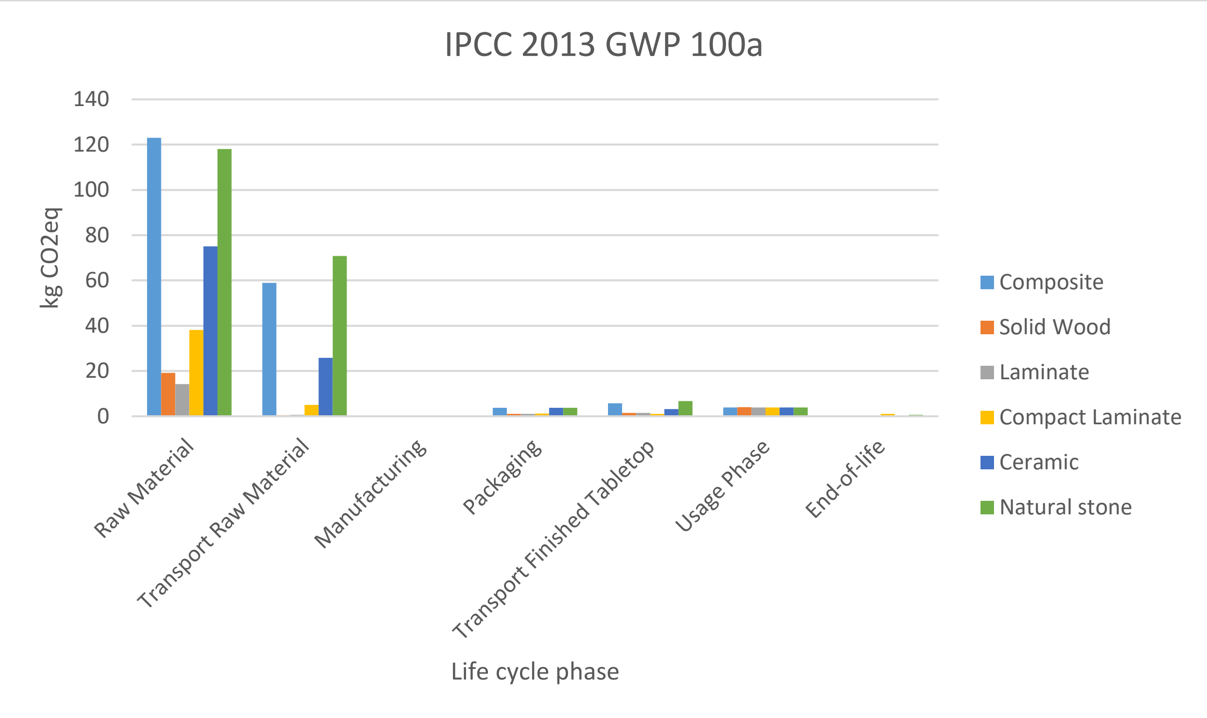

Figure 16 Impact on climate change in the different life cycle stages.

Table 22 Impact on climate change in the different life cycle stages.

	Raw Material	Transport Raw Material	Manufacturing	Packaging	Transport Finished Tabletop	Usage Phase	End-of-Life
Composite	123	59	0.27	3.7	5.8	3.9	0.31
Solid Wood	19	0.45	0.41	1.0	1.4	4.1	0.25
Laminate	14	0.68	0.42	1.0	1.5	3.9	0.22
Compact Laminate	38	5.0	0.34	1.2	1.0	3.9	1.1
Ceramic	75	26	0.27	3.7	3.1	3.9	0.24
Natural Stone	118	71	0.33	3.7	6.8	3.9	0.69

4.3.1.2 Climate change potential Composite tabletop

A Sankey diagram shows the flow with the thickness of the arrows. The cut-off of the Sankey Diagram is set to 1% which means that only processes that contribute to more than 1% of the total climate change potential are included in the diagram. Seen to the total 16 of 12915 contributing processes are shown in the Sankey diagram.

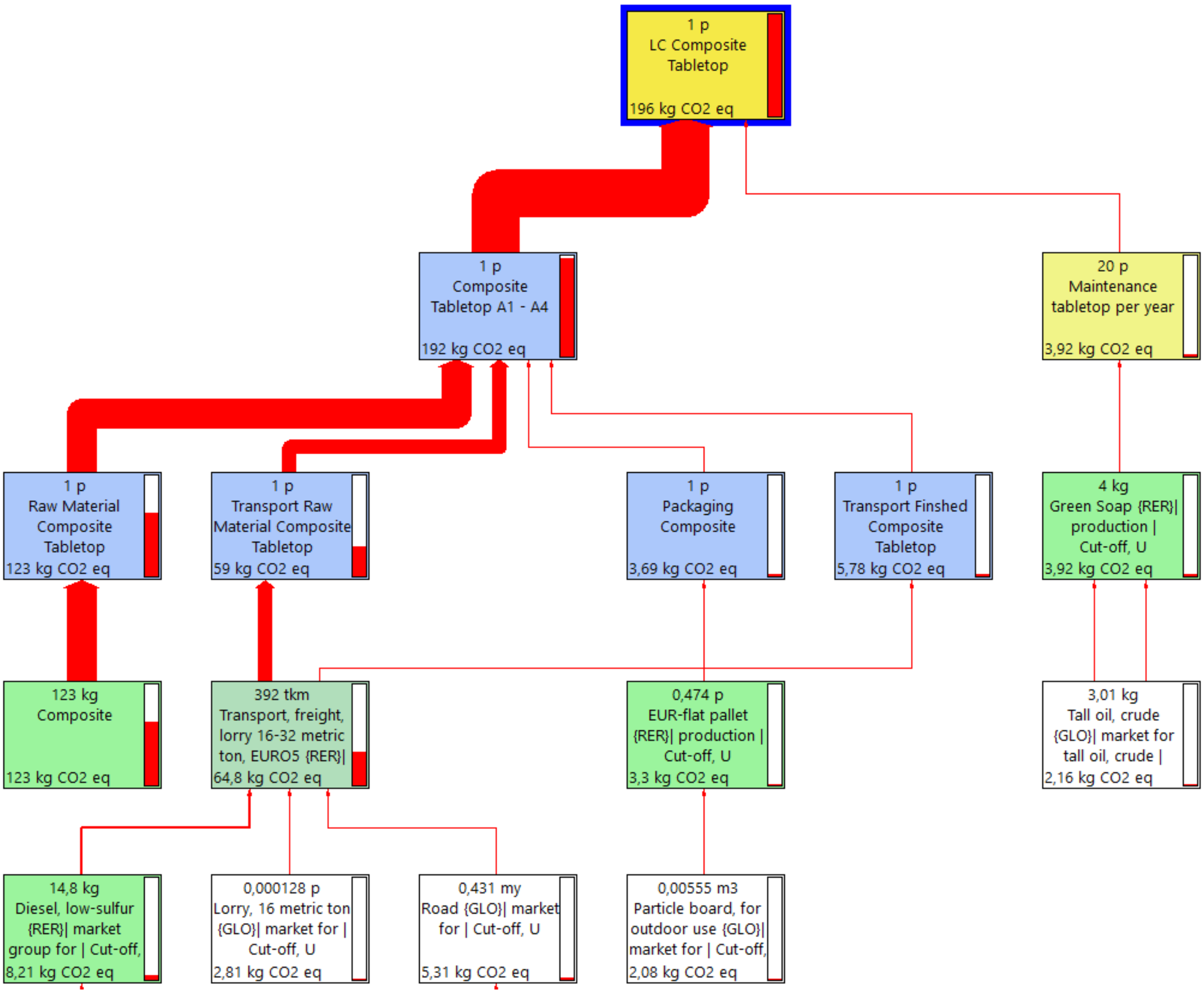

Figure 17 Sankey diagram showing impact on climate change (IPCC) for the composite tabletop.

4.3.1.3 Climate change potential Solid wood tabletop

A Sankey diagram shows the flow with the thickness of the arrows. The cut-off of the Sankey Diagram is set to 3% which means that only processes that contribute to more than 3% of the total climate change potential are included in the diagram. Seen to the total 15 of 12891 contributing processes are shown in the Sankey diagram.

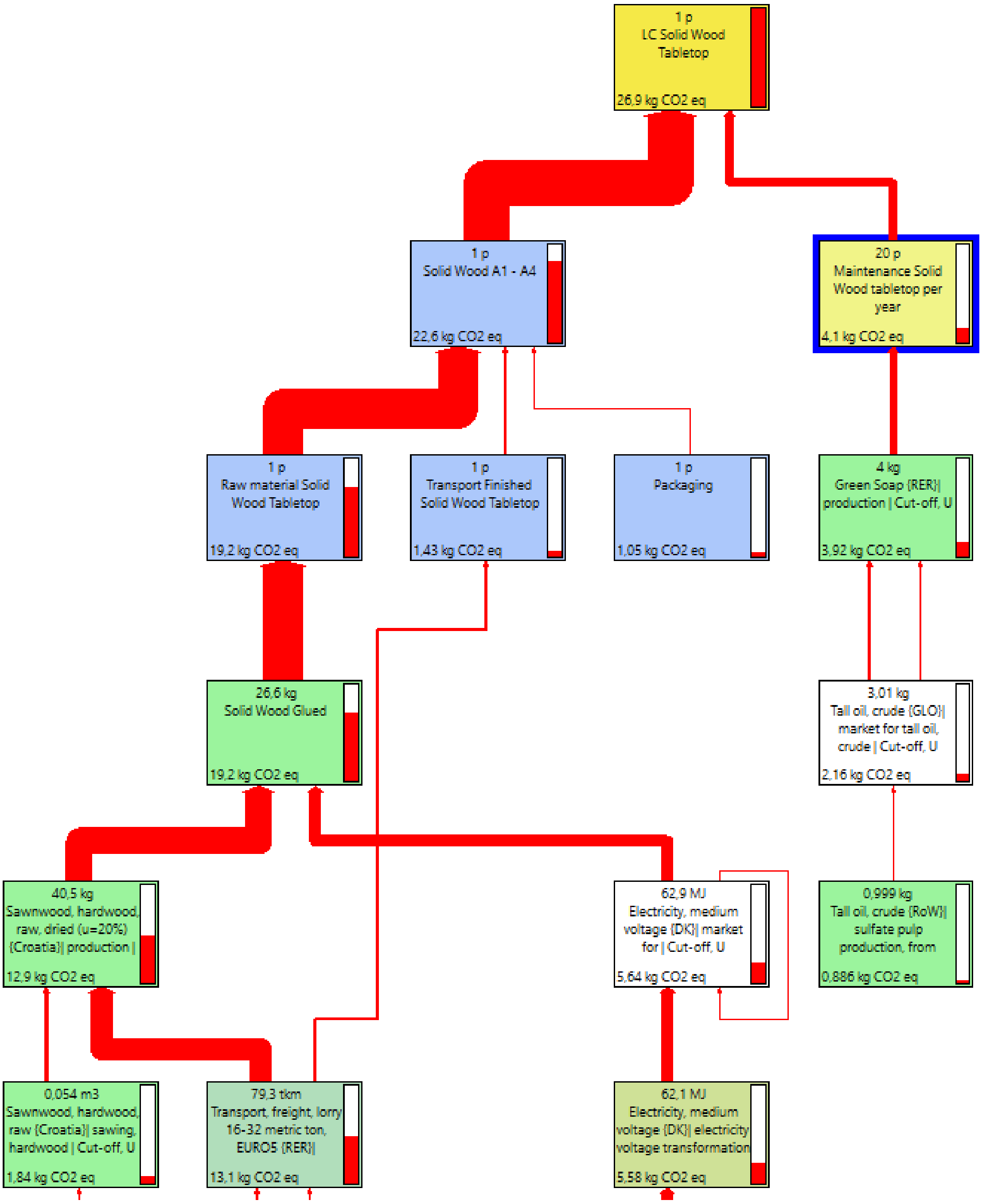

Figure 18 Sankey diagram showing impact on climate change (IPCC) for the solid wood tabletop.

4.3.1.4 Climate change potential Laminate tabletop

A Sankey diagram shows the flow with the thickness of the arrows. The cut-off of the Sankey Diagram is set to 4% which means that only processes that contribute to more than 4% of the total climate change potential are included in the diagram. Seen to the total 17 of 12895 contributing processes are shown in the Sankey diagram.

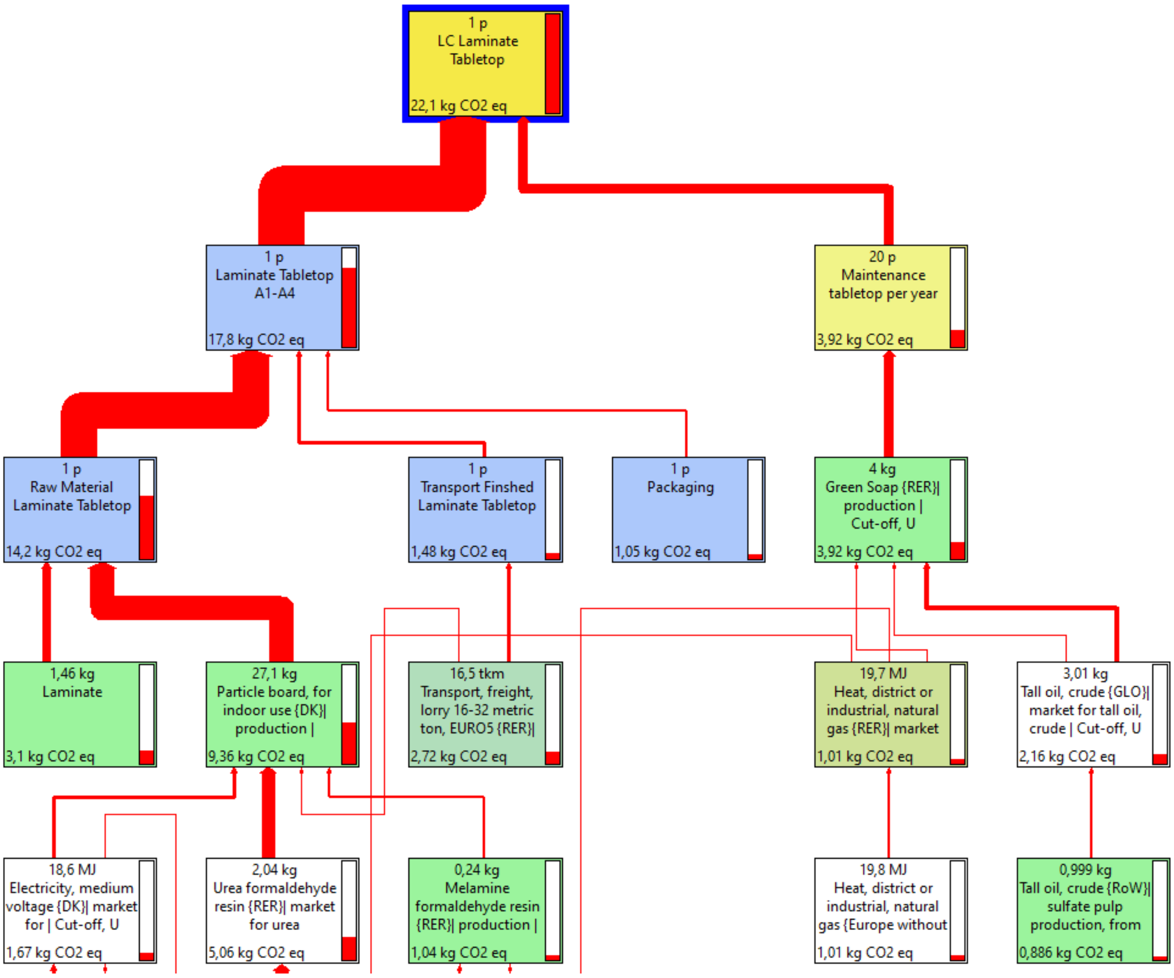

Figure 19 Sankey diagram showing impact on climate change (IPCC) for the laminate tabletop.

4.3.1.1 Climate change potential Compact laminate tabletop

A Sankey diagram shows the flow with the thickness of the arrows. The cut-off of the Sankey Diagram is set to 2% which means that only processes that contribute to more than 2% of the total climate change potential are included in the diagram. Seen to the total 13 of 12884 contributing processes are shown in the Sankey diagram.

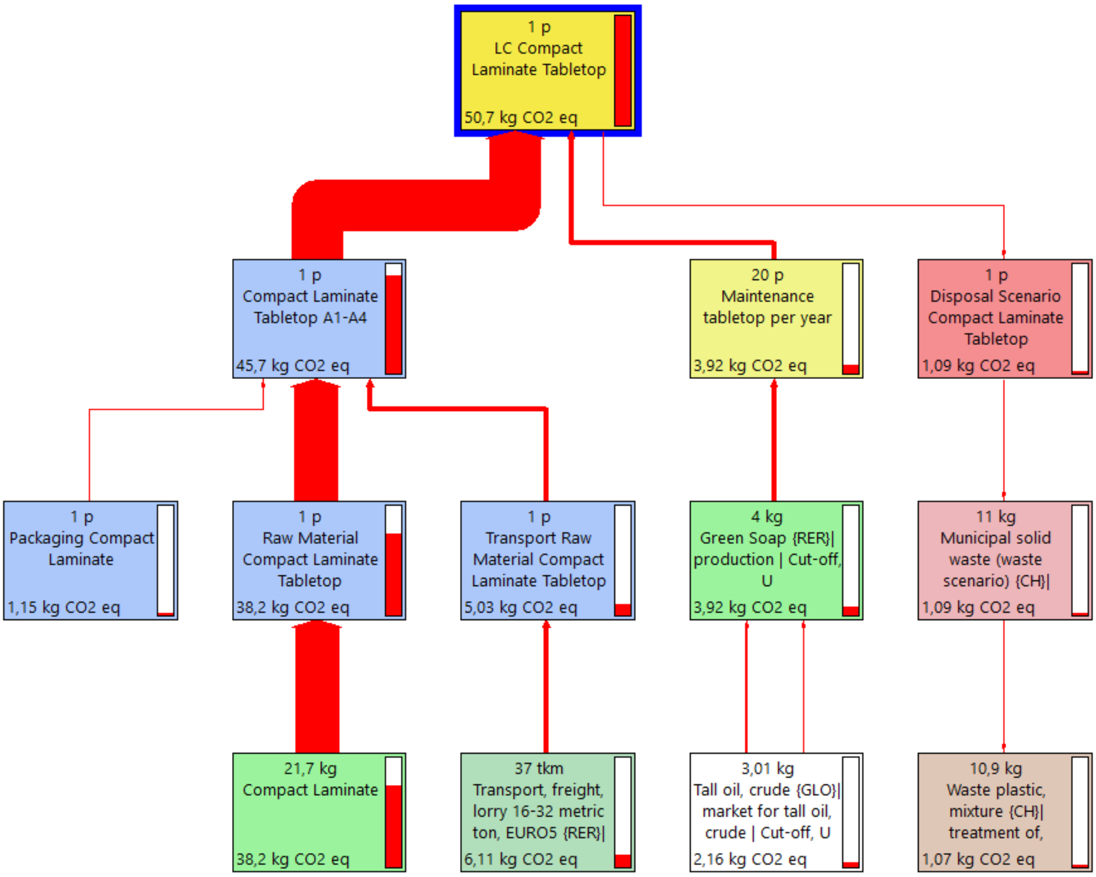

Figure 20 Sankey diagram showing impact on climate change (IPCC) for the compact laminate tabletop.

4.3.1.2 Climate change potential Ceramic tabletop

A Sankey diagram shows the flow with the thickness of the arrows. The cut-off of the Sankey Diagram is set to 1% which means that only processes that contribute to more than 1% of the total climate change potential are included in the diagram. Seen to the total 16 of 12915 contributing processes are shown in the Sankey diagram.

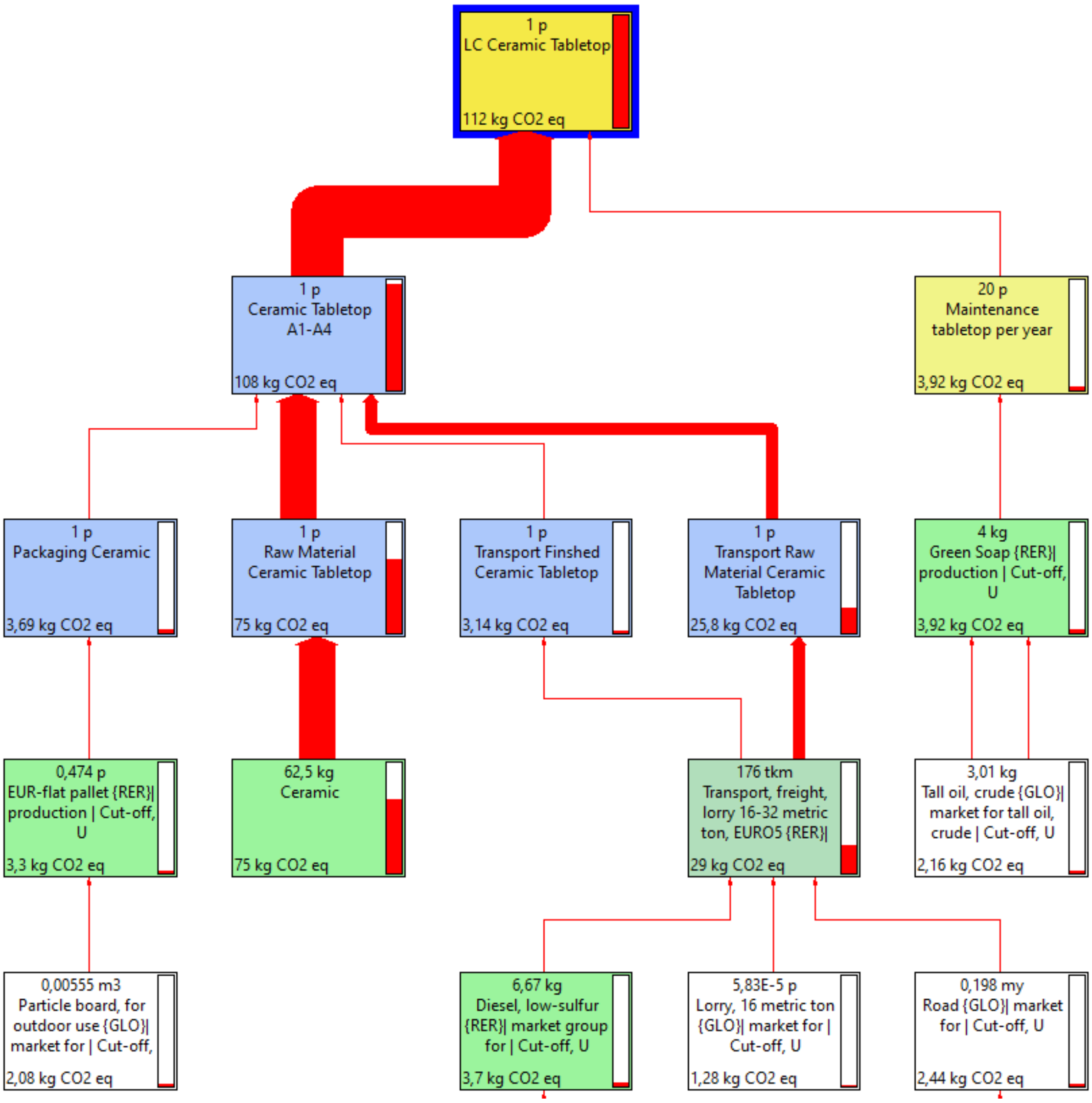

Figure 21 Sankey diagram showing impact on climate change (IPCC) for the ceramic tabletop.

4.3.1.3 Climate change potential Natural stone tabletop

A Sankey diagram shows the flow with the thickness of the arrows. The cut-off of the Sankey Diagram is set to 2% which means that only processes that contribute to more than 2% of the total climate change potential are included in the diagram. Seen to the total 15 of 12921 contributing processes are shown in the Sankey diagram.

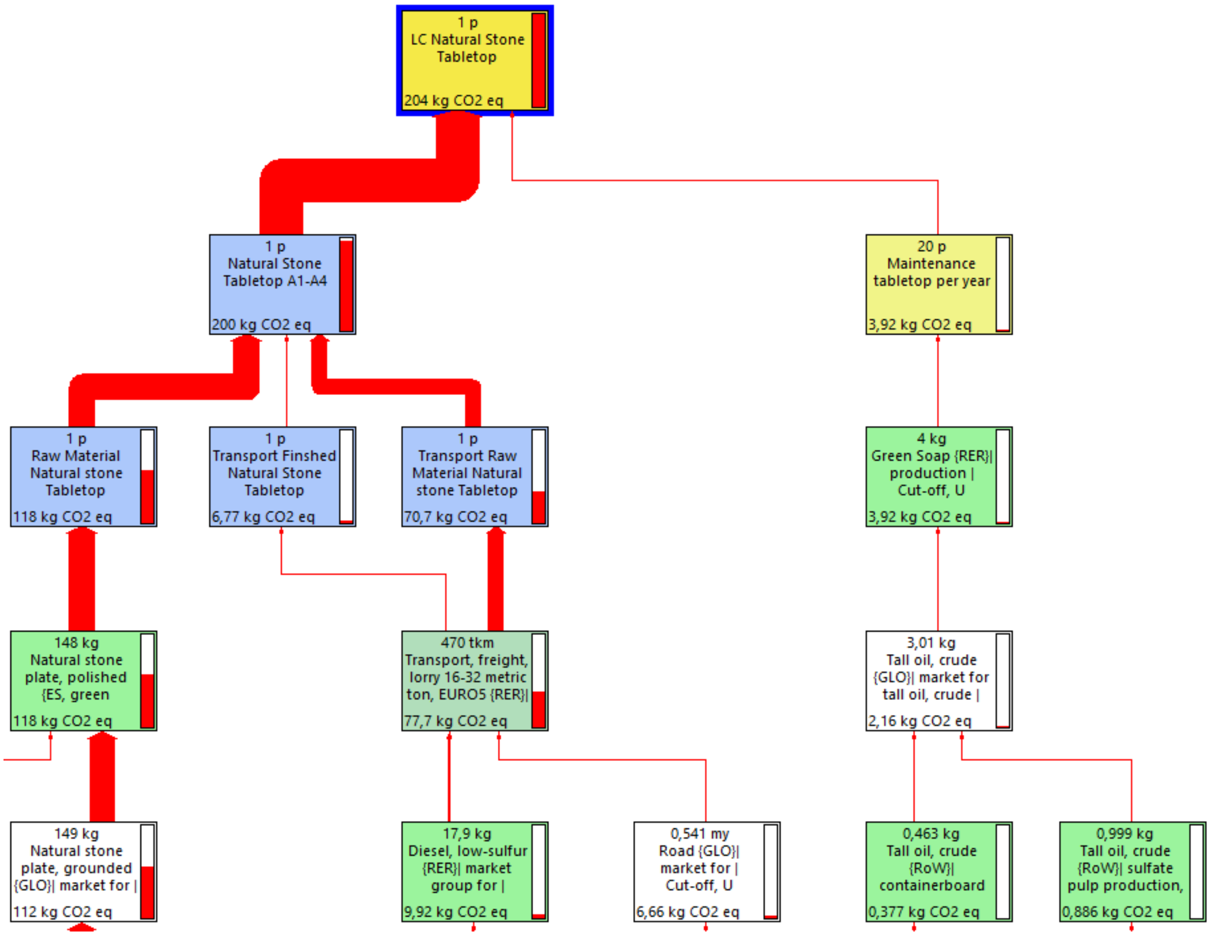

Figure 22 Sankey diagram showing impact on climate change (IPCC) for the natural stone tabletop.

4.3.2 EPD (2018)

The results from the EPD (2018) method are presented in Table 23.

Table 23 Total impact per impact category for all tabletops.

	Composite	Solid Wood	Laminate	Ceramic	Compact Laminate	Natural Stone
Climate change (kg CO2 eq)	196	27.0	21.9	112	50.6	203
Ozone layer depletion (kg CFC11 eq)	2.75E-05	2.6E-06	2.19E-06	1.49E-05	1.64E-06	2.39E-05
Acidification (kg SO2 eq)	0.811	0.117	0.0744	0.365	0.136	0.983
Photochemical oxidation (kg NMVOC eq)	0.428	0.126	0.109	0.208	0.0770	0.982
Eutrophication (kg PO4 eq)	0.149	0.0456	0.0343	0.0610	0.0868	0.296
Resource use, minerals and metals (kg Sb eq)	0.00212	0.000638	0.000503	0.00116	0.000365	0.00276
Resource use, fossils (MJ)	3048	397	389	1170	1123	2633

5 Interpretation

5.1 Completeness check

The objective of the completeness check is to ensure that all relevant information and data needed for the interpretation are available and complete. If any relevant information is missing or incomplete, the necessity of such information for satisfying the goal and scope of the LCA shall be considered. This finding and its justification shall be recorded.

In reference to the goal and scope of the report the report is considered to be complete.

5.2 Sensitivity check

For the natural stone tabletop the raw material has been represented by the dataset *Natural stone plate, polished {CH}| production | Cut-off*, U where the electricity has been modified to represent production at Consentino in Spain with 64% wind power, 25% hydro power and 11% solar power. If the electricity instead came from the national grid in Spain the total impact on climate change (IPCC) from the natural stone tabletop is increased eith 22kg CO2eq, corresponding to an increase of 11%, see Figure 23.

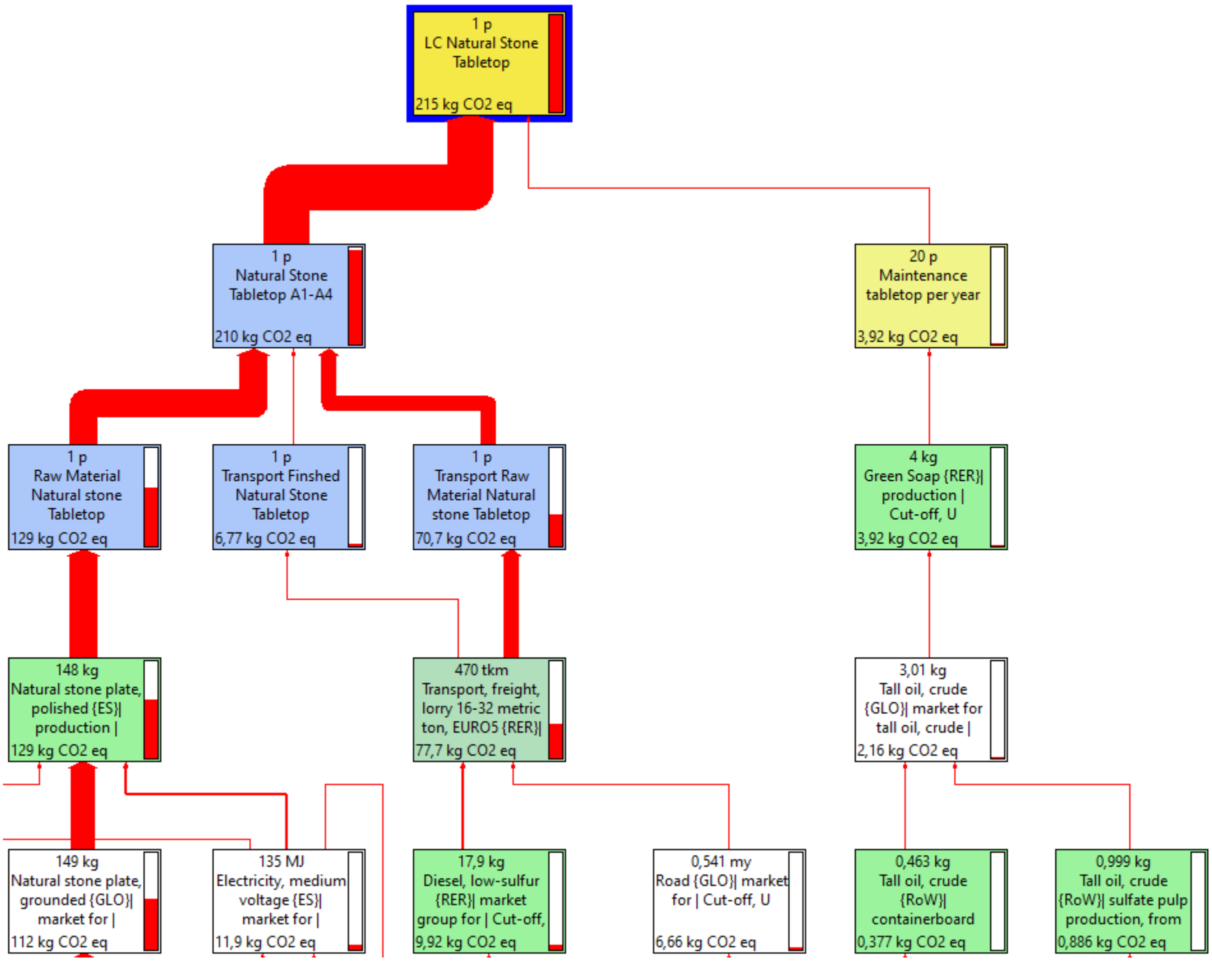

Figure 23 Total impact on climate change (IPCC) from the natural stone tabletop with electricity from the Spanish grid.

5.3 Conclusions

5.3.1 Overview

The tabletops with the highest impact on climate change (IPCC) are the natural stone tabletop, with an impact of 204 kg CO2 eq, and the composite tabletop with an impact of 196 kg CO2eq, see Figure 15. The tabletops with the least impact on climate change are the laminate tabletop, 22 kg CO2 eq, and the solid wood tabletop, 27 kg CO2eq. The natural stone tabletop has 12 times higher impact than the laminate tabletop.

The common denominator for all tabletops is that the raw material phase contributes most to the impact on climate change, Figure 16.

5.3.2 Most important impact categories

The Environmental Footprint 3.0 method, see Appendix 1, was used to get a weighted result and determine which categories in the EPD (2018) that are most important to look into. The EF 3.0 method is not 100% compatible with the EPDs used for the raw materials, which is why it is not used for the results. It can however give the indication of which impact categories that should be focused on. The categories of most interest are climate change, resource use minerals and metals as well as resource use fossils. Therefore, extra focus is on the climate change potential of the tabletops in the interpretation.

The results from the EPD method shows that for the impact categories resource use, mineral and metals (Table 24), and resource use, fossils (Table 25), the raw material phase and the transports are important.

Table 24 Resource use, minerals and metals (kg Sb eq)

	Raw material	Transport of raw material	Manufacturing at DFI Geisler	Packaging	Transport finished tabletop	Usage phase	End-of-Life
Composite	8.12E-05	0.00161	1.78E-05	6.77E-05	0.000158	0.000155	3.54E-05
Solid wood	0.000384	1.23E-05	2.07E-05	3.46E-06	3.9E-05	0.000155	2.36E-05
Laminate	0.00025	1.86E-05	2.5E-05	3.46E-06	4.03E-05	0.000155	1.07E-05
Compact laminate	1.85E-05	0.000137	2.22E-05	4.22E-06	2.76E-05	0.000155	8.34E-07
Ceramic	0.000106	0.000705	1.79E-05	6.77E-05	8.56E-05	0.000155	2.05E-05
Natural stone	0.000361	0.00193	1.93E-05	6.77E-05	0.000185	0.000155	4.07E-05

Table 25 Resource use, fossils (MJ)

	Raw material	Transport of raw material	Manufacturing at DFI Geisler	Packaging	Transport finished tabletop	Usage phase	End-of-Life
Composite	1968	878	4.07	60.3	86.1	45.1	6.40
Solid wood	269	6.73	5.42	24.4	21.3	65.0	5.29

Laminate	278	10.1	6.23	24.4	22.0	45.1	3.18
Compact laminate	954	74.9	5.47	26.3	15.1	45.1	2.40
Ceramic	1125	385	4.10	60.3	46.7	45.1	3.71
Natural stone	1360	1054	4.92	60.3	101	45.1	7.35

5.3.3 Composite tabletop

For the composite tabletop 63% of the impact on climate change comes from the raw material phase. It is not possible to break out which processes in the raw material phase that contribute most because the results from the EPD are an aggregation of the three steps raw material, transport to factory in Spain and manufacturing.

30% of the total impact comes from the transport of raw material to DFI Geisler from Spain. The impact from the transport is calculated using the weight and the distance. The composite tabletop weighs more and has a longer transport distance in relation to the other tabletops (except from natural stone). A reduction of the waste at DFI Geisler would reduce the impact from the transport, since the weight of the transported material decreases. It would also reduce the amount of raw material needed, which in turn reduces the impact from the production of raw material.

Reducing the waste of the composite tabletop at DFI Geisler with 10% would reduce the total impact from the composite tabletop with 6%, corresponding to 11kg CO_2 eq. A 20% reduction of the waste would reduce the total impact on climate change with 11%, 22 kg CO_2 eq.

5.3.4 Solid Wood tabletop

For the solid wood tabletop 71% of the impact on climate change comes from the production of raw material at the supplier. The long transport of the wood from the extraction site to the supplier contributes most to the impact on climate change, followed by the impact from the electricity at the supplier. The transport of wood corresponds to 43% of the total impact and the electricity used for production at the supplier 21%.

Reducing the waste at Herning massivtræ with 10% decreases the total impact with 5%.

If the supplier uses electricity from wind power instead of from the national grid it would reduce the total impact with 19%.

If DFI Geisler reduces the waste of solid wood tabletop with 10% it would reduce the total impact on climate change with 6%, 1.5 kg CO_2 eq.

5.3.5 Laminate tabletop

The impact on climate change from the raw material phase for the laminate tabletop is 64%. It is the particle board and the laminate layer that contribute most to the total impact on climate change, with 42% and 14% respectively.

For the laminate layer an EPD has been used (with aggregated data for production, transport and manufacturing of the laminate) to model the material and therefore it is not possible to break down the material further. For the particle board the component that contributes most to the impact on climate change is the urea formaldehyde resin. Reducing the amount of urea formaldehyde with 50%, and replacing it with wooden content, reduces the impact on climate change with 11%, 2.5 kg CO2 eq.

5.3.6 Compact laminate

The raw material phase of the compact laminate tabletop contributes with 75% of the total impact on climate change. For the compact laminate an EPD with aggregated data for production of raw materials, transport to manufacturing site and the manufacturing of the compact laminate has been used to model the material. It is therefore not possible to identify the hot spots in the production of the compact laminate.

Reducing the waste of compact laminate tabletop at DFI Geisler with 10% reduces the total impact on climate change with 6%, 3 kg CO2eq. Reducing the waste with 20% decreases the impact on climate change with 6.1 kg CO2eq, corresponding to a reduction of the total impact with 12%.

The transport of the raw material for the compact laminate tabletop contributes with 10% of the total impact on climate change. It is transported 1400km by truck from Austria to DFI Geisler. If this transport was made by train instead of truck it would reduce the total impact with 7%, 3.3 kg CO2 eq. If 50%, half of the distance, of this transport is made by train it would reduce the impact with 3%, 1.6 kg CO2 eq.

5.3.7 Ceramic

For the ceramic tabletop 67% of the total impact on climate change comes from the raw material. Also for the ceramic tabletop an EPD has been used to model the raw material. Due to the aggregated data in the EPD, for production of raw materials, transport to manufacturing site and the manufacturing of the ceramic, it is not possible to identify the hot spots for the raw material.

23% of the total impact on climate change comes from the transport of the raw material from the supplier to DFI Geisler.

The amount of waste of ceramic tabletop occurring at DFI Geisler is 79%. Reducing the waste at DFI Geisler with 20% reduces the impact on climate change with 10 %, corresponding to 11kg CO2eq. A 40% reduction of the waste reduces the impact on climate change with 20%, 22.1 kg CO2eq.

5.3.8 Natural Stone tabletop

For the natural stone tabletop 58% of the impact on climate change comes from the raw material phase. Most impact comes from the use of electricity and diesel in the production of the natural stone. It is assumed that the sources of electricity are 100% renewable, but if the electricity comes from the Spanish national grid instead the impact increases with 11%, see 5.2 Sensitivity check.

34% of the impact comes from the transport of the natural stone raw material to DFI Geisler from Spain. Like the composite tabletop, see 5.3.3, the natural stone tabletop is heavier and has a longer transport distance in relation to the other tabletops. Reducing the waste at DFI Geisler reduces the impact from both the transport of raw material as well as the raw material phase.

Reducing the waste at DFI Geisler with 10% would reduce the total impact with 11 kg CO2eq, corresponding to a 5% reduction of the total impact. Reducing the waste at DFI Geisler with 20% gives a reduction of the total impact with 11%, 23 kg CO2.

5.3.9 Lifetime & communication to customer

Although there is in general a low impact from the usage phase, one important factor for the environmental burden is the lifetime of the product, which is decided in this phase. The lifetime of the tabletop depends on how the user perceives the entire kitchen and also how the user handles the kitchen. If the user decides to change kitchen once during 20 years due to damage, trends or other reasons, the environmental burden will double.

High quality is therefore a prerequisite for a long lifetime. It means that a material with high quality and long lifetime but a larger environmental burden can be justified compared to a material with lower quality and shorter lifetime but a smaller environmental burden.

It is therefore of great interest to communicate the importance of quality and lifetime to the customer as a way to increase the lifetime (Johansson, 2020). According to Gabler, Butler and Adams (2013) it is important for businesses to provide more information to customers, and when doing so businesses should clearly state exactly how their projects or initiatives affect the environment. Vague claims create confusion for the customer and may be perceived as greenwashing. Communication without greenwashing means that except from green marketing the company must show that practices and policies across all functional areas of the business are green. More available information is a way of strengthening the link between the consumer's beliefs and behaviour (Gabler, Butler & Adams, 2013). The authors say that if consumers had more information that enhance their sense of contribution, their behaviour can be altered.

5.4 Recommendations

- Reduce the waste at DFI Geisler
- Investigate the possibility to use train instead of trucks for the transports
- Investigate possibilities to dig deeper into the most contributing aspects of the raw materials where EPDs have been used to see where efficient measures kan be taken
- Communicate to suppliers the importance of reducing waste and using energy with low environmental impact in production
- For the laminate tabletop – investigate the possibility to use a particle board with less urea formaldehyde content
- Recommend the customer to use laminate or solid wood tabletops rather than natural stone or composite
- Communicate to the customer that they have an important role to play regarding the lifetime of the tabletop

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7 Appendix

Appendix 1, Methods for Impact Assessment

The **Environmental Footprint 3.0 method** method is the most recently updated, the most comprehensive and the best adapted to all the environmental effects that are recommended by the PCR. Environmental Footprint 3.0 is especially harmonized with the demands from EN 15804:2012+A2:2019.

Classification
Classification means that all categories of data are sorted into different categories of environmental effects. Readymade methods for this have been used in order to evaluate a broader perspective and find the most potential categories. The mostly used methods being Ecoindicator and EPS. These methods include also characterisation (and weighting described further).

The aim with the characterisation is to quantify each element's contribution to the different categories of environmental effect, respectively. To do this, each category of environmental effect is multiplied with characteristic factors which are specific for the data- and the category of environmental effect. The result from the characterisations gives answer about what or which emissions that leads to a significant environmental influence. For each characteristic factor calculates the potential environmental influence which could arise if an element released to the environmental or if a resource is consumed.

Classification and characterisation are where all items in the inventory are assigned to the effect it is likely to have on the environment.

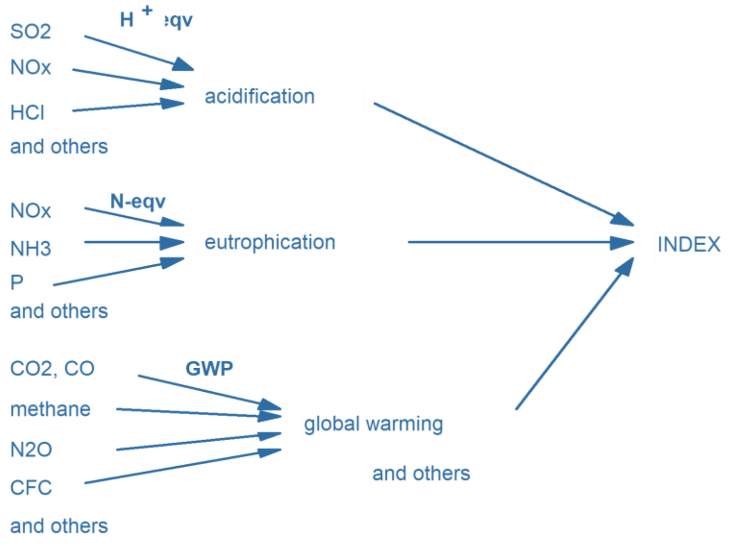

Figure 24: An illustration of the Impact Assessment of an LCA.

When this link is determined, we call it an environmental aspect. This environmental aspect has to be linked between the environment and the process before you can say that it is established and that the process is unsustainable. In the early stages of Lifecycle Assessment substances that were found in the inventory was assigned to environmental aspects. In order to reach for the ultimate goal of sustainability, it is important also to describe the local and global environment. Environmental aspects that may have an impact are located and after that, the link to the inventory and to the process path features may be analyzed and established.

Weighting
The results of an LCA may depend on the method for impact assessment. There are a few different models to assist in assessment of the environmental impacts connected to the life cycle e.g. ecological scarcity (ECO), the environmental theme method (ET), ECO indicator (EI), ReCiPe and the Environmental Priority Strategies in Product Design (EPS) method.

Weighting method implies that all of the data classes are weighted together so that only one number is expressed for the weighting method. To do a weighting, different data categories are weighed from some form of valuations principle. The basis of a valuation could be either individual or a community's political and/or morality valuations. The weighting expresses the relation between values in the community and variations in the nature. The more effect or deviation an environmental aspect has from the valuations, the higher weighting value gets the environmental aspect [Lindahl et al. (2002)].

The basis of valuations which are used to develop a weighting methods could be; political decisions, technical-financial conditions, nature conditions, effects of the health, panels, and studies of behavioural patterns. In a weighting method, there are either only one of this valuation basis or it will be a combination of these valuation bases. Since the basis of valuations varying for each weighting method, a comparison between different methods will give a shifting in the result [Lindahl et al. (2002)].

The mostly used weighting methods are collected in the book "The Hitch Hiker's Guide to LCA", written by Baumann H. & Tillman A-M. (2004), and the most important are presented below:
Ecoindicator'99: is a weighting method based on the distance-to-target principle and the target is established as environmental critical loads 5 % ecosystem degeneration, or similar. Ecoindicator'99 are determined from three different cultural perspective; hierarchism, egalitarian and individualist. An average value from the three cultural perspectives has been calculated and is used in this study. Ecoindicator'99 is based on Goedkoop and Spriensma (1999) [Baumann H. & Tillman A-M. (2004)].

EPS 2000: is different from the two other weighting methods above in that case that it is not based on the distance-to-target principle. Instead this method is based on the willingness-to-pay for avoiding damages on environmental safeguard subjects. The EPS method is especially suitable for assessment of global impacts, such as climate change potential and resource depletion. The EPS indices are prepared by a group at Chalmers University of Technology and a steering committee from the industry in Sweden.

Appendix 2, Certificate according to Guarantee of Origin

Miljøvenlig El sikrer, at elforbruget kommer fra de nordiske vandkraftanlæg.

Energi Danmark A/S' revisor PWC dokumenterer i forbindelse med revidering af regnskabet balance mellem købt og solgt Miljøvenlig EL

Virksomhedsnavn	Aftagenummer	Adresse	Postnr.	By
DFI Geisler A/S	571313133122287410	Industrivej 21	7900	Nykøbing M

Energi Danmark A/S bekræfter hermed, at: **DFI Geisler A/S**

har købt sin andel af elforbruget i perioden 01.07.2019 - 31.12.2021 som Miljøvenlig El produceret på nordiske vandkraftværker.

Forventet årligt forbrug er **2.040.228 kWh**

Jørgen Holm Westergaard
Adm. direktør
24.05.2019

Energi Danmark®

Ægtheden af Miljøvenlig El dokumenteres af Energi Danmark A/S' revisor PWC.

Appendix 3, IPCC 2013

Direct solar radiation heats the Earth. The heated crust emits heat radiation which partially are absorbed by gases, known as greenhouse gases, in the Earth's atmosphere. Some of this heat radiation rays back to Earth and heat the Earth. This natural greenhouse effect is essential for life on Earth. However, because of human activity, the presence of greenhouse gases in the atmosphere, such as carbon dioxide, methane, and nitrous oxide, have increased. This affects the natural radiation balance, which leads to global warming and climate changes.

The potential impact on the climate is calculated using the IPCC 2013 GWP 100 v.1.03 (IPCC, 2013), model Global Warming Potential, GWP. The impact of climate gases is expressed as carbon dioxide equivalents, CO2 eq. It is the most established scientific method. It has been implemented in other methods, such as GHG protocol and ReCiPe, but then with adaptions.

Appendix 4, ecoinvent

Ecoinvent is one of the world-leading databases with consistent, open, and updated Life Cycle Inventory Data (LCI).

With several thousand LCI data sets in the fields of agriculture, energy supply, transport, biofuels and biomaterials, bulk and speciality chemicals, construction and packaging materials, basic and precious metals, metals, IT and electronics and waste management, ecoinvent offers the most comprehensive international LCI database.

Ecoinvents high-quality LCI data sets are based on industrial data and have been compiled by internationally recognised research institutes and LCA consultants.